The New Encyclopædia Britannica

PROPÆDIA

Outline of Knowledge and Guide to the Britannica
How to use the PROPAEDIA

As its title indicates, the PROPAEDIA, or Outline of Knowledge, is intended to serve as a topical guide to the contents of the Encyclopædia Britannica, enabling the reader to carry out an orderly plan of reading in any field of knowledge or learning chosen for study in some depth. The PROPAEDIA’s table of contents gives the reader an overview of the Outline of Knowledge as a whole; the introductory essays for each of the ten parts illuminate the major concerns of that part of human knowledge; the headnotes that are affixed to parts and divisions prepare the reader for examination of the subjects being covered there; and the outlined presentations of these subjects, with their lists of related article titles, enable the reader to carry on a course of study that may be more or less extensive and detailed in accordance with individual interests and desires.

Structure. Each of the 10 parts, 41 divisions, and 177 sections that make up the PROPAEDIA is marked in the table of contents by a heading, which is followed by the number of the page on which that unit of the PROPAEDIA begins. This structure provides three ways to utilize the outline: (1) one may turn to any of the parts as a whole and examine the contents of that part; (2) one may select a particular division of a part and examine the contents of that division; or (3) one may focus on a single section or several sections of such a division and examine the contents of that section or those sections.

Sectional outlines. The sectional outlines present, in an orderly arrangement of topics, subjects that are treated in articles in the MACROPAEDIA and MICROPAEDIA. Each section number incorporates the numbers of the part and division to which it belongs. For example, Section 725 is the fifth section in Part Seven, Division II; Section 96/10 is the tenth section in Part Nine, Division VI. In each sectional outline the major subjects are indicated by capital letters (“A,” “B,” etc.). There are always at least two major subjects, but there may be many more in a given section. When it is necessary to subdivide a major subject, up to three additional levels may appear in the outline; the first is indicated by Arabic numerals, the second by lowercase letters, and the third by Roman numerals, as shown below:

B. Metallurgy
1. Mineral processing: crushing and grinding of ores, concentration of metallic minerals
2. Extractive metallurgy: separation of metallic elements from mineral form
   a. Pyrometallurgy: processes that involve the use of heat
      i. Roasting: oxidizing, reducing reactions
   ii. Smelting: processes for removing molten metal from molten slag

The INDEX, with its alphabetically arranged subject headings, is indispensable in finding where a given subject appears in the Outline of Knowledge. These headings, where appropriate, carry specific citations pointing to the part, division, or section of the PROPAEDIA that covers the subject in question. A subject referred to in a sectional outline is, in many cases, treated fully in an article of the same title in the MACROPAEDIA or MICROPAEDIA, each such title being included in the list of suggested reading at the end of the section. These titles, as well as significant references to the subjects in other contexts, are cited in the INDEX. It may be helpful to compare the functions of the PROPAEDIA and the INDEX: Both are guides to the contents of the Encyclopædia Britannica, but the PROPAEDIA’s primary purpose is to indicate what subjects are covered, while the INDEX’s primary purpose is to indicate where they are covered.
"The alphabetical system of arrangement," observed the Editors of the Eleventh Edition of the *Encyclopaedia Britannica* (1910-11), "with its obvious advantages, necessarily results in the separation from one another of articles dealing with any particular subject." Consequently, "the student who desires to make a complete study of a given topic must exercise his imagination if he seeks to exhaust the articles in which that topic is treated." This result is certainly a serious defect in the system for anyone who feels—as did the Editors of the Eleventh Edition—that an encyclopaedia should not be merely a "storehouse of facts," but should also be "a systematic survey of all departments of knowledge." To remedy this defect, the Editors constructed a "Classified Table of Contents," which they believed to be "the first attempt in any general work of reference at a systematic subject catalogue or analysis of the material contained in it."

Remarkable as it was at the time, that Table of Contents did not fully succeed in achieving its objective of overcoming the defects of an alphabetical organization of encyclopaedic articles by means of a topical presentation of their content. A quick glance at the 24 major categories into which the Table of Contents was divided will reveal that the alphabet was still the thread on which the parts were strung: I. Anthropology and Ethnology; II. Archaeology and Antiquities; III. Art; IV. Astronomy; V. Biology; VI. Chemistry; VII. Economics and Social Science; VIII. Education; IX. Engineering; X. Geography; XI. Geology; XII. History; XIII. Industries, Manufactures and Occupations; XIV. Language and Writing; XV. Law and Political Science; XVI. Literature; XVII. Mathematics; XVIII. Medical Science; XIX. Military and Naval; XX. Philosophy and Psychology; XXI. Physics; XXII. Religion and Theology; XXIII. Sports and Pastimes; XXIV. Miscellaneous. In each of these categories, the only further subdivisions involved the distinction of general from particular subjects, and the distinction of both of these from biographical entries. Under each of these headings, titles of the encyclopaedia's articles were listed in strictly alphabetical order.

In planning this Fifteenth Edition of *Encyclopaedia Britannica*, the Editors, while deciding to retain the alphabetical ordering of the articles in the set, sought to improve upon the effort that their predecessors had made to overcome the defects of an alphabetical organization by giving the reader a truly topical, and totally nonalphabetical, Table of Contents. It would serve the purpose that the Editors of the Eleventh Edition had in mind, which was to enable the reader to "make a complete study of a given topic"—that is, a department of knowledge or field of learning.

It may be asked why it was not thought better to abandon the alphabetical principle entirely and construct a purely topical encyclopaedia, in which all the articles would be assembled, volume after volume, according to some general schema for the organization of human knowledge. The answer is twofold. First, a purely topical organization of the articles themselves cannot avoid the appearance of a certain tendentiousness or arbitrariness in the editorial commitment to one rather than another organizing schema or set of principles. The reader is, therefore, provoked to ask: Does this order, volume by volume and article by article, reflect the only right or proper exposition of the whole of human knowledge?

Second, a purely topical encyclopaedia provides its readers with only one mode of access to its contents. This may be alleviated somewhat, perhaps, by the addition of an alphabetical index; but an index, by its very nature, serves the purpose of enabling the reader to look up particular items of information; it does not provide a general and systematic mode of access to the contents of the encyclopaedia.

The basic plan of the new *Britannica*, therefore, aims to give its readers access to its contents by both the topical and the alphabetical modes. General and systematic topical access is provided by the Outline of Knowledge contained in this volume, called the "Propædia" because it is a kind of preamble or antechamber to the world of learning that the rest of the encyclopaedia aims to encompass. Alphabetical access is provided not only by the two-volume Index but also by the alphabetical ordering of the short articles in the Micropædia.

Unlike the Classified Table of Contents in the Eleventh Edition, which was alphabetically organized by categories and subjects, the Outline of Knowledge in this Fifteenth Edition is a purely topical presentation of the subjects covered in the articles to be found in both the Macropædia and the Micropædia. It is, therefore, reasonable to ask how such a purely topical outline of encyclopaedic content avoids the tendentiousness or arbitrariness that is attributable to an encyclopaedia in which the articles themselves are topically rather than alphabetically arranged. Does not the Outline of Knowledge here presented reflect, perhaps even con-
The Circle of Learning

cereal, a commitment to one set of organizing principles rather than another? Does it not embody biases or preconceptions that are not universally acceptable?

It is hardly possible to say “No, not at all” to these questions. Two points, however, can be made affirmatively that tend to reduce or alleviate whatever degree of arbitrariness remains unavoidable in a topical outline of the whole of human knowledge. One is that the Outline of Knowledge, while conceived by the Editors, was constructed and corrected in the light of detailed recommendations, directions, and analytical contributions from scholars and experts in all the fields of knowledge represented. A list that includes the advisers who worked with the Editors in the construction of the Outline of Knowledge follows Part Ten of the Propædia.

The second point is that the Outline of Knowledge is conceived as a circle of learning. To say that the contents of an en-cyclo-pædia form a circle of learning is more than a literal transliteration from Greek to English. In Greek or English, reference to the circle introduces a powerful metaphor, the understanding of which should help the reader to overcome whatever arbitrariness still resides in the Outline of Knowledge in spite of determined efforts on the part of all concerned to minimize this defect. A circle is a figure in which no point on the circumference is a beginning, none is a middle, none is an end. It is also a figure in which one can go from any point, in either direction, around the circumference; in addition, one can go across the circle from any point to any other; or, by any number of transecting lines, starting from a given point, one can go to any number of other points on the circumference, near or far.

The 10 parts into which the Outline of Knowledge is divided are disposed not along a finite straight line beginning at this point and ending at that; they are disposed rather as segments of the circle. While it is true that, in this arrangement, one part may lie next to another and at some distance from still another, it is also true that, since the circle can rotate around its axis, any one of the 10 parts may be regarded as standing at the top of the circle, or at the left or right side of it, or at the bottom. In other words, with the circular arrangement of the parts, and with the rotation of the circle, the reader can begin anywhere in the circle of learning and go to adjacent parts around the circle; or, moving along interior transecting lines, the reader can go from any point across the circle to parts that are not adjacent on the circumference. This view of the Outline of Knowledge can be represented in a number of diagrams.

For a synopsis of the subject matter covered in each of the 10 parts of the outline, the reader is referred to that part of the Table of Contents set forth on pages 9–15 of this volume. The titles of the individual parts are given in the following list:

| Part One. | Matter and Energy |
| Part Two. | The Earth |
| Part Three. | Life on Earth |
| Part Four. | Human Life |
| Part Five. | Human Society |
| Part Six. | Art |
| Part Seven. | Technology |
| Part Eight. | Religion |
| Part Nine. | The History of Mankind |
| Part Ten. | The Branches of Knowledge |

The pair of diagrams below shows the 10 parts as segments of a circle. Part One is placed at the top of the diagram to the left, and Part Nine is at the top of the diagram to the right, to illustrate the effect achieved by rotating the circle.

The second pair of diagrams, following, places one of the 10 parts at the centre of the circle with the remaining nine parts as segments of the circle formed by lines radiating from the centre. The point being made here is that any part can occupy the central position—the place in the circle of learning at which one begins, going thence in all directions to the remaining nine parts. To illustrate this, Part Five occupies the centre in the diagram to the left; Part Three, the centre in the diagram to the right.

The final diagram offers still another approach to the circle of learning. In this diagram, Part Ten occupies the central position; and here there is only one diagram rather than a pair because the reason for placing Part Ten in the central position applies to it alone and to none of the other nine parts.
The reason for this special placement of Part Ten stems from the one organizing principle to which the Editors were explicitly committed in planning and producing this new *Britannica*. Briefly stated, that principle involves a distinction between (a) what we know about the world of nature, of man and society, and of human institutions by means of the various branches of learning or departments of scholarship; and (b) what we know about the branches of learning or departments of scholarship—the various academic disciplines themselves. For the most part—there are a few exceptions—Parts One through Nine represent the knowledge of nature, of human society, of human institutions, and their history. In clear contradistinction, Part Ten mainly covers the disciplines themselves—the branches of knowledge or fields of scholarship—by which one inquires into, thinks about, or comes to have knowledge of the world in which he lives. Part Ten examines the nature, methods, problems, and history of the various branches of knowledge or scholarly disciplines, the actual content of which is set forth in Parts One through Nine.

Thus, for example, Section 10/34 in Division III of Part Ten examines the nature, methods, problems, and history of the biological sciences; but the knowledge of life that the biological sciences afford is outlined in Part Three. Or, to take another example, Section 10/41 in Division IV of Part Ten examines historiography and the study of history; but the actual history of mankind is outlined in Part Nine.

There are, however, three departments of learning that are exclusively treated in Part Ten—both with regard to the nature and history of the disciplines themselves and also with regard to the knowledge or understanding afforded by these disciplines. They are logic (in Division I of Part Ten), mathematics (in Division II), and philosophy (in Division V). The reason for this exceptional treatment of these three disciplines is given in the Introductory Essay to Part Ten.

The special character of Part Ten thus explains the diagram in which it occupies the centre of the circle of learning, but that must not be interpreted as attributing prime importance to it. This diagram simply indicates the special function Part Ten performs in relation to the other parts. It alone stands in close relation to all the rest; there are varying degrees of relatedness among the other parts. For example, Parts Three and Four, dealing with Life on Earth and with Human Life, are closely related; Parts Four and Five, dealing with Human Life and with Human Society, are also closely related; but Part Four has a different relatedness to Part Three, on the one hand, and to Part Five, on the other. In the presentation of the Outline of Knowledge, the headnotes and the cross-references give the reader an indication of these interrelationships.

Anyone who is in a position to compare the classified list of articles in the Eleventh or even the Fourteenth Edition with the Outline of Knowledge will be persuaded, the Editors think, that whereas the immediately preceding editions of *Britannica* represented a 19th- and early 20th-century view of the state of human knowledge, the new *Britannica*, in its Fifteenth Edition, is an encyclopaedia that reflects the many changes and innovations in man’s knowledge and understanding that are emerging at the end of this century and will continue into the next.

The reader’s attention should be called to the following features of the Propedia, or Outline of Knowledge:

1. It serves as a Table of Contents for the long articles in the Macropedia and also for the tens of thousands of shorter articles in the Micropedia.
2. Each of the 10 Parts of the Outline and the several Divisions of each of those Parts is prefaced by a brief summary of the topics covered.
3. The Divisions of each Part are followed by a number of Sections in which each of the topics covered is outlined.
4. At the end of each sectional outline, there is a list of Suggested Readings, first in the Macropedia, second in the Micropedia, which is followed by a list of the biographical articles that are relevant to the subjects covered in the outline of that Section.
5. In the topical outline of each Section, cross-references are made, when relevant, to other Sections in the Propedia on which related subjects are treated.

Because it is constructed in this manner, the Propedia provides the reader who wishes to pursue the study of a whole field of knowledge with an easily used guide. The Propedia thus offers readers a more comprehensive and detailed study guide for the use of the *Encyclopaedia Brittanica* than has ever been furnished before.

To facilitate their use of the Propedia as a study guide, readers should turn to pages 9–15, which follow. Here they will find a synoptic Table of Contents of the Propedia itself, set forth in the order of the 10 Parts, under each of which the component Divisions are listed, and under each Division, the component Sections.

This synoptic Table of Contents gives readers an overview of the Outline of Knowledge as a whole. The introductory essays for each of the 10 Parts, each writ-
ften by an authority in that field, illuminate the major concerns of that area of human knowledge.

The Propedia, or Outline of Knowledge, helps readers answer for themselves the question that, in its most general form, is as follows: *What can I learn from the Britannica concerning one or another area of human knowledge?* More specifically, the question might be: *What can I learn about the Earth?* or *What can I learn about art?* The reader's interest may be even more specific. In the field of the Earth sciences, the question might be: *What can I learn about the Earth's constituent minerals and rocks?* or *What can I learn about weather and climate?* In the field of art, the question might be: *What can I learn about the theory and classification of the arts?* or *What can I learn about music?*

Another point should be mentioned because, in the view of the Editors, it distinguishes the Fifteenth Edition from all preceding editions.

The Outline of Knowledge presented in this Propedia volume was constructed before those articles themselves were named, outlined, commissioned, written, and edited. The outline served as the basis for determining what articles should be written, what their scope should be, how they should be related to other articles, and so on. It was, therefore, in origin a table of intents rather than a table of contents. It represented the intentions of the Editors in laying down a comprehensive plan for producing a new encyclopaedia, appropriate to the state of human knowledge and learning at the end of the 20th century and looking forward to emergent developments in the century to follow. What was originally, or in the planning stage of the work, a Table of Intents, then subsequently became, after the writing and editing of the articles was completed, a Table of Contents that tries to reflect accurately and faithfully the actual content of the articles.

All preceding editions of *Britannica,* as most other encyclopaedias, have been constructed from classified lists of articles. Such classified lists may vary from one edition to another, as they have from the First Edition of *Britannica* through the Fourteenth, but the variations are relatively minor as compared with the fact that they are all the same in form—nothing but classified lists of articles, as exemplified by the one presented in the Eleventh Edition, already referred to. In sharp contrast to such editorial procedures, the Fifteenth Edition has the distinction of being planned not in accordance with a classified list of articles, but rather in the light of an orderly topical outline of the whole of human knowledge, in the form of the circle of learning that is an *en-cyclo-pedia.*

MORTIMER J. ADLER
Director of Planning
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“Give me matter and I will build a world from it.” For 200 years since the philosopher Immanuel Kant uttered it, physicists, chemists, and astronomers have striven to make good that boast. That they can now tell an almost unbroken story of events from the birth of the universe to the origin of life on Earth is the cumulative result of many lifetimes spent in careful observation and experiment. Yet even amid this success in updating the first verses of Genesis, new questions nag. Why does familiar matter adopt the forms it does? Are the laws of nature that are known to us enforced throughout the vast, tumultuous universe? What unimaginable worlds of fire or blackness can nature conjure up, quite different from our own?

When men presume to take the fire of the Sun and put it experimentally in a bottle, they forfeit all hope of certainty and repose. Yet the great quest for control over nature starts gently enough. A child at play with building blocks or sand or a rubber ball is a human mind engaged in discovering how matter behaves. Experiments with the rubber ball, for example, reveal laws of reflection. The child finds that the ball will come back to him only if he projects it accurately at a right angle to a flat surface (wall or floor); otherwise it bounces away from him and another child may grab it and interrupt the research program.

If all grown-up children had abandoned this kind of play, the human species would still believe that the Earth was at the centre of the universe, that the planets were propelled by angel-power, and that thunder was the voice of God. But some adults retained the boundless inquisitiveness of the young. Isaac Newton, not the most modest of discoverers, or floor); otherwise it bounces away from him and another child may grab it and interrupt the research program.

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A series of discoveries in the late 19th and early 20th centuries illuminated the hidden mechanisms of our electric world like star shells on a dark night. Diligent work by chemists had shown that all matter was composed of vast numbers of atoms, different for each chemical element and capable of combining in predictable ways to make molecules and crystals. Indeed there was a remarkable pattern in the so-called “periodic table”: when the chemical elements were listed by weight, it turned out that elements 3, 11, and 19 . . . all had similar properties; 4, 12, and 20 . . . were also very much alike, and so on.

This pattern made sense only when the physicists discovered the construction of atomic matter. An atom consists of a heavy nucleus surrounded by a number of lightweight electrons exactly neutralizing the electric charge on the nucleus. The electrons group themselves around the nucleus in “shells,” like the layers of an onion, each shell being capable of accommodating a definite number today those waves and electrons enable lesser men to preen themselves on television screens in 260,000,000 homes.

In this latter part of the 20th century, a word-association test for physicist may very well evoke bomb. By coincidence, investigators of the nature of matter and energy stumbled upon a way of breaking open the storehouse of energy in the nucleus of the atom just at the time the human species was entering a period of unprecedented warfare. The swarms of nuclear-powered submarines that cruise with nuclear-tipped, city-killing missiles are a grim enough outcome of the “game.” The fact remains that the heart of physics itself is not directed to any such purpose but is an open, cooperative effort by scientists of all nations to understand the material universe we live in.

We inhabit an electric world. It is true that gravity stops us from falling headfirst into the abyss of space; true also that the daylight that powers all life comes from the nuclear reactor that we call the Sun. But of the great set of natural forces known to the physicist—gravitational, nuclear, and electromagnetic—the last, electromagnetism, is the chief governor of events on Earth.

It operates so discreetly, though, that when men started rubbing amber on their sleeves and found it attracted dust, or considered the seeming magic of the north-pointing lodestone, nothing suggested that these were more than curiosities. There was laughter when Benjamin Franklin said that lightning was electric—until he proved it. Nothing suggested that the colour, quality, and chemical behaviour of all familiar matter would be explained by research in electricity and magnetism. But that is in the nature of physics: you ponder the falling of an apple and realize what holds the planets in their courses; you look to see what happens when you pass electric currents through a gas and, in due course, you find out what holds a stone together and why grass is green.

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of electrons. The outward face of the atom, its outermost shell of electrons, is crucial in determining its chemical behaviour. The number of electrons to be fitted in depends on the charge on the nucleus. In some elements, the metals, there are only one or two easily detachable electrons in the outermost shell. Other elements, the most reactive nonmetals, fall short by only one or two electrons in having a complete outermost shell. These “surplus” and “missing” electrons create a supply-and-demand situation in which atoms combine chemically by exchanging or sharing electrons. The repetition of chemical properties throughout the periodic table arises as one shell of electrons is completed and the next one begins to fill.

The mechanisms sketched in these last few sentences account for almost all the chemical behaviour of all the matter on Earth. The electrical and magnetic behaviour of materials also depends on the arrangements of electrons in their atoms and, in some cases, on the combined effects of many atoms packed together in a crystal. The strength of the chemical bonds formed by electrons, and the related forces between molecules, determine whether materials are solids, liquids, or gases; and they help to fix the strength and flexibility of solids, but in this case the explanations are complicated by the invisible flaws that exist in all materials. The colour of materials is explicable by the “jumps,” from one position to another in the vicinity of an atom, which the rules allow an electron to make as the atom, molecule, or crystal absorbs or emits light of particular energy, or colour. Make the same electrons in vast numbers of atoms “jump” the same way simultaneously and you have a very intense laser beam.

Light and its invisible counterparts—radio waves, infrared, ultraviolet, and X-rays—are the purest form of energy. These “electromagnetic radiations” are created by the jerking of electrons, sometimes quite gently, as in a radio antenna, and sometimes very fiercely, as when a beam of fast-moving electrons is suddenly halted by the target in an X-ray tube. The normal “jumps” of electrons in atoms are of intermediate intensity. All these radiant forms of energy can travel through empty space, for example from the Sun to the Earth.

But energy can readily change from one form to another. Sunlight captured by green leaves is converted into the chemical energy of plant-stuff. Coal is plant-stuff buried millions of years ago when continents collided, and a boiler can convert the chemical energy of coal into a scalding jet of steam that turns the blades of a turbine—these are forms of kinetic energy, the energy of directed movement. Using Faraday’s trick, the turbine can generate electrical energy. At the end of this chain of transformations, you can switch on the electrical energy and reconvert it to light energy, thereby enjoying the benefits of sunlight after the Sun has set.

The vibrations of sound and the gravitational energy of water about to cascade down a mountainside are other forms of energy. Sooner or later, though, a shout dies away, water comes to rest, the light from your electric bulb is absorbed in the wallpaper. Where has the energy gone? It has been taken up in those random motions of atoms and molecules that we call heat. All energy degrades to meaningless heat eventually.

Unless there were continuous supplies of new energy, life and indeed all interesting activity in the universe would quickly cease. For example, your brain is kept functioning by food—chemical energy produced by sunlight just in the past few months. Those new supplies of energy come from the transformation of matter into energy.

The Sun is a very ordinary star, lying in the suburbs of a galaxy consisting of about 100,000,000,000 stars; we see the rather flat cross section of the galaxy as the Milky Way, a brushstroke of light across the night sky. There is nothing special, even, about our Galaxy; it is just one of vast numbers of galaxies scattered like ships in a great ocean of space.

The universe is a battleground between gravity and nuclear forces. To make a star, gravity sweeps together a mass of hydrogen gas; it becomes hot and nuclear reactions begin. The nuclei of hydrogen atoms combine together to make heavier elements almost, but not quite, as heavy as the sum of the hydrogen nuclei that went into them. The little bit of matter that is lost is converted into a relatively immense amount of energy. It would blow the star apart but for the strenuous restraint of gravity. A balance is struck, and the size and brightness of a star depends on its mass and on how much of its nuclear fuel has been burned. Fortunately, our star, the Sun, is a slow-burner; nevertheless, inexorable physical changes billions of years from now will make the Sun grow to fill the whole of our sky and swallow the Earth.

In a star more massive than the Sun, this “burning” of nuclear fuel proceeds faster and culminates in a vast explosion called a supernova. In the explosion, nuclear reactions proceed apace and make all the different chemical elements. The diverse atoms, heavier than hydrogen, of which our own bodies are constructed, were made in stars that exploded before the Sun was formed. Some of the heavy material was left swirling around the newborn Sun and made the Earth. Radioactive energy stored in some of the elements provided an internal source of heat for the Earth that accounts for volcanoes, earthquakes, and the slow movements of continents. Sunlight stirred the materials on the surface of the Earth into chemical activity. Eventually this activity became organized in peculiar ways, and life began.

So far, so good. But there are new mysteries that are “out of this world,” in the sense that matter and energy are involved in events far more violent than anything normally encountered on the Earth or even in the Sun. The paramount questions with which physicists are now wrestling can be paraphrased as follows: Why is hydrogen the raw material of the universe? Experiments with the nucleus of the hydrogen atom—the proton—are undertaken in the big accelerators that transform the stuff of the atomic nucleus into bizarre, short-lived particles. These particles have properties, similar to electric charge, called the hypercharge and the baryon number. For example, the proton itself has, besides an electric charge of +1, a hypercharge of +1 and a baryon number of 1. However the particles may transform themselves in violent interactions, the totals of charge, hypercharge, and baryon number do not change.

Attempting to find out why this partial order remains amid the confused varieties of nuclear matter. theorists are led to the idea that the particles we see consist of
combinations of other, quite different particles that they have named quarks. An early success of this theory was the prediction of the existence of a new combination, a particle called the omega minus that eventually turned up in 1964 during an experiment with the big machine at the Brookhaven National Laboratory, Long Island, N.Y. The quarks themselves have not been discovered at the time of writing.

The next big leap in understanding may well come when the theory of how small pieces of matter behave is blended with the theory of gravity, which at present concerns the huge pieces of matter that make up our universe of galaxies, stars, and planets. With such a "unified" theory physicists may at last be able to answer that question about the raw material of the universe—why hydrogen? At the same time, we shall perhaps come to understand why matter was formed in the "big bang," with which (as many astronomers now suppose) the universe came into existence some 10,000,000,000 years ago, or why the "big bang" was not merely a "big flash."

Even so fundamental an advance would not exhaust the opportunity for fresh discovery in the physical sciences. Another set of pregnant problems results from very strange objects recently discovered in the sky, namely "hot" galaxies, quasars and pulsars. The quasars, in particular, are compact objects of such extraordinary energy that existing laws of physics seem scarcely able to account for them. The pulsars, which flash many times a minute, are also very odd, but less baffling. They are evidently remnants of exploded stars that have collapsed to the enormous density of the material of the atomic nucleus. If an ocean liner were compressed to the density of a pulsar, it would be no bigger than a grain of sand.

The evidence of the pulsars encourages a further idea—one of the strangest in the whole history of man's study of matter and energy. In a pulsar, nuclear forces prevent collapse to even greater densities. But if the collapsed star were even more massive, gravity would be stronger and it would overwhelm even the nuclear forces. Then there would be nothing to stop the process until the whole star had collapsed to smaller than a peanut. Through the intense gravitational field thus set up, no light could escape, and the star would in effect disappear from the universe. Only its gravity would remain, like the grin of the Cheshire Cat in _Alice in Wonderland_, and, if a space traveler ran into one of these "black holes," he too would be drawn to the same invisible kernel, there to disappear forever—or at least until the laws of physics change.

The possibility that such black holes exist holds out a hope of explaining the quasars as objects of this kind from which material somehow "bounces" out. But that is only a little comfort when scientists have now to reexamine the theory of gravity, which they thought Einstein had cleared up 60 years ago, and to work out the implications of a universe peppered with black holes where the familiar laws of nature are unlikely to apply. There is even the uncomfortable suggestion that our whole universe may be just a big black hole in someone else's universe! Physics, the master science, cannot evade these new battles of the mind.
Three points should be noted about the scope of Part One and its relations to other parts.

The sciences of physics, chemistry, and astronomy have themselves been the object of historical and analytical studies regarding their nature, scope, methods, and interrelations. Part Ten, on the branches of knowledge, is concerned with such studies. The outline in Section 10/32 of Part Ten deals with the sciences of physics, chemistry, and astronomy and treats their history, their nature and scope, and their principal problems and interrelations.

The design and operation of observational and experimental instruments are important in the development of the physical sciences. The treatment of scientific instrumentation is placed in Section 723 of Part Seven, on technology.

Accounts of the several kinds of mathematics used in observation and experiments, and in the derivation and application of physical theories, are set forth in Division II of Part Ten.

The three increasingly complementary physical sciences of physics, chemistry, and astronomy house the knowledge and the organizing theories about matter in all its dimensions, from subatomic particles to the cosmos, about all the states of matter, all the forms of energy, and all the interrelations of matter and energy.

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II. Energy, Radiation, and the States and Transformation of Matter 22
III. The Universe: Galaxies, Stars, the Solar System 51

Division I. Atoms: Atomic Nuclei and Elementary Particles

The outlines in the two sections of Division I deal with subatomic and atomic physics.

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Section 111. The Structure and Properties of Atoms

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   b. The emission spectra of singly and multiply ionized atoms
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   d. The effects of magnetic fields and the effects of electric fields on atomic spectra
   e. Intensities, isotope shifts, and fine and hyperfine structures of atomic spectral lines as related to atomic structure
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Suggested reading in the *Encyclopædia Britannica*:

MACROPAEDIA: Major articles dealing with the structure and properties of atoms
Analysis and Measurement, Physical and Chemical
Atoms: Their Structure, Properties, and Component Particles
Physical Science, Principles of
Physical Sciences, The
**MicroPædia: Selected entries of reference information**

**General subjects**

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   [see 723.G.8]

Suggested reading in the *Encyclopædia Britannica:*

**MACROPAEDIA:** Major articles dealing with the atomic nucleus and elementary particles
Analysis and Measurement, Physical and Chemical
Atoms: Their Structure, Properties, and Component Particles
Physical Sciences, The

**MICROPAEDIA:** Selected entries of reference information

**General subjects**
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  - positron
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Section 121. Chemical Elements: Periodic Variation in Their Properties

A. The systematic classification of the elements on the basis of their chemical and physical properties and atomic structures: the periodic law of the elements

B. The groups of the chemical elements in the long form of the periodic table: their occurrence, history, physical and chemical properties, principal compounds, production, and uses

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3. The alkaline-earth metals, or the Group IIA elements of the periodic table: beryllium, magnesium, calcium, strontium, barium, radium

4. The boron group of the elements, or the Group IIA elements of the periodic table: boron, aluminum, gallium, indium, thallium

5. The carbon group of the elements, or the Group IVa elements of the periodic table: carbon, silicon, germanium, tin, lead

6. The nitrogen group of the elements, or the Group Va elements of the periodic table: nitrogen, phosphorus, arsenic, antimony, bismuth

7. The oxygen group of the elements, or the Group VIA elements of the periodic table: oxygen, sulfur, selenium, tellurium, polonium

8. The halogen elements, or the Group VIIa elements of the periodic table: fluorine, chlorine, bromine, iodine, astatine

9. The noble gases, or the Group 0 elements of the periodic table, formerly called the inert gases: helium, neon, argon, krypton, xenon, radon

10. The zinc group elements, or the Group IIb elements of the periodic table: zinc, cadmium, mercury

11. The transition elements: elements with partly filled d or f orbitals occupying the middle portion of the periodic table

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   b. Individual elements of the second and third transition series: zirconium and hafnium, niobium and tantalum, molybdenum and tungsten, technetium and rhenium, ruthenium and osmium, rhodium and iridium, palladium and platinum, silver and gold

INDEX: See entries under all of the terms above
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c. The actinide elements
   [see B.13., below]

12. The rare-earth, or lanthanide, elements of the periodic table: scandium, yttrium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, lutetium
   [see also 724.C.3.u.]

13. The actinide elements of the periodic table: actinium, thorium, protactinium, uranium, neptunium, plutonium, americium, curium, berkelium, californium, einsteinium, fermium, mendelevium, nobelium, lawrencium

14. The transactinide elements of the periodic table: unnilquadium (or rutherfordium), unnilpentium (or hahnium), unnilhexium, unnilseptium, unniloctium, unnilennium; heavier elements which have yet to be discovered but whose existence is extrapolated based on the periodic law

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1. Metals; semimetals, or metalloids; nonmetals
2. Stable and radioactive elements
3. Native and combined elements
4. Noble metals, including the platinum group of metals
5. Synthetic elements: transuranium elements
6. Biologically active or essential elements
   [see 335.A.3.]
7. Technologically significant elements
   [see 724.C.3.]

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   b. In the hydrosphere
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   c. In the atmosphere
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   d. In the biosphere
2. In the solar system
   [see also 133.A.]
3. In the stars
   [see also 132.D.7.b.]
4. In the rest of the universe
   [see also 131.A.1.a.]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with chemical elements: periodic variation in their properties
Chemical Compounds
Chemical Elements

MICROPAEDIA: Selected entries of reference information

General subjects

actinide elements:  fermium  thorium  rubidium
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actinium  mendelevium  alkali metals:  alkaline metals:
actinium  neptunium  alkali metal  alkaline-earth metals:
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berkelium  plutonium  francium  metal
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**Section 122. Chemical Compounds: Molecular Structure and Chemical Bonding**

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2. Quantum mechanical and electrostatic approaches to the theory of molecular structure
3. Molecular bonds and shapes
   a. Spatial arrangement of atoms: chains, rings, chelates, polymers
   b. Isomers: structural isomers, stereoisomers
4. Time-dependency properties of molecules
5. Molecular structure and its relation to the properties of bulk matter
   a. The physical properties of matter as affected by molecular size, shape, and interactions, and interactions of molecules with radiations and fields
   b. The chemical behaviour of matter as determined by the nature of molecular bonds
   c. The chemical, physical, and biochemical properties of a substance inferred from its known or postulated molecular structure
B. Experimental and theoretical procedures for the determination of molecular structures

1. The separation, isolation, and purification of chemical substances based on chemical equilibria and rate phenomena
   a. By volatility differences: distillation, sublimation, evaporization
   b. By chromatography: liquid phase, gas phase, thin layer
   c. By solubility differences: precipitation, crystallization, zone melting, solvent extraction
   d. By ion-exchange reactions
   e. By electrophoresis and electrolytic methods
   f. By mechanical methods: filtration, sedimentation, sieving, flotation, centrifugation

2. Classical methods of qualitative and quantitative analysis

3. Instrumental methods used to identify functional groups, molecular sub-units, and structural features
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   b. Mass spectrometry
   c. Magnetic resonance spectrometry
   d. Thermometric methods: thermogravimetry, calorimetry, cryoscopy
   e. Radiochemical methods: radiometric analysis, activation analysis, isotopic dilution
   f. Electrochemical methods: potentiometry, polarography, electrodeposition, oscillometry

4. Diffraction methods for determining molecular structures: electron, X-ray, and neutron beam diffraction

5. Physical methods used to determine optical activity, magnetic susceptibility, calorific values, heat of combustion, activation energy, and reaction rates

6. The synthesis and characterization of derivatives, or specifically modified molecules

7. The determination of molecular weight based on thermodynamic theory, on transport phenomena, and on known spatial arrangements of atoms in the solid state

8. The principles of conformational analysis as related to molecular structure

9. The scattering of molecular beams and its usefulness in the study of molecular interactions

C. Spectra of molecules

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3. The interpretation of molecular band spectra in determining molecular structure

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   b. The early electronic theory of bonding
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      ii. The nature of covalent and coordinate bonds: the octet
   c. Application of the quantum theory to atomic structure

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   b. Bonding in the hydrogen molecule
   c. Bonding in simple polyatomic molecules
   d. Quantum-mechanical calculations

3. Other bonding effects: hydrogen bonding; metallic bonds in metals, intermetallic compounds, and coordination compounds; bonds in crystals, in weak associations, and in electron-deficient compounds

4. Experimental observation of chemical bonding
5. Anomalous molecular structures, or molecular fragments with apparently anomalous valences: free radicals, carbenes, carbanions, carbonium ions

E. Systems of classification of chemical compounds or substances
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2. By their bond type: ionic, covalent, and coordination compounds
3. By their chemical reactivity: acids, bases, and salts; oxidizing and reducing agents
4. By their physical state: gas, liquid, and solid
5. By their origin: natural and synthetic

F. Inorganic compounds
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2. Structural classification of inorganic compounds
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   b. Oxides, anhydrides, acids, and bases
   c. Coordination compounds
   d. Organometallic compounds
      [see G.1.c., below]
   e. Catenates
   f. Inorganic polymers
   g. Special nonmetallic derivatives
3. Methods of preparation of inorganic compounds
4. Reactions of inorganic compounds; e.g., acid–base, substitution, isomerization, oxidation–reduction, addition

G. Organic compounds
1. The major groups of organic compounds: their nomenclature, chemical and physical properties, synthesis, occurrence, reactions, and analysis
   a. Hydrocarbons: aliphatic and aromatic
   b. Organic halogen compounds: alkyl, alkenyl, and alkynyl halides; aryl halides
   c. Organometallic compounds
   d. Alcohols, phenols, and ethers
   e. Carboxylic acids and their derivatives
   f. Aldehydes, ketones, and their derivatives
   g. Organic nitrogen compounds
   h. Organic sulfur compounds
   i. Organic phosphorus compounds
   j. Organic silicon compounds
   k. Heterocyclic compounds
   l. Oils, fats, and waxes
   m. Carbohydrates
   n. Amino acids, proteins, and peptides
   o. Isoprenoids and terpenes
   p. Steroids and their derivatives
   q. Nucleotides and nucleosides
   r. Nucleic acids: DNA and RNA
   s. Alkaloids
   t. Dyestuffs and pigments
   u. Organic polymers
2. Preparation and purification of organic compounds
3. Physical properties of organic compounds
4. Reactions of organic compounds: addition, substitution, displacement, hydrolysis, pyrolysis, condensation, polymerization, molecular rearrangement

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with chemical compounds: molecular structure and chemical bonding

- Biochemical Components of Organisms
- Chemical Compounds

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

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<th>amino acids, proteins, and peptides:</th>
<th>carboxylic acids:</th>
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**esters:**

- ester
- ethyl acetoacetate
- lactone

**polyester ethers:**

- ether
- ethylether
- polyether

**heterocyclic compounds:**

- coumarin
- furan
- imidazole
- indole
- lactone
- melamine
- purine
- pyran
- pyrazine
- pyrazole
- pyridine
- pyrimidine
- pyrole
- quinoline
- thiazine
- thiazole
- thioephene

**hydrocarbons:**

- acetylene
- benzene
- biphenyl
- butadiene
- butane
- butene
- ethane
- ethylene
- hydrocarbon
- methane
- naphthalene
- olefin
- paraffin
- hydrocarbon
- propane
- styrene
Division II. Section 122

toluene
xylene

**Inorganic acids and oxides:**
- acid
- carbon dioxide
- carbon monoxide
- Dry Ice
- hydrogen chloride
- hydrogen cyanide
- hydrogen ion
- nitric acid
- nitric oxide
- nitrous acid
- phosphate acid
- phosphorous acid
- rare-earth metal
- silica gel
- silicic acid
- sulfur oxide
- sulfuric acid
- water glass

**Inorganic nitrogen compounds:**
- ammonia
- ammonium
- hydroxide
- azide
- hydrazine
- hydroxylamine

**Isoprenoids and terpenes:**
- abietic acid
- camphor
- carotene
- isoprene
- limonene
- menthol
- pinene
- terpene

methods of chemical analysis:
- assaying
- chemical
- precipitation
- chromatography
- colorimetry
- countercurrent distribution
- differential thermal analysis
- electrophoresis
- gas chromatography
- gel chromatography
- gravimetric analysis
- iodine value

nephelometry and turbidimetry
paper
chromatography
polarimetry
polarography
qualitative chemical analysis
quantitative chemical analysis
spectrochemical analysis
thin-layer chromatography
titration
volumetric analysis

**Molecular bonds and shapes:**
- configuration
- conformation
- diastereoisomer
- enantiomorph
- isomerism
- optical activity
- racemate
- resolution
- strain theory
- tautomerism

**Nucleic acids and their components:**
- adenine
- adenosine
- triphosphate
cytosine
DNA
guanine
nucleic acid
nucleoside
nucleotide
RNA
thymine
uracil

**Oils, fats, and waxes:**
- babassu palm
- castor oil
- Chinese wax
cod-liver oil
cohune oil
copa
cottonseed
essential oil
fat
fish oil
grease
lard
linseed
lipid
oil
phospholipid
pine oil
sperm oil
spermaceti
tallow
triglyceride
wax
whale oil

**Organic halogen compounds:**
- acid halide
- aldrin
- benzene
- hexachloride
carbon
tetrachloride
chloral hydrate
chloride
chlorobenzene
chboroform
chlorotrifluoroethylene
cyanogen halide
DDT
dichlorobenzene
ethyl chloride
ethylen chloride
ethylene chloride
Freon
halocarbon
halon
iodoform
methyl bromide
methyl chloride
methylene chloride
phosgene
polychlorinated biphenyl
tear gas
tetrachloroethylene
tetrachloroethylene
tetrafluoroethylene
toxaphene
trichloroethane
trichloroethylene
vinyl chloride
vinylidene chloride

**Organic nitrogen compounds:**
- amide
- amine
- aniline
- azo compound
- benzidine
- biotin
- choline
diazonium salt
dimethoate
ethanalamine
isocyanide
nitrile
nitro compound
nitrobenzene
nitroglycerin
nitroso compound
oxide
parathion
PETN
phorate
picric acid
polysulfide
sulfide
sulfonamide
sulfonic acid
sulfoxide
thiol
thiourea
urea
xanthate

**Organometallic compounds:**
- carbaborane
- ferrocene
- Grignard reagent
- metal carbonyl
tetraethyl lead

** Peroxy compounds:**
- hydrogen peroxide
- peroxide
- peroxy acid

**Petroleum, gasoline, oil, and coal:**
- gasoline
- kerosine
- microcrystalline wax
- napalm
- naphtha
- paraffin wax
- petrochemical petroleum

**Polymers and resins:**
- balsam
copal
copolymer
dammar
dragon’s blood
elastomer
frankincense
gamboke
initiator
latex
Lucite
macromolecule
mastic
monomer
neoprene
polycrylonitride
polychlorotrifluoroethylene
Biographies
See Section 10/32 of Part Ten

INDEX: See entries under all of the terms above
B. Energy changes in chemical reactions
   1. The classification of chemical reactions according to energy changes involved: exothermic and endothermic
   2. The significance of activation energy in chemical reactions
   3. Thermodynamic relations in chemical reactions: chemical equilibrium, free energy and entropy changes

C. Rates of chemical reactions
   1. Factors that affect the rate or direction of chemical reactions
      a. Solvents
      b. Temperature
      c. Pressure
      d. Catalysts
      e. Collisions
      f. Light
      g. Isotopic substitution
      h. Molecular structure
   2. Factors that affect the kinetic order of chemical reactions: concentration of reactants, mechanism of reaction, conditions of the reaction
   3. Factors that affect the extent of chemical reactions: equilibrium constant
   4. Complex reactions: reactions governed by more than one reaction rate
   5. Experimental methods for studying chemical kinetics
      a. Measurement of reaction rates
      b. Determination of the order of reactions
      c. Relaxation methods
   6. Kinetic studies as a means of elucidating reaction mechanisms

D. Mechanisms of chemical reactions
   1. Factors influencing the course of a reaction: reactants, transition state, solvent, catalysts, products, reaction conditions
   2. Energy changes through single-stage and multi-stage processes
   3. Factors that reveal the mechanisms of a reaction: chemical and stereochemical nature of the reactants, intermediates, and products; kinetics of the reaction
   4. Classification of reaction mechanisms based on the nature of electron pairing in the transition state, on the nature of the attacking species, on the nature of catalysis, on the number of components of the transition state
   5. Mechanisms of the principal types of reactions: nucleophilic and electrophilic substitution, addition and elimination reactions

E. Acid–base reactions and equilibria
   1. General properties of acids and bases
   2. Theoretical approaches to acid–base concepts
      a. The definition of an acid as a substance that gives rise to hydrogen ions and of a base as a substance that gives rise to hydroxyl ions in aqueous solutions
      b. The Brønsted–Lowry concept defining an acid as a proton donor and a base as a proton acceptor
      c. The Lewis electronic theory defining an acid as an electron acceptor and a base as an electron donor
   3. Acid–base reactions
      a. Proton-transfer reactions
      b. Lewis acid reactions
      c. Acid–base catalysis
4. Quantitative aspects of acid–base equilibria
   a. Equilibria in aqueous solutions
   b. Equilibria in nonaqueous solvents
   c. Equilibria involving Lewis acids
   d. The effect of molecular structure on acid–base equilibria
5. The experimental study of acid–base reactions and equilibria

F. Oxidation–reduction reactions
   1. Major classes of oxidation–reduction reactions: oxygen atom transfer, hydrogen atom transfer, electron transfer
   2. Definitions of oxidation and reduction based on the reaction's stoichiometry
   3. Theoretical aspects of oxidation–reduction processes
      a. The concept of oxidation state
      b. Half reactions and the determination of redox potentials
      c. Oxidation–reduction equilibria and reaction rates
      d. Mechanisms of redox reactions
   4. Electrochemical reactions: chemical changes associated with the passage of an electrical current
      a. The electrochemical process: types of reactions
      b. Complex electrochemical reactions
      c. The Nernst and Butler–Volmer equations
   5. Oxidation–reduction reactions in biological systems
   6. Oxidation–reduction reactions in combustion and flames

G. Photochemical reactions
   1. The photochemical process
   2. Experimental methods used in the study of the photochemical process and photochemical reactions
   3. The application of photochemical processes

H. Chemical reactions and chemical theory in the synthesis of chemical compounds
   1. Factors that affect the choice of a specific synthetic path
   2. Factors that affect the choice of reaction conditions
   3. The separation and purification of reaction products
      [see 122.B.1.]
   4. The identification, characterization, and analysis of reaction products
      [see 122.B.2. through 9.]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with chemical reactions
   Chemical Reactions
   Physical Sciences, The

MICROPAEDIA: Selected entries of reference information

General subjects

| acid–base reactions and equilibria: | Lewis theory | electrochemistry: | electromotive series |
| acid–base reaction | pH | catalysis of reactions: | anodizing electrical double layer |
| Bronsted–Lowry theory | | acid–base catalysis | electrochemical reaction |
| buffer | | catalyst | electrolychemistry |
| hydrogen ion | | catalyst poison | electrolysis |
| hydroxide | | Ziegler–Natta catalyst | electrolytic cell |

kinetics and mechanism:

activation energy
Arrhenius equation
chain reaction
Section 124. Heat, Thermodynamics, and the Nonsolid States of Matter

A. The principles of thermodynamics

1. The description of physical phenomena based on the concepts of system, state of a system, and changes of state

2. The first law of thermodynamics

3. The second law of thermodynamics

4. Stable equilibrium
   a. Equations relating properties of systems that are in, or are passing through, stable equilibrium states
   b. Temperature considered as the potential governing the flow of energy between systems
   c. Heat
      i. The definition of heat as a form of energy transferred from one body to another under the influence of a difference in temperature
      ii. Theories of heat: the phlogiston theory, the caloric theory, the kinetic molecular theory
      iii. Heat transfer in matter: heat conductivity in solids, convection in liquids and gases, heat transfer in boiling liquids, evaporation and condensation
      iv. Technical applications of heat energy
         [see 721.B.7. and 725.A.5.a.]
   v. Heat and its relation to entropy, work, and change of energy

5. Thermodynamic relations in simple systems
   a. The Carnot cycle
   b. Maxwell’s equations relating entropy to pressure, volume, and temperature for closed systems that assume only stable equilibrium states
   c. Phase changes and equilibria
   d. Simple one-component systems: processes at constant volume and at constant pressure; the equation of state, which relates pressure, volume, and temperature for stable equilibrium states
   e. Simple multicomponent systems: the Maxwell relations, Dalton’s law for mixture of gases, Raoult’s law and Henry’s law for ideal solutions
f. Bulk flow
g. Equilibrium in chemical reactions
   [see 123.B.3.]

6. The third law of thermodynamics

7. The effects of applied force fields on simple systems

8. Steady rate processes; e.g., systems approaching stable equilibrium, flow of a substance through a barrier

9. Statistical thermodynamics
   a. The laws of thermodynamics that consider the detailed microscopic structure of physical systems and the states of such systems
   b. Statistics of grand systems

B. The gaseous state of matter
   1. The nature and properties of a gas
   2. The thermodynamic approach to gases: the macroscopic view that deals with bulk measurable properties
      a. The simple gas laws
      b. The thermal equation of state for perfect gases
      c. Empirical equations of state for real gases
   3. The particle-description approach to gases
      a. The distribution function
      b. The Boltzmann transport equation and the single-particle distribution function
      c. The N-particle distribution function and the thermodynamic-equilibrium properties and transport properties of dense gases
      d. The behaviour of a gas at the hydrodynamic and thermal relaxation stages

C. The liquid state of matter
   1. The behaviour and properties of liquids at equilibrium
   2. The molecular structure of liquids based on distribution functions, which measure the probable distribution of some property of molecules through the liquid
   3. Properties of liquids
      a. Transport properties
      b. Acoustic properties: propagation of sound waves
      c. Electrical and magnetic properties
      d. Thermodynamic properties
      e. Optical properties
      f. Surface tension

D. Solutions and solubility
   1. General classes of solutions: electrolytes and nonelectrolytes, solutions of weak electrolytes, endothermic and exothermic solutions
   2. Properties of solutions
      a. Composition ratios: molarity, molality, mole fraction
      b. Equilibrium properties: correlation of the vapour pressure of a solution to its composition
      c. Colligative properties: rise in boiling point, decrease in freezing point, osmotic pressure
      d. Transport properties: viscosity, thermal conductivity, diffusivity
   3. Thermodynamic and molecular aspects of solvent and solute interactions
      a. Energy considerations: entropy, enthalpy, Gibbs free energy
      b. Effects of molecular structure and weak intermolecular forces
      c. Effects of chemical interactions; e.g., hydrogen bonding, chemical combinations
   4. General theories of solution: the prediction of solubility and solution properties
a. Solutions of nonelectrolytes: Raoult's law and Henry's law for ideal solutions; theoretical expressions for the excess properties of regular athermal, associated, and solvated solutions
b. Solutions of electrolytes: Debye–Hückel theory and modifications, Arrhenius dissociation theory

5. Effects of temperature and pressure on the solubility of solids and gases

E. Physical effects at surfaces
1. Surface tension and surface energy: cohesion and adhesion
2. Adsorption on liquid and solid surfaces
3. Tribological phenomena, the mechanical and physical effects at interfaces: friction, wear, lubrication
4. Colloids: the kinds of dispersions and their properties and preparation
   a. Irreversible colloidal systems: lyophobic sols, emulsions, foams, pastes, gels
   b. Reversible colloidal systems: solutions of polymers and proteins, solutions of soaps and dyes

F. The plasma state of matter: completely ionized gases interacting with magnetic and electric fields
1. Basic plasma properties and parameters: electrical quasineutrality, electron density, kinetic temperature, particle velocities, magnetic and electric field strengths
2. Elastic and inelastic collisions of plasma particles
3. Radiation from plasmas; e.g., X rays, synchrotron radiation, excitation radiation
4. The formation of plasmas
5. The behaviour of plasmas in magnetic and electric fields
6. The determination of plasma variables
7. Fluidlike behaviour in plasmas
8. Applications of plasmas; e.g., power production, jet propulsion
   [see 112.G.4., 721.B.8.a., and 721.C.3.]
9. The existence of plasmas in nature: in the extraterrestrial medium, in the Sun and stars, on Earth

G. The properties of matter at extreme conditions
1. Properties of matter at low temperatures
   a. Effects of low temperature on entropy, heat capacity, magnetic properties, and conductivity
   b. Special physical phenomena at very low temperatures: superconductivity, superfluidity
   c. Special methods for obtaining and characterizing low temperatures: adiabatic cooling, adiabatic dilution
2. Special properties of matter at high temperatures
3. Effects of high pressure on the physical, chemical, electronic, and magnetic properties of matter

H. Transport phenomena
1. The kinetic molecular theory of the transport properties of gases, liquids, suspensions, and polymers
2. Phenomenological expressions of transport
3. Hydrodynamic aspects of transport phenomena
4. Transport phenomena in macrosystems

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with heat, thermodynamics, and the nonsolid states of matter

Matter: Its Properties, States, Varieties, and Behaviour
Physical Sciences, The
Thermodynamics, Principles of
Section 125. The Solid State of Matter

A. Crystals and crystallography

1. Patterns of atoms in crystals
   a. The three-dimensional periodic arrangement of atoms in crystals: crystal planes and their notation
   b. Symmetry considerations in the classification of crystal systems

2. Diffraction of X rays, electrons, and neutrons by crystal structures

3. Processes of crystal growth
   a. Theoretical aspects of crystal growth: energy considerations, growth of eutectics, constitutional supercooling, nucleation
   b. Preparation of crystals: monocomponent and polycomponent crystal growth

4. Imperfections and dislocations in crystalline materials and their effects on the properties of the crystals

5. Effects of temperature, pressure, and alloying on the strength and hardness of crystals

B. The theory of the crystalline solid state

1. The classification of solids according to their electronic structure and bonding: ionic solids, covalent solids, metallic solids, molecular solids, hydrogen-bonded solids
2. The arrangement of atoms in crystalline solids
   [see A.1.a., above]

3. The elastic and plastic properties of solids

4. The thermal and thermodynamic properties of solids: specific heat, thermal conductivity

5. The electronic structure of solids
   a. The nature and mobility of electrons in conductors, insulators, and semiconductors
   b. Electron emission: thermionic emission, photoelectric emission, field emission
   c. The nearly free electron approximation
   d. The energy-band theory of the solid state

6. The principal types of magnetic behaviour exhibited by solids: paramagnetism, diamagnetism, ferromagnetism

7. The interaction of light with solids
   a. The behaviour of solids illuminated with radiation: reflection, absorption, or transmission of photons
   b. The generation of electromagnetic radiation from the energy supplied to the solid
   c. The photoelectric effect

C. Ionic crystals
   1. Bonding in ionic crystals
   2. The structure of ionic crystals
      a. Perfect ionic crystals
      b. Defects in ionic crystals: Frenkel defect, Schottky defect, colour centres
   3. Properties of ionic crystals
      a. Vibrational and electronic properties
      b. Thermal properties
      c. Polarizing and diffusion properties and the nature of ionic conduction
      d. Optical properties

D. Metals
   1. Structural aspects of metals and alloys
   2. Elementary description of metals: the use of the free electron model to explain thermal and electrical conductivity of metals
   3. The electronic structure of metals and related effects
      a. The interaction between the periodic lattice and the conduction electrons: the weak pseudopotential
      b. Electron motion in a magnetic field and conduction-related effects
   4. Band structure and properties of metal groups: alkali metals, semimetals, noble metals, transition metals
   5. Lattice vibrations: interaction between ions; interaction between electrons, phonons, and dispersion
   6. Metal surface phenomena: thermionic and field emission of electrons, electron tunnelling, photoemission, free carrier absorption and interband transitions
   7. Many-body effects: plasma oscillations, spin waves, Fermi liquid theory, dynamic effects and shake-off electrons
   8. Superconductivity in metals
      a. Thermal properties of superconductors: transition temperature, specific heat and thermal conductivity, energy gaps
      b. Magnetic and electromagnetic properties of superconductors: critical field, Meissner effect, phase coherence effects
   9. Magnetic phenomena in metals: diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, nuclear magnetic resonance
E. Semiconductors and insulators

1. General properties of semiconductors and insulators
3. Electrical conduction in semiconductors
   a. Chemical approach: impurity conduction, hopping process
   b. Physical approach: energy band and gaps, lattice vibrations, statistical properties
   c. Extrinsic and intrinsic semiconductors
   d. Measurement of conductivity and of energy gaps
4. Principles involved in semiconductor applications
   a. Optical effects: photoelectric effect, photovoltaic effect, luminescence
   b. Electrical and related effects: hot electron effects, thermoelectric effects
   c. Junction effects
   d. Pressure and stress effects

F. The glassy or amorphous state of matter

1. Effects of temperature and composition on glass properties
2. The structure of glass
3. General properties of glasses: mechanical, chemical, optical, and electrical properties

Suggested reading in the Encyclopaedia Britannica:

MACROPÆDIA: Major articles dealing with the solid state of matter
   Matter: Its Properties, States, Varieties, and Behaviour
   Minerals and Rocks

MICROPÆDIA: Selected entries of reference information

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      b. Dynamics: balance of forces and torques
   2. Constitutive equations: stress-deformation relations in different media
   3. Yield strength of materials: fracture and fatigue
   4. The application of molecular theories to explain rheological phenomena

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the mechanics of particles, rigid bodies, and deformable bodies: elasticity, vibrations, and flow
   Energy Conversion
   Matter: Its Properties, States, Varieties, and Behaviour
   Mechanics: Energy, Forces, and Their Effects

MICROPAEDIA: Selected entries of reference information

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   b. Motion of charges in uniform flux density
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   2. Mathematical treatment of fields
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   4. Examples of scalar, vector, and tensor fields in ordinary space
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      b. The wave–particle duality of the photon
      c. The interaction of electromagnetic radiation with atomic and molecular structures:
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      d. The relation of electromagnetic radiation to quantum theory and relativity
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   2. Applications of relativistic principles in the treatment of electromagnetic and nuclear force
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with electricity and magnetism
   Electricity and Magnetism
   Electromagnetic Radiation
   Energy Conversion
Part One. Matter and Energy

MICROPAEDIA: Selected entries of reference information

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   6. Physical aspects of musical sound
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with waves and wave motion

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   b. The formation and development of stars
   c. The origin of the solar system

3. Time scale of the universe: dating of significant events in the history of the universe

4. Theories of the possible fate of the universe

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the cosmos
   Analysis and Measurement, Physical and Chemical
   Cosmos, The
   Gravitation
   Physical Sciences, The
   Relativity

MICROPAEDIA: Selected entries of reference information

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   b. Regions of the Galaxy: the nucleus, the central bulge, the disk, the spiral arms, the spherical component, the massive halo
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   b. Chemical evolution: the problem of the distribution of heavy elements
   c. Star formation: theories concerning the gravitational condensation of galactic dust and gas clouds

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1. Globular clusters: systems containing many thousands to a million old stars in a symmetrical, roughly spherical form
2. Open clusters: systems containing about a dozen to hundreds of stars, usually in an unsymmetrical arrangement
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   c. Star names and designations
   d. Modern star maps and catalogs

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   a. Intrinsic stellar brightness: absolute magnitudes, total luminosities
   b. Stellar masses
   c. Stellar diameters
   d. Stellar temperatures
   e. The average characteristics of main-sequence, or dwarf, stars

4. Stellar variability
   a. Geometric variables; e.g., eclipsing binaries
   b. Intrinsic variables
      i. Pulsating stars; e.g., Cepheid, RR Lyrae, and Beta Canis Majoris variables
      ii. Explosive variables; e.g., novae, supernovae, and novalike variables

5. Statistics of stars
   a. Correlations between luminosity, spectrum, mass, and radius: the Hertzsprung–Russell diagram and other relations
   b. Statistics of binary star systems
   c. Statistics of special types of stars

6. Stellar structure
   a. Stellar atmospheres
   b. Internal structure of stars

7. Stellar evolution
   [see also 131.E.2.]
   a. The life history of a typical star
      i. Formation of a protostar by gravitational contraction
      ii. Attainment of the main sequence
      iii. Evolution away from the main sequence
      iv. Estimates of stellar ages
   b. Formation of chemical elements in stars
   c. Probable fates of stars: white dwarfs, neutron stars, black holes

Suggested reading in the *Encyclopædia Britannica:*

MACROPAEDIA: Major articles dealing with galaxies and stars
- Cosmos, The
- Galaxies
- Nebula
- Physical Sciences, The
- Stars and Star Clusters
Section 133. The Solar System

A. A survey of the solar system

1. The Sun
   [see B., below]

2. The major planets of the solar system, their surfaces and atmospheres, their satellites
   [see C., D., and E., below]

3. Other constituents of the solar system
   a. Minor planets, or asteroids
   b. Comets
   c. Meteoroids, meteors, and meteorites
   d. The interplanetary medium

4. Regularities of the solar system: the distances of the planets from the Sun, the distribution of natural satellites
5. Interactions among various bodies in the solar system: gravitational perturbations, actual physical encounters

6. Theories of the origin of the solar system: origin by an orderly process, origin by catastrophe [see also 131.E.2.c.]

B. The Sun

1. The Sun's surface layers and their features: the quiet Sun
   a. Solar data derived from observations of the photosphere, the visible luminous surface of the Sun
   b. The chromosphere, the relatively transparent layer that forms a transition zone between the Sun's photosphere and corona: the flash spectrum, spicules, supergranulation
   c. The corona, the luminous, high-temperature, rarefied gas envelope of the Sun: form, structure, physical properties; the solar wind

2. Solar features that occur with increased frequency during the active phase of the solar cycle: the active Sun
   a. Centres of activity: areas of localized strong magnetic fields at the Sun's surface
   b. Sunspots: their physical nature, the sunspot cycle of about 11 years
   c. Other features: e.g., faculae, prominences, flares, coronal condensations

3. The solar interior: energy generation, the evolution of the Sun [see also 132.D.7.]

4. Solar radiation, including light, radio waves, and particles

5. Solar-terrestrial relationships and interactions

C. The planets and their satellites

1. The terrestrial planets
   a. Mercury
   b. Venus
   c. Earth [see D., below]
   d. Mars

2. The minor planets, or asteroids [see A.3.a., above]

3. The giant planets and Pluto
   a. Jupiter
   b. Saturn
   c. Uranus
   d. Neptune
   e. Pluto

D. The Earth as a planet

1. The distance of the Earth from the Sun: the astronomical unit and solar parallax

2. The orbital motion of the Earth around the Sun and the rotation of the Earth on its axis: the year, the day, the precession of the equinoxes [see also E.7.a., below]

3. Effects of the Earth's orbital position and speed on astronomical observations
   a. Astronomical parallax
   b. Aberration of light

4. The Earth's magnetism, temperature, and other physical properties [see 212]

5. The structure and composition of the Earth's interior [see 213]

6. The origin of the Earth, its atmosphere, hydrosphere, and surface features [see 232 and 241]
E. The Moon

1. The shape, radius, mean density, and varying brightness of the Moon

2. The motion of the Moon
   a. The apparent motion: the month, or sidereal and synodic periods of the Moon; optical and physical librations
      [see 7.a.ii., below]
   b. The actual motion

3. The mass and gravitational field of the Moon
   a. Underlying theory: basic gravitational properties of the Moon
   b. Discovery of lunar mascons: gravity anomalies on the Moon

4. The physical nature of the Moon
   a. Observations from Earth and from space vehicles: results of remote lunar photography, manned lunar landings, and close-up photography
      [see also 738.3.]
   b. The lunar surface features: craters, lineaments (e.g., mare ridges, the lunar grid system, rilles); temporary or transient features
   c. Theories of origin of the Moon's surface features: the volcanic and impact theories

5. The origin and evolution of the Moon
   a. Probable development of the Moon's orbit
   b. Evidence from the composition and physical properties of the Moon

6. The chemical nature of the Moon
   a. Surface composition: findings of the chemical analysis of lunar rock samples
   b. Possible zonal variations of the interior

7. The Sun–Earth–Moon system
   a. Relative motions of the Sun, Earth, and Moon
      i. The geometry of the Sun–Earth–Moon system: the celestial equator, the apparent motion of the Sun along the ecliptic, the inclination of the Earth's axis to its orbit
      ii. Motions of the Sun–Earth–Moon system as the astronomical basis of chronology: the day, month, and year; the Sothic cycle, Metonic cycle, and other complex cycles
   b. Eclipses of the Sun and Moon
   c. Tides in the Earth and in the Moon
      [see also 222.G.3.]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the solar system. See also Section 211 of Part Two
- Calendar
- Earth, The: Its Properties, Composition, and Structure
- Eclipse, Occultation, and Transit
- Physical Sciences, The
- Solar System, The

MICROPAEDIA: Selected entries of reference information

General subjects
- calendars:
  - Aztec calendar
  - Chinese calendar
  - day
  - Dionysian period
  - Egyptian calendar
  - French republican calendar
  - Greek calendar
  - Gregorian calendar
  - intercalation
  - international date line
  - Jewish calendar
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solar wind
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sunspot
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Biographies
See Section 10/32 of Part Ten

INDEX: See entries under all of the terms above
Introduction to Part Two:
The Great Globe Itself

by Peter J. Wyllie

We all have a sense of awareness and appreciation of the Earth; we all admire the scenery. One of the rewards of studying and understanding the Earth is the development of this sense to a greater extent. This development brings us closer to nature, closer to an awareness of some transcendental power, closer to God if we choose to define God in these terms. To “commune with nature” is to seek peace, but of course the Earth is not always peaceful and benevolent; sometimes it is powerful and savage. Even cities, the culmination of man’s domination of the landscape, are not immune to the ravages of nature. They have been devastated by floods, wracked and ripped by tornadoes and hurricanes, ruined by ash or lava from volcanoes, and demolished by earthquakes. These events, too, we wish to understand.

Man’s appreciation of the Earth begins with physical contact. This immediate experience of the senses is followed by the spiritual desire and need to understand where the Earth and its human observers came from, and why. The third stage of appreciation comes from scientific analysis and interpretation. Before we examine the relationship between man and the Earth in more detail, we should consider our position in the solar system and the universe.

Human civilization has developed and flourished in a small niche in space. Our home is perched on the surface of a sphere, enormous to us but tiny compared to the universe, that spins around its axis once each day while moving at a fantastic speed around the Sun, completing an orbit once each year. Although normally unaware of it, we too are spinning and moving at the same speed as the Earth, but we are held securely on the surface by the gravitational attraction of the mass of rocks beneath us.

The Sun, a huge globe of burning gas, provides the energy that fuels the activities and processes of our immediate environment, the boundary layer between the rocky surface of the Earth and the fluid envelope of air and water that separates the Earth from the starkness of space. The air and water nurture life and simultaneously protect it from the potentially damaging radiation and particles that approach the Earth from other parts of the solar system and beyond.

A view of the Earth from space differs markedly from what we see from within our own restricted environment at the Earth’s surface. From where we stand, it appears that the Sun, the Moon, and the stars are moving in great arcs around the Earth, and it was once believed that this was the way of the universe. Man on his world was surely the centre of all things. But we know now that this is only a relative picture; although the Moon does orbit the Earth, the Earth–Moon system moves around the Sun, which is itself speeding through the universe.

We exist because the Earth exists, and we claim the Earth as our own by referring to it as Mother Earth, the universal provider. The Earth provides all of our material needs and satisfies some of our spiritual needs: “I will lift up mine eyes unto the hills, from whence cometh my help.” A day in the mountains, at the seashore, or in the countryside sharpens that sense of awareness of the Earth which was compared above with an awareness of God.

Since he first appeared on Earth, man has wondered at nature’s awesome beauty and trembled at its indomitable power. The dread engendered by the physical experience of nature on the rampage, in storms, floods, or earthquakes, has shaped the development of primitive religions. Mystical or sacred attributes were assigned to natural objects and phenomena, and ceremonies were devised to honour and placate the unknown powers. Modern man has become increasingly insulated from his natural surroundings, partly because he is separated from them by masses of concrete, partly because scientific investigation tends to dispel the mystery of nature. This is not to imply that no problems remain to be solved, but we have learned enough to be reasonably sure that all are ultimately explicable in terms of rational science. Therefore, we no longer feel the need to populate the sky, mountains, trees, and winds with gods, spirits, and souls. But we can still enjoy the sensuous and spiritual appreciation of the Earth and retain or rediscover the intimacy with our natural surroundings that was experienced by primitive man.

One of the appealing aspects of Earth study is that wherever we go, our favourite subject is right there with us. There is always something new to be seen, to be admired, or to be examined in detail. While traveling in a commercial airliner, a meteorologist can examine the upper portions of the clouds as a change from his normal ground-based view and can track the flight right through the fronts and the high- and low-pressure regions charted on the newspaper weather map in his lap. An oceanographer flying over the coastline can see at a glance the large-scale patterns in the waves rolling shoreward and the effect of coastal prominences on these patterns. A geologist peering through the plane window can examine the distribution of hills and valleys laid out below him, gaining a bird’s-eye view to supplement the pattern of features that he had previously seen only on maps. These pleasures are not reserved for the professional Earth scientist. Anyone can observe the Earth and Earth processes in action, almost anywhere.

Man is a curious species; he needs to know how and why things happen. The simple, visual pictures of nature are beautiful, awe-inspiring, and on occasion terrifying, but they can be more satisfying if they invoke a series of additional images. Just as one’s appreciation of any work of art is enhanced by knowing something of the artist and his position in art history, so one’s appreciation of nature’s pictures is enhanced by knowing something about natural history. For a full appreciation of the splendour of mountain peaks rising abruptly from the plains, reaching
for the puffs of cloud that ride above them, we need to know something of the processes that raise mountains—or were they always there? We need to know something of the winds that carry moisture from the oceans to the skies, because we see that the clouds come, change their shapes, and then disappear. We can gain a great deal by learning a little about the scientific approach to appreciation of the Earth. And it is not at all difficult for the nonprofessional to read about and to understand many of the necessary concepts.

Two of the most troublesome concepts are time and size—dimensions that distinguish the Earth sciences from any other Earth-bound subject. It is very difficult for us to grasp the meaning of the statement that the Earth formed 4,600,000,000 years ago. Similarly, the enormous volume of water in the oceans or the volume of rocks in a mountain range almost defy comprehension. We have been considering the Earth and scenery as it is exposed to us at the present. But when we study the Earth, we realize that the present scenery is merely a transient feature in the immense span of geological time. Early students of the Earth were hampered by the belief that the Earth was only a few thousand years old. Many of them were seeking answers to two recurrent questions that we find throughout human history. How and when was the Earth formed? How and when was man formed? Attempts to answer these questions are responsible for many myths and religions in various cultures, both ancient and modern.

In the early part of the 19th century the study and interpretation of rocks led geologists to conclude that the Earth must be of far greater antiquity than the age implied by a literal interpretation of the Bible. They realized that the layers of rock now exposed at the surface contain records of the history of the Earth during the times that each layer was formed. One major branch of the Earth sciences is devoted to the discovery, translation, and interpretation of the "record of the rocks." Many rock layers enclose fossils, and these remnants of animals and plants serve as illustrations in the historical book of nature, making it possible to trace the development and changes of species through time.

Fossil hunting has been a popular pastime for many generations. With a little experience and a little knowledge, an amateur fossil hunter can add interpretation to his discoveries. From a few fossil shells and corals in a limestone, he can reconstruct in his mind's eye the whole flourishing community of life that once existed on a coral reef, now frozen into the rock record. A piece of coal, with fossil imprints of leaves, ferns, and other plant remains from which the coal was formed, can conjure up a picture of a luxuriant swamp of 300,000,000 years ago, populated by strange beasts long since vanished from the Earth. The history of the Earth, the evolution of life, and the origin of man, at least in part, are preserved in the rocks. It is here that fundamentalists still supporting "creationism" will find much evidence for the evolution of life forms, if they care to examine it. This aspect of Earth study has almost universal appeal. Earth history and human history overlap in archaeology, and the records of early civilizations exposed in excavation sites always excite public curiosity.

The scientific approach to the appreciation of nature informs us that the key to interpretation of the past history of the Earth from the record of the rocks lies in processes occurring at the present time. These processes have been grouped into great cycles. Two of the most important are the hydrologic cycle, concerned with the circulation of water, and the mountain-building cycle.

The oceans constitute a vast reservoir for the hydrologic cycle. The atmosphere and the oceans are in constant motion, driven by the energy from the Sun and the rotation of the Earth. Masses of humid air, carrying water that has evaporated from sun-drenched tropical oceans, migrate to cooler latitudes, where the water is precipitated as rain or snow and thus returned to the ocean reservoir either directly or indirectly, over or through the ground. The moving air masses and ocean currents bring to the continental masses rain or drought, heat or cold, making them hospitable, habitable, or uninhabitable for human colonies. Minor changes in atmospheric circulation have converted fertile plains to barren deserts and caused major changes in the development of ancient civilizations.

The hydrologic cycle shapes our local environment. The features that we know collectively as scenery are produced mainly by flowing water, although ice, wind, and solar energy also contribute. The force of gravity and the rivers together carry the products of weathering downhill to the ocean reservoir. The average rate at which the surface of the land is being worn down and the land dispersed into the oceans is a trivial 1.5 inches per 1,000 years, but the dimensions of geological time give significance to small numbers. At this rate, all of the continents would be worn down to sea level within 20,000,000 years. This means that during the 4,600,000,000 years since the Earth was formed, the continents could have been worn down to sea level at least 200 times. By now there should be no land rising above sea level, but we still see high mountains.

The mountains exist and persist because the effects of the hydrologic cycle are offset by the mountain-building cycle. Forces within the Earth cause large regions of the surface to rise very slowly, imperceptibly in human terms. Imperceptible, that is, until an earthquake signals an abrupt movement in the continuing process of mountain building. While some parts of the Earth rise, other regions sink. This slow rhythm has been termed "the pulse of the Earth." Although we do not understand the details of what is happening within the Earth, we are now confident that internal forces are responsible for shaping the major features of the Earth's surface, such as the distinction between continents and ocean basins and the persistence of mountain ranges on the land and beneath the ocean. The detailed sculpture of the surface results from the conflict between the mountain-building cycle and the hydrologic cycle.

The internal forces do more than cause the land surface to rise and fall; they cause the land to move sideways as well. It is now generally believed by most scientists that the continents drift. There is persuasive evidence that the surface of the Earth is covered by a small number of very large shell-like plates, about 60 miles thick, across which the continents are scattered rather like logs frozen into the ice on a lake. The rigid shells of rock slide over the Earth's interior, carrying the continents with them and grinding against each other along their edges like ice floes. The plate boundaries are sites of geological activity: earthquakes and
volcanoes are concentrated along them. Because of these movements, supercontinents have been rifted apart, and ocean basins have opened, expanded, and closed again as continents collided. Collisions of continents have thrust up great mountain ranges such as the Himalayas. The continents are still drifting at rates of an inch or two per year: the Atlantic Ocean is increasing in size, and the Pacific Ocean is becoming smaller. Most people are fascinated by the theory of continental drift. The theory is not only aesthetically pleasing but also has practical applications.

What stokes the subterranean fires that drive the Earth's engine, causing continental drift, mountain building, volcanic eruptions, and earthquakes? We have no satisfactory answer to this question, but we do know that an enormous amount of energy is involved in the activity along the plate margins. One major earthquake releases more energy than a hydrogen bomb. Modern man is a powerful animal, thanks largely to his exploitation of the Earth for material and energy, and he dominates the landscape like no species before him. He feels reasonably secure in his command of the environment while contemplating the urban scene, because the landscape is largely a product of his industry, and it is clearly subservient to his wishes and his computer-operated control panels. But when the Earth releases a minute fraction of its internal energy in a major earthquake, man becomes helpless. All control is lost while the surface of the Earth rises and falls in solid waves.

Man cannot live in harmony with his environment during an earthquake. It has become clear, however, that he must learn to do so at other times if he is to avoid the dire predictions of those who evaluate such factors as projected world populations, the material and energy resources of the Earth, projected rates of consumption of these resources, and the volume and toxicity of waste materials discarded. We live in a restricted environment with finite space and resources, and we have become a force producing major modifications in the environment at rates very rapid compared with normal rates of Earth evolution. Social decisions about the continued exploitation of the Earth should be made with full information about the problems, and social decisions are based on votes, in theory at least. This alone is sufficient reason for any intelligent person to inform himself about the Earth, quite apart from the fascination of the subject, because his future depends upon it.
Part Two. The Earth

Several points about the relations of this part to other parts should be noted. The consideration here of the Earth's physicochemical properties presupposes the physical and chemical knowledge and theories set forth in Part One. Knowledge of the Earth is in turn presupposed by Parts Three, Four, and Five, which are Life on Earth, Human Life, and Human Society, respectively. The several Earth sciences have themselves been the objects of historical and analytical studies concerned with their nature, scope, methods, and interrelations. These studies are set forth in Section 10/33 of Part Ten. The instrumentation used in the Earth sciences is dealt with in Section 723 of Part Seven.

Division I. The Earth's Properties, Structure, and Composition

The outlines in the four sections of Division I treat the Earth as a planet; the Earth's physical properties; the structure and composition of the Earth's interior; and the Earth's constituent minerals and rocks.

Section 211. The Planet Earth

A. The orbital motions of the Earth
   1. The revolution of the Earth about the Sun, the rotation of the Earth on its axis
   2. Forces and dynamic effects related to the rotation of the Earth
      a. The Coriolis force
      b. The effects of centrifugal force
      c. Tidal friction

B. The figure of the Earth
   1. The conventional definition of the figure of the Earth: the geoid
   2. The development of improved approximations to the Earth's size and shape
   3. The world geodetic system: the measurement of geodetic parameters
      a. The astrogravimetric method
      b. Satellite measurements
      c. Correlation of data from different methods
Section 212. The Earth’s Physical Properties

A. The Earth’s gravitational field
   [see also 131.B.]
   1. Characteristics of the terrestrial field
   2. Measurement of gravitational acceleration
      [see also 723.D.2.d.]
   3. Interpretation of gravity data: inferences about the Earth’s interior
      a. Isostasy: the approximate balance between the elevation of the Earth’s surface and the
density of the rocks below
      b. Gravity anomalies

B. The Earth’s magnetic field
   1. Measurement and representation of magnetic fields
   2. Sources and characteristics of the Earth’s main magnetic field
   3. Variations in the main magnetic field, including polarity reversals, magnetic storms,
magnetospheric substorms, and magnetic pulsations

C. The Earth’s electrical properties
   [see also 127.B.]
   1. Currents produced by the motion of charged particles in the Earth’s ionosphere
      [see also 221.A.3.b]
   2. Electrical conductivity and dielectric behaviour of the Earth’s rocks and minerals
   3. Currents induced by magnetic-field variations, currents generated by the Earth’s core

D. The Earth’s thermal properties
   [see also 124.A.4.c.]
   1. Sources of the Earth’s heat
      [see also 112.C.5.]
   2. Transmission of heat from the Earth’s interior to its surface: thermal conductivity and
      gradients, heat flow data
   3. Geologic aspects of heat flow: convection currents within the Earth, rock metamorphism,
      and mountain building
   4. Surface manifestations of heat flow: volcanoes, hot springs, geysers, and related phenomena
E. The mechanical properties of the Earth

1. The fundamental mechanical properties of the Earth's body and the indirect evidence used to determine them

2. Nature of deformable media: stress and strain, models of the stress-strain behaviour of materials, seismic waves
   [see also 126.D.]

3. The basic internal mechanical properties of the Earth

4. The Earth's departures from spherical symmetry: oblateness, lateral variations associated with crustal structure, isostasy and its effects
   [see also 211.A.2.b.]

5. Anelasticity in the Earth

6. Response of the Earth to stresses of long duration

F. Physical properties of Earth materials

1. Volumetric properties: rock density and porosity

2. Mechanical properties
   [see also 126.D., E., and G.]

3. Thermal properties: specific heat and thermal conductivity, thermal expansion and rock melting

4. Magnetic and electrical properties
   [see also C.2, above]

5. Hydraulic properties: porosity and permeability, the capacity to store and transmit fluids

6. Optical properties: colour, lustre

G. The deformation of materials in the Earth's crust

1. Stress and strain of rocks
   a. Response to stress
   b. Elastic and plastic deformation

2. Folding of rocks
   a. Tectonic folding
   b. Foliation, lineation
   c. Nappes (large rock sheets thrust over other rock formations)
   d. Salt domes and other diapiric structures
      [see also 724.B.1.b.]
   e. Nontectonic folding; e.g., slumping of recently deposited sediments

3. Fracture in rocks: joints, faults

4. Structural interference: the superposition of strains produced by the tectonic events of different ages

5. The deformation of ice in sheets and glaciers
   [see also 222.A.3.a.]

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Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with the Earth's physical properties

Earth, The: Its Properties, Composition, and Structure
Minerals and Rocks
Volcanism

**MICROPAEDIA:** Selected entries of reference information

General subjects

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Section 213. The Structure and Composition of the Earth's Interior

A. The Earth's concentric layers
   1. Physical properties and zonal structure of the Earth
      [see also 212]
   2. The basic divisions of the solid Earth
      a. The crust: the Earth's outer layer, which is differentiated into continental and oceanic crust
      b. The Mohorovičić discontinuity: the zone that separates crust from mantle
      c. The mantle: the layer between crust and core that comprises the bulk of the Earth's volume
      d. The core: the Earth's innermost region, thought to be molten liquid except for a solid inner portion
   3. The development of the Earth's structure and composition
      [see 241.A.]

B. Earthquakes: sources of seismic waves within the Earth
   1. Causes of earthquakes
   2. Distribution of earthquakes
   3. Magnitude, motion, and energy of earthquakes
      [see also 126.D. and 128.A.]
   4. Seismic measurements and their interpretation
      [see also 723.F.6.]

C. Distribution of elements in the Earth's core, mantle, and crust
   [see 214.C.]

D. The indirect geophysical and geochemical evidence used to infer the structure and composition of the Earth's interior
   1. Geophysical evidence, mainly from earthquake analyses
      [see also 212.E.]
      a. Seismic wave velocities
      b. Density distribution
   2. Geochemical evidence
      a. Investigations of geochemical equilibria at high temperatures and pressures: phase transitions in the Earth's interior
      b. The composition and mineralogy of meteorites that may correspond to rocks forming the Earth's interior
      c. Evidence from crustal igneous rocks that are derived from the upper mantle; e.g., andesite lava flows, peridotite and eclogite inclusions in lava flows and some igneous rocks

Suggested reading in the *Encyclopædia Britannica*:

MACROPAEDIA: Major articles dealing with the structure and composition of the Earth's interior
   Earth, The: Its Properties, Composition, and Structure
   Earthquakes
Section 214. The Earth's Constituent Minerals and Rocks

A. The mineral constituents of the Earth

1. The chemical composition, internal structure, and morphology of minerals

2. The physical properties of minerals: cleavage; hardness; tenacity; specific gravity; magnetic, optical, and radioactive properties

3. Classification of minerals in terms of crystal structure and chemical composition
   a. The principal nonsilicate minerals
      i. Native elements
      ii. Sulfides and sulfarsenides
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      iv. Oxides and hydroxides
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      vi. Carbonates
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     x. Phosphates, arsenates, and vanadates
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b. The silicate minerals
   i. Silicate structure and composition: the basic structural unit, the silicon-oxygen tetrahedron
   ii. Isolated and double tetrahedral group silicates
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4. The occurrence of minerals in nature
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      i. The olivines; e.g., forsterite, fayalite
      ii. The pyroxenes; e.g., augite, jadeite
      iii. The amphiboles; e.g., hornblende, actinolite
      iv. The micas; e.g., muscovite, biotite
      v. The feldspars; e.g., orthoclase, albite
      vi. The feldspathoids; e.g., nepheline, leucite
      vii. The silica minerals; e.g., quartz, tridymite
      viii. The clay minerals; e.g., kaolinite, illite
ix. The carbonates; e.g., calcite, dolomite
[see A.3.a.vi., above]

x. The garnets; e.g., almandine, pyrope

xi. Other major rock-forming minerals; e.g., magnetite, pyrite

b. The occurrence of mineral associations and phase equilibrium
   i. In igneous and metamorphic rocks
   ii. In sedimentary rocks and precipitates
   iii. In the Moon, planets, and meteorites
[see also 133.C., 133.E.6.]

c. Ore deposits: concentrations of metals and metalliferous minerals
[see also 724.C.3.]

d. Minerals of gem quality

B. Rocks and other constituents of the Earth's crust

1. Igneous rocks
   a. Properties of igneous rocks: composition, texture, and structure
   b. Classification of igneous rocks
   c. Formation of igneous rocks: magmas
[see also 212.D.4.]
   d. Distribution and abundance of igneous rocks
   e. Principal families of igneous rocks
      i. The intrusive igneous rocks that result when magma cools and solidifies below the
         surface of the Earth; e.g., granite, gabbro, diorite
      ii. The extrusive igneous rocks that form from magma that erupts at the surface of the
         Earth; e.g., basalt, rhyolite, andesite
      iii. The pyroclastic igneous rocks that form from deposits of explosive volcanic eruptions;
         e.g., pumice, tuff, scoria

2. Sedimentary rocks
   a. Properties of sedimentary rocks: texture and mineralogical and geochemical composition
   b. Classification systems: clastic, nonelastic
   c. Sedimentary structures
   d. Sedimentary environments: marine, nonmarine
   e. Principal types of sedimentary rocks
      i. Conglomerates, breccias, and other heterogeneous clastic rocks (e.g., tillites)
      ii. Sandstones: arenites and wackes
      iii. Mudrocks, including shales
      iv. Limestones and dolomites
      v. Siliceous rocks
      vi. Phosphorites
      vii. Evaporites
[see also 724.B.1.b.]
      viii. Iron-rich sedimentary rocks
      ix. Organic-rich sedimentary rocks
[see 5., below]
   f. Distribution of sedimentary rocks through time

3. Metamorphic rocks
   a. Metamorphic variables: temperature, pressure, and rock composition
   b. Textural and structural features
   c. Origin of metamorphic rocks
Division I. Section 214

4. The rock associations formed in different environments of the Earth’s crust
   a. In the oceanic regions: basaltic lavas, reef limestones, abyssal sediments of the deep oceans
   b. In the stable continental regions: conglomerates, sandstones, evaporites, coal measures
   c. In the continental borderlands: sandstones, shales, limestones
   d. In the island arcs: andesite and spilite lavas, ultrabasic intrusive rocks, graywackes, shales
   e. In the major mountain ranges: regionally metamorphosed rocks, granitic batholiths, early-stage basalts and peridotites, late-stage andesite lavas
   f. In the piedmont regions that are adjacent to mountain ranges: gabbros, basalts, arkoses

5. Fossil fuels
   a. Coals
      [see also 724.B.1.b. and C.2.]
   b. Petroleum
      [see also 122.G.1.a. and 724.B.2. and C.1.]
   c. Tar sands and oil shales
      [see also 724.B.2. and C.1.]
   d. Natural gas
      [see also 122.G.1.a. and 724.B.2.]

C. Occurrence of the elements in the Earth and its envelope
   [see also 121.D.1.]
   1. Core
   2. Mantle (depleted and undepleted)
   3. Crust: igneous, sedimentary, and metamorphic rocks; soils
   4. Hydrosphere
      [see 222.B. and C.]
   5. Atmosphere
      [see 221.A.]
   6. Biosphere: selective concentration of elements by plants and animals
   7. The geochemical cycle: the primary geochemical differentiation of the Earth; the migration of elements throughout the atmosphere, hydrosphere, and solid Earth

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the Earth’s constituent minerals and rocks
   Chemical Elements
   Earth, The: Its Properties, Composition, and Structure
   Fuels, Fossil
   Minerals and Rocks
   Volcanism

MICROPAEDIA: Selected entries of reference information

General subjects

<table>
<thead>
<tr>
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<th>malachite</th>
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cerargyrite
fluorite
halide mineral
halite
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diabase
dike
diorite
dunit
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gabbro
granite
granodiorite
granite
igneous rock
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laccolith
lamprophyre
latite
leucite
mafic rock
magma
monzonite
myrmekite
nepheline
nepheline syenite
nepheline
obsidian
pegmatite
peridotite
perlite
phonolite
picrite
pitchstone
pumice
pyroxene
pyroxenite
pyroxene
quartz
roof pendant
sill
spilit
spilitic syenite
syenite
tachylite
teschenite
trachyte
trachyte
volcanic glass
xenolith
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anatexis
cataclastite
charnockite
eclogite
epidote-amphibolite facies
glaucophane schist facies
gneiss
granitization
granulite facies
greenschist facies
hornfels facies
induration
metamorphic rock
metamorphism
metatexit
migmatite
phyllite
sandstone facies
schist
skarn
zeolite facies
chips
industrial diamonds
natural elements
molybdate and tungstate minerals:
ominous minerals:
native elements:
unknown minerals:
mineral fuels and deposits:
rock
coal
energy
uranium
geode
diamond
native element
oxide and hydroxide minerals:
anatase
boehmite
cassiterite
chromite
chrysoberyl
columbite
corundum
cuprite
emery
gibbsite
goethite
gossan
hematite
ilmenite
limonite
magnetite
oxide mineral
pitchblende
pyrochlore
pyrolusite
ruby
ruby spinel
rutile
sapphire
spinel
thorium
uraninite
phosphate minerals:
ambygonite
apatite
arsenate mineral
carnotite
deschozite
erthite
fluorapatite
hurzite
mimetite
phosphate mineral
pyromorphite
scorodite
triphyllite
turquoise
vanadate mineral
variscite
sedimentary rocks
and their formation:
akrose
banded-iron formation
black shale
breccia
cementation
conglomerate
diagenesis
diatomaceous earth
dolomite
evaporite
flysch
geode
graphite
geode
gravel
graywacke
halite
limestone
lithification
loess
lutite
marl
molasse
nodule
oil
phosphorite
porcellanite
quartzite
sand
sandstone
diyed facies
diyed rock
shale
silicic rock
silt
siltstone
stratification
stilbite
subgraywacke
tillite
silica minerals:
agate
amethyst
citrine
carnelian
chalcedony
chert and flint
chrysotile
coeite
cristobalite
fulgite
jasper
lechatelierite
mass agate
onyx
opal
phosphinite
quartz
rock crystal
rose quartz
sard and sardonyx
sepiolite
serpentine
silica
calcium
smoky quartz
tridymite
silicate minerals:
actinolite
aegirine
almandine
amphibole
andalusite
andradite
augite
beryl
### Division II. The Earth's Envelope: Its Atmosphere and Hydrosphere

[For Part Two headnote see page 65.]

The outlines in the three sections of Division II treat the Earth’s atmosphere, its hydrosphere, and weather and climate.

**Section 221. The Atmosphere**

**Section 222. The Hydrosphere: the Oceans, Freshwater Bodies, and Ice Masses**

**Section 223. Weather and Climate**

### Section 221. The Atmosphere

#### A. The composition, structure, and features of the atmosphere

**[see also 241.R. and 723.G.5.]**

1. **Division of the atmosphere by composition**

   a. **The homosphere**

      i. **Water cycle**

         [see also 222.D.3. and 223.A.1.]

      ii. **Carbon budget**

      iii. **Nitrogen budget**

      iv. **Sulfur budget**

   b. **The heterosphere**

      i. **Oxygen dissociation**

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<table>
<thead>
<tr>
<th>Term</th>
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<td>zoisite</td>
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**sulfate minerals:**

- alunite
- anhydrite
- barite
- celestite
- gyspum
- halotrichite
- sulfate mineral
- antimonide
- argentite
- arsenide
- arsenopyrite
- galena
- marcasite
- ore
- pyrite
- pyrrhotite
- sphalerite

**zeolite minerals:**

- chrysotile
- riebeckite
- tetrahedrite
- zeolite

**other:**

- accessory mineral
- amphibolite
- bentonite
- chromate mineral
- clay mineralogy
- cleavage
- colour index
- crocoite
- devitrification
- Eh-pH diagram
- filter-pressing
- foliation
- fracture
- fuller’s earth
- gemstone
- grade scale

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**INDEX:** See entries under all of the terms above
ii. Escape of helium and hydrogen from the upper atmosphere

2. Thermal structure
   a. The troposphere
   b. The stratosphere
   c. The mesosphere
   d. The thermosphere

3. Regions and phenomena of the upper atmosphere
   a. The ozonosphere
      i. Absorption of ultraviolet radiation of wavelengths harmful to plant and animal life
      ii. Heating of the upper atmosphere
   b. The ionosphere
      i. Ionospheric variations and disturbances of atmospheric origin
      ii. Ionospheric variations and disturbances of solar origin: auroras and magnetic storms
      [see also 212.B.]
      iii. The effects of the ionosphere on radio waves
      [see also 735.1.5.]
   c. The exosphere
      i. Effects of low particle density on the properties of the exosphere
      ii. Determination of the critical zone, the layer above which the number of particle collisions is negligible
      iii. The Van Allen radiation belts
      [see also 133.B. and 212.B.]

B. The large-scale motions of the atmosphere
   [see also 223]
   1. The general nature and relative scales of atmospheric motions: the resolution of winds into zonal (east–west), meridional (north–south), and vertical components
   2. The relation of wind to pressure and temperature: the cause of winds, the effect of Coriolis force, idealized winds derived from simplified models—the geostrophic and thermal winds
      [see also 211.A.2.a.]
   3. Jet streams
   4. The westerlies of the mid-latitudes
      a. Standing waves of the mid-latitude westerlies and related systems
      b. Mid-latitude traveling disturbances: cyclones, anticyclones
      [see 223.B.1.]
   5. Tropical wind systems
      a. Trade winds
      b. Tropical disturbances: nonecyclonic storms, hurricanes and typhoons
      [see 223.B.4.]
      c. Monsoons
   6. Stratospheric and mesospheric wind systems
      a. Polar-night westerlies
      b. Summer easterlies of the mesosphere and stratosphere
   7. The mean meridional circulations of the atmosphere
   8. The driving mechanism of the atmosphere: the energy balance and the transport of heat and momentum

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major article dealing with the atmosphere

Atmosphere
### General subjects

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### Atmospheric phenomena:

- anticyclone
- thunderstorm
- tropical cyclone
- updraft and downdraft
- wind
- atmospheric optical phenomena
- airglow
- atmospheric corona

### Other:

- aurora
- halo
- regions and zones of the atmosphere
- D region
- E region
- air
- air mass
- atmosphere
- atmospheric pressure
- radiation belt

### Biographies

See Section 10/33 of Part Ten

### INDEX:

See entries under all of the terms above

---

### Section 222. The Hydrosphere: the Oceans, Freshwater Bodies, and Ice Masses

**A. The distribution of water in the hydrosphere**

1. Saltwater bodies
   - Oceans and marginal seas
   - Gulfs and bays

2. Freshwater bodies
   - Rivers, lakes, and marginal bodies such as estuaries and swamps
     [see 232.C.1., 2., and 3.]
   - Groundwater contained within the pores of rocks

3. Ice
   - Ice sheets and glaciers
     [see also 212.G.5. and 232.C.6.]
   - Icebergs and pack ice
   - River ice and lake ice

4. Water in the biosphere
   [see 351]

**B. The physical and chemical properties of seawater**

[see also 241.C.]

**C. The physical and chemical properties of freshwater**

**D. The hydrologic cycle**

1. The general nature of the hydrologic cycle: the types of processes involved and their complex interaction, scales of magnitude of the interrelated components of the global hydrologic system, influences of climate and other factors
2. The roles of evaporation and transpiration in the hydrologic cycle
   [see also 336.B.4.]
3. The role of water vapour in the hydrologic cycle: condensation, precipitation
   [see also 223.A. and E.1.e.]
4. Runoff and subsurface water in the hydrologic cycle
   [see also 232.A-4.]
5. The role of ice in the hydrologic cycle
   [see also A.3., above]
6. Water resources and supply
   [see also 737.A.1.]

E. Ocean-atmosphere interactions
1. Radiation, heat, and water budgets
2. Oceanic waters as an important sink for carbon dioxide
3. Impact of ocean-atmosphere interactions on climate and weather
   a. Link between ocean surface temperature and climate anomalies
   b. El Niño/Southern Oscillation (ENSO)
   c. Moderating effects of the Gulf Stream system on climate

F. Effects of human activities on the hydrosphere: e.g., cultural eutrophication; acidification
   of precipitation resulting from the emission of sulfur dioxide and nitrogen oxides; potential
   disruption of the water balance due to greenhouse warming induced by carbon dioxide buildup

G. Waves in the hydrosphere
   [see also 126.F., 128.A., and 232]
1. Surface waves: simple waves, ocean waves, tsunamis
2. Internal waves
3. Tides
   [see also 133.E.7.c.]

H. Ocean currents
1. The distribution of ocean currents
2. The forces that cause and affect ocean currents: pressure gradients, Coriolis force, frictional
   forces
   [see also 211.A.2.a.]
3. The general surface circulation
4. Subsurface ocean currents
   a. The general deep-sea circulation
   b. Tidal currents: periodic currents associated with tides in the sea
   c. Density currents down continental slopes, produced by differences in temperature, salinity,
      or sediment concentration
      [see also 231.C.3.]

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the hydrosphere: the oceans, freshwater bodies, and ice
masses

- Earth. The: Its Properties, Composition, and Structure
- Hydrosphere. The
- Ice and Ice Formations
- Lakes
- Oceans
- Rivers

**MICROPAEDIA:** Selected entries of reference information

General subjects

- freshwater resources
- groundwater
- lake
- river
- aquifer
- ice
- reservoir
- spring
Section 223. Weather and Climate

A. Condensation of water in the atmosphere producing clouds, fogs, and precipitation

1. Moisture in the atmosphere
   [see also 221.A.1.a. and 723.G.5.]
   a. Humidity indices: absolute, specific, and relative humidity; dew-point temperature
   b. Climatic aspects of atmospheric humidity
      [see E.1.c., below]
   c. Effects of atmospheric humidity on the life and health of humans and other life-forms
      [see E.4., below]

2. Condensation of atmospheric water vapour
   a. Convection, air-mass convergence, and other processes that lead to condensation
      [see also 221.B.]
   b. Condensation nuclei: atmospheric ions, salt and dust particles
   c. Dew
   d. Frost

3. Clouds and fogs
   a. Formation and growth of clouds
   b. Description and classification of clouds
   c. Clouds and weather
   d. Fog
   e. Artificial modification of clouds and fogs

4. Precipitation
   [see also 222.D. and 723.G.5.]
   a. Origin of precipitation in clouds, mechanisms of precipitation release
      [see also A.3.a., above]
   b. Types of precipitation: drizzle, rain, freezing rain; snow; sleet, hail
   c. The world distribution of rainfall
   d. Effects of precipitation

B. Winds and storms
   [see also 221.B.]
   1. Development and distribution of cyclones and anticyclones
   2. Lightning and thunderstorms
      [see also 127.A. and B.]
   3. Tornadoes, hail, and other severe phenomena associated with organized storms or squall lines
   4. Tropical cyclones: hurricanes and typhoons
C. Weather forecasting

1. Synoptic weather data: the collection and correlation of meteorological observations
2. Numerical weather prediction and numerical climate modeling
3. Short-range forecasting
   a. Nowcasting: predictions based on computer analyses of radar and satellite observations of local atmospheric conditions
   b. Model Output Statistics: extrapolation of weather conditions, using statistical relations between numerical model forecasts and past weather phenomena
4. Long-range forecasting
   a. Enhancing the reliability of extended-range prediction through systematic studies of atmosphere-ocean interactions; e.g., El Niño/Southern Oscillation (ENSO)
   b. Limits to predictability

D. Weather lore

E. Climate: the aggregate of weather
   [see also 133.B.5., 221, and 723.G.5.]

1. Factors that generate climate
   a. Solar radiation
      i. Variability of incident radiation; the solar constant
      ii. Effects of the atmosphere: absorption by dust and gases, including the trapping of solar radiation of infrared wavelength (the so-called greenhouse effect)
      iii. Variations in the Earth's albedo due to clouds and ice
   b. Temperature
   c. Atmospheric pressure
   d. The world's oceans
   e. The moisture cycle
2. Climatic variation
   a. Seasonal changes resulting from the north-south migration of belts of cyclonic activity and other cyclic processes
   b. Local effects: modification of climate by local terrain and surface conditions
   c. Effects of human activities on global climate; e.g., greenhouse warming induced by high concentrations of carbon dioxide (from the burning of fossil fuels) and other trace gases in the atmosphere
   [see also 241.B.5. and 737.C.1.]
3. Climatic types: the Köppen classification system, world climates and their distribution
4. Influences of climate on terrestrial life
5. Microclimates
   [see also 351.B.]
6. Climatic change
   a. Evidence: e.g., landscape features associated with glaciations; fluctuations of lake and sea levels; pollen stratigraphy; archaeological and historical data
   b. Identified causes of certain forms of climatic variation: variations in the tilt of the Earth's axis and orbital motion; variations in atmospheric composition; volcanic dust loading of the atmosphere; and changes in the distribution of land and sea due to plate-tectonic activity

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major article dealing with weather and climate

Climate and Weather
Division III. Section 231

The Earth's Surface Features

The outlines in the two sections of Division III deal with the basic physical features of the Earth's surface and with the features produced by geomorphic processes acting on the Earth's surface.

Section 231. Physical Features of the Earth's Surface 79

Section 232. Features Produced by Geomorphic Processes Acting on the Earth's Surface 81

Section 231. Physical Features of the Earth's Surface

A. Vertical relief of the Earth's surface

1. Hypsography of the Earth's surface: distribution of land and sea, elevation of the continents, coastlines

2. Physiography of the continents: Europe, Asia, Africa, Australia, North America, South America, Antarctica

3. The oceanic regions

a. Principal oceanic features: continental margins, oceanic ridges, deep-sea trenches, and abyssal hills and plains

[see C., D., and G., below, and 723.G.3.]
b. Oceanic physiography

B. The stable platform regions of the continents
   1. The continental shield areas and their age, structure, and constituent rocks
      [see also 214.B.4.b.]
   2. Uplift, downwarp, and fracture of continental platforms
      a. Plateaus and basins
      b. Rift valleys
      c. Water bodies occupying fault-bounded structural depressions: lakes and landlocked seas; inland seas with outlets to the oceans; elongated seas formed by crustal separation

C. The continental shelf, slope, and rise
   1. Composition: evidence from bottom samples, geophysical techniques
   2. Structure and origin
   3. Submarine canyons incising the continental terrace

D. The oceanic deeps
   1. Components of ocean basins
      a. The oceanic crust
      b. Major features of the deep-ocean floor: oceanic ridges, aseismic ridges, trenches, fracture zones, and transform faults; seamounts and guyots; abyssal hills and plains; sediments of the ocean floor
         [see also G., below]
   2. The origin of ocean basins
      [see also 241.F.]

E. Coral islands, coral reefs, and atolls
   [see also 354.B.2.]

F. The major mountain ranges and fracture zones of the Earth’s crust on the continents and beneath the oceans
   1. Types of mountains; e.g., volcanic, block-fault, folded
   2. The worldwide system of mountain ranges, fracture zones, and volcanic island arcs
      a. The Circum-Pacific System
      b. The Tethyan System
      c. Subsidiary mountain ranges
      d. The volcanic island arc systems
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   3. Occurrence and distribution of ridges in the Atlantic, Pacific, and Indian oceans

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with the physical features of the Earth’s surface

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2. Soil formation as a result of weathering
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4. Fluvial processes
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   b. Erosion, deposition
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   b. Effects of wind transport
   c. Deposition by wind: formation and migration of dunes, the role of vegetation
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7. Glacial processes: erosion, transport, deposition, glacial loading and unloading, periglacial processes
   [see also C.6., below]

8. Lacustrine processes
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b. Sedimentation in lakes

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b. Effects of vegetation type and density on sediment yield
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c. Effects of humankind on the Earth's surface features: e.g., land cultivation, mining, construction of artificial channels and dams
[see also 355, 731, 733.B., 734, 736, and 737]

2. Extraterrestrial processes: the occurrence of meteorite craters
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3. Volcanic-tectonic processes
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c. The geometry of river systems

d. Streamflow and fluvial landforms: peak discharge and flooding, river floodplains and terraces, river deltas, ephemeral streams, waterfalls

e. The evolution of river systems through geologic time

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iv. Coral reefs
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   b. Surficial features of deserts
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      ii. Alluvial fans: fan-shaped sedimentary deposits bordering highlands from which the sediment was derived
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      v. Playas, pans, saline flats
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6. The glacial environment
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   b. Landforms produced by glacial erosion
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      ii. Ice-contact deposits, kames, eskers, and other landforms of stratified drift
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7. The polar environment
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11. Karst topography

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1. The concept of uniformitarianism
   [see also 242.A.2.a.]

2. The concept of the cycle of erosion

3. The concept of morphogenetic regions

4. The concept of dynamic equilibrium

5. The concept of entropy
   [see also 124.A.]
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the features produced by geomorphic processes acting on the Earth's surface

- Continental Landforms
- Earth, The: Its Properties, Composition, and Structure
- Geomorphic Processes
- Ice and Ice Formations
- Lakes
- Oceans
- Rivers
- Soils
- Volcanism

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   5. Effects of human activities and their ramifications; e.g., acid rain resulting from the emission of sulfur dioxide; ozone depletion caused by the release of chlorofluorocarbons; greenhouse warming induced by the buildup of carbon dioxide
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E. The formation and growth of mountain ranges and belts
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   3. The geosynclinal hypothesis of mountain building
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F. The theory of plate tectonics
   1. Early speculations about the existence of a single supercontinent and its fragmentation into the present-day landmasses
2. Wegener's concept of continental drift
3. Hess' seafloor spreading model
4. Plate tectonics as a unifying theory
   a. Lithospheric plate boundaries as sites of volcanism, seismicity, and orogeny
   b. The impact of continental drift on the evolution of life-forms

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the origin and development of the Earth and its envelopes
- Atmosphere
- Earth, The: Its Properties, Composition, and Structure
- Plate Tectonics
- Volcanism

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   - b. Carbonate rocks
   - c. Volcanic rocks
   - d. Cyclic deposits: cyclothsms, varved deposits

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   - c. The idea of a fossil succession
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3. Stratigraphic nomenclature in theory and practice
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b. Stratigraphic boundary problems

c. Special stratigraphic terminologies and divisions

B. The paleontological interpretation of the geologic record

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2. The fossil record

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   i. The origin of life  
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   ii. Precambrian protists, plants, and animals: the Gunflint Chert deposits, Ediacara fauna, and other remains

b. Post-Precambrian life: the Phanerozoic fossil record  
[see also 243 and 313]
   i. Fossil plants
   ii. Fossil protists
   iii. Fossil sponges
   iv. Fossil cnidarians (e.g., corals)
   v. Fossil mollusks (e.g., ammonoids)
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   ix. Fossil arthropods (e.g., trilobites)
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1. Application to geologic problems: stratigraphic correlation and the relative geologic time scale  
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   a. Radioactivity and radioactive decay  
   [see 112.C.]
   b. Principles of radiometric dating
c. Definition of time zero, sources of error in radiometric dating

d. Dating methods

3. Non-radiometric dating: biological and geologic processes as absolute chronometers

4. Applications of absolute dating
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   b. Determination of the age of the Earth and the ages of rocks and meteorites
   c. Determination of the rates of seafloor spreading

E. The paleogeographical interpretation of the geologic record

F. The reconstruction of the geologic history of the Earth based on the global correlation of the accumulated evidence from the rock record

[see 241 and 243]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the interpretation of the geologic record

Earth, The: Its Properties, Composition, and Structure
Geochronology: The Interpretation and Dating of the Geologic Record

MICROPAEDIA: Selected entries of reference information

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   a. The Pleistocene Epoch
      [see also 223.E.6. and 232.C.6.]
   b. The Holocene, or Recent, Epoch

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the eras and periods of geologic time

Earth, The: Its Properties, Composition, and Structure
Geochronology: The Interpretation and Dating of the Geologic Record
Volcanism

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Introduction to Part Three:
The Mysteries of Life

By René Dubos

We take for granted the existence of life on Earth. Yet, as far as we now know, life exists nowhere else in the solar system, its origin is still a mystery, and its effects on our planet have been little short of miraculous. Without life the surface of the Earth and its atmosphere would be very different from what they are now. We are both spectators and actors in a continuing performance where life is both author and producer, and for which the Earth serves as an ever-changing stage.

Cataclysms give us now and then a glimpse of what our planet would look like without life. In 1883, a series of stupendous volcanic eruptions destroyed two-thirds of Krakatoa Island in the Malay archipelago and covered what was left of it with a thick layer of lava. All living things were killed, not only on Krakatoa itself, but also on the neighbouring islands that were in the path of the tidal wave generated by the explosion and of the volcanic fallout. What had once been a luscious tropical forest suddenly became a gray and lifeless landscape, as desolate as the surface of the Moon.

Pictures taken of Krakatoa in the months following the disaster help us to realize that what we regard as the surface of the Earth is less a geological structure than a living mantle. Our planet would be drab and dusty, an ever-changing stage.

Krakatoa remained a desolate landscape for a long time after the 1883 volcanic explosion. But progressively the wind and the sea brought back to its sterilized surface a multiplicity of living things, some of which managed to establish a permanent foothold on the lava. Today, the island harbours once more a rich flora and fauna, not qualitatively different from the rest of the living world or that of the native forest of the Malay archipelago.

There is a paradox in the marvelous resiliency of nature. On the one hand, all individual forms of life are extremely delicate. And yet life itself has been capable of prevailing over brute physical forces for several billion years, and has generated immensely diversified ecosystems that have remained viable even under the most inhospitable conditions. Life probably emerged from inanimate matter, but it is now more powerful than inanimate matter.

All biological phenomena are of practical importance because they determine the characteristics of the Earth's surface and therefore affect the quality of human life. Men have always been concerned with the contributions that living things make to their immediate environment and to the global economy; they have wondered how the flora and fauna become more or less stabilized under normal conditions, and manage to reestablish stable ecosystems after cataclysms; in our times they worry to what extent living things can be disturbed or eliminated by urbanization and industrialization without thereby threatening human welfare.

But the phrase "life on Earth" also raises other questions of a more philosophical character, questions that have been in the minds of humble, uneducated people even before they became the preoccupation of scholars. In the universe at large, lifelessness is the rule, life the puzzling exception. How do living things differ from inanimate matter? How did they originate? And can life be created de novo? Is man qualitatively different from the rest of the living world or merely a higher, or the highest, specimen in its evolution, the paragon of animals?

It is clear from the geological record that life has been at home on the Earth for immense periods of time. The types of fossils found in rock formations indicate that all major groups of animals and plants were already represented by recognizable ancestors some 400,000,000 years ago. Furthermore, microscopic structures closely related to the present forms of blue-green algae have been found in geologic formations that are even very much older—some 3,000,000,000 years old. Since these fossils of algae-like organisms have a complex cellular organization, it can be assumed that they had been preceded by simpler forms, and that the origin of life is more ancient than the oldest traces of it which have been detected. In fact, there is no way to know when life first appeared on Earth, because its earliest manifestations were certainly so minute, fragile, and undifferentiated that none of them have survived as fossils.

There is a peculiar fascination to the phrase "the origin of life" because it means different things to different men, and reaches into the deepest layers of their beliefs. For the religious man, it implies the mysteries of divine creation—whether expressed as biological species in their final forms, or as the potentialities posited by Aristotelian philosophers and medieval theologians. For the student of myths, it evokes Aphrodite emerging fully developed from the foam of the sea. The myth may have a factual basis if it is true, as it is commonly believed, that the cradle of life was to be found in the primitive oceans. For the modern scientist the phrase "origin of life" refers to the kind of chemical reactions that first generated complex organic molecules and assembled them in such a manner that they could duplicate themselves—thus converting inanimate matter into living substance.

Whatever the mystical or rational basis of a person's beliefs, there is a universal poetic quality in the thought that life once arose from matter, and has been perpetuating itself ever since. But the only real clue to the origin of life is
that all its forms—at least all the living things we know—have many physicochemical characteristics in common. In particular, they all transfer their hereditary endowment from one generation to the next through the agency of a peculiar kind of molecule known as nucleic acid, the now famous DNA. This uniformity of fundamental structure holds true irrespective of the size, shape, and complexity of the organism—whether it be microbe, plant, animal, or man. Indeed, the similarity in structure of the genetic apparatus throughout the living world is so perfect that it cannot possibly be a matter of chance. The conclusion seems inescapable that all the living forms that now exist have had a common origin.

The simplest hypothesis to account for the origin and evolution of life is that all biological phenomena are caused by the physicochemical forces that govern the inanimate world. Some scientists believe, indeed, that there is nothing very unusual in the emergence of a living molecule from matter. According to them, it is probable that life repeatedly emerged \textit{de novo} on Earth and that it is still emerging today somewhere in the cosmos. By making the reasonable assumption that one of the living forms that appeared on Earth proved more vigorous than the others, it is easy to account for the single origin of all surviving species. If an entirely new genetic form of life were to appear today on Earth, it would have no chance of success, because it could not compete with the established form and all its variations.

The hypothesis that life is nothing more than a special manifestation of ordinary physicochemical forces has the merit of being economical of thought; in addition, it is supported by the fact that all biological phenomena go hand in hand with the kind of reactions observed in the inanimate world. But even if we grant that living phenomena always obey physicochemical laws, this does not constitute decisive evidence that life is merely an expression of these laws. Other theories are conceivable. One of them, rarely voiced because it is not scientifically fashionable, is that some unknown principle runs like a continuous thread through all living forms and governs the organizations of their physicochemical processes. The illustrious Danish physicist Niels Bohr, for example, suggested that “the very existence of life must be considered an elementary fact, just as in atomic physics the existence of a quantum of action has to be taken as a basic fact that cannot be derived from ordinary mechanical physics.”

Uncertainties concerning the fundamental nature of life and its origin would disappear if it were possible to generate at will self-reproducing molecules from inert material. Some experimental findings have recently been quoted as evidence of this possibility.

A fully developed virus, which had been naturally produced by a living organism, was separated into its component parts by chemical procedures. When these separate parts were tested for biological activity, they were found to be inert, that is, they were unable to multiply in a susceptible organism. This biological activity was restored, however, when the parts of the virus were chemically reassembled in the test tube under the proper conditions. Spectacular as this achievement is from the chemical point of view, it does not constitute—as has been claimed—the production of life \textit{de novo}. Since the virus first had to be produced by a living organism, and since its reassembled parts showed activity only when introduced into a living susceptible organism, all the biological machinery essential for its reproduction had to be provided by preexisting life.

In a completely unrelated kind of experiment, several complex molecules similar to those found in living things have been produced in the laboratory by exposing simple chemicals to the kind of radiation that probably existed in the primitive atmosphere. But this chemical feat does not constitute production of life \textit{de novo} because the molecules so produced have not been assembled—organized—in a way enabling them to duplicate themselves and to develop. An organic molecule, however complex and similar to the kind found in living things, still belongs to the realm of inanimate matter if it cannot reproduce and evolve.

To become “living,” an assembly of biogenic molecules must contain the information needed for its further development and must be able to transmit this information to its progeny. Even in its simplest manifestations, life is historical; it embodies the past and carries instructions for the future.

More than a century ago, the French physiologist Claude Bernard gave a clear formulation of the now classical view that the earmark of a living thing is not the chemical composition of its parts but their organization. He wrote: “Admitting that vital phenomena rest upon physicochemical activities, which is the truth, the essence of the problem is not thereby cleared up; for it is no chance encounter of physico-chemical phenomena which constructs each being according to a preexisting plan, and produces the admirable subordination and the harmonious concert of organic activity.

“There is an arrangement in the living being, a kind of regulated activity, which must never be neglected, because it is in truth the most striking characteristic of living beings...”

In this celebrated passage, Bernard used the word “arrangement” to denote the interdependence and integration of the structures and properties of any given living organism. But biological organization applies also to the ecological system of which the organism is a part. All living things, without exception, depend on other living things for their survival and development. Furthermore, the higher the organism is on the evolutionary scale, the more exacting is its dependence on a complex web of life.

One of the major trends of evolution has thus been the emergence of more and more complex ecosystems, exhibiting high degrees of integration. But, paradoxically, an opposite trend can also be detected as one ascends the evolutionary scale—namely, a trend toward freedom or at least toward increasing independence of the individual organism within the constraints of the ecosystem. Freedom becomes more and more apparent as one proceeds from the protoplasmic jelly of biological beginnings to warm-blooded animals roaming in the wild, and finally to man who modifies his environment according to his views of the future. In a real way, evolutionary development is associated with the gradual insertion of more and more freedom into matter and into individual lives.

In the \textit{Outline of Knowledge}, Part Three, concerned with life on Earth, is placed between Parts Two and Four, concerned, respectively, with the Earth itself and
with human life. This positioning is reasonable enough, but one could read into it an assumption that reaches far deeper than the logical ordering of concepts and facts. The tacit assumption is that human life has emerged from the inanimate matter of the Earth through the same kind of evolutionary continuum that links all the other living forms in a great chain of being. In reality, however, the theory of evolution does not provide decisive evidence for this assumption. What is known of biological evolution applies only to the anatomical structures and physiological functions of organisms that have lived in the past or are living now. The successive steps from matter to life, and from life to consciousness, have not yet been shown to have taken place through the kind of mechanisms that account for the evolutionary changes of anatomical structures of physiological functions. There exists a continuum from one form of life to another, but extending this continuum to inanimate matter on the one hand, and to human consciousness on the other, is a matter of faith rather than of scientific knowledge.

Even the most cursory observation of nature reveals that all living forms are conditioned by environmental forces, and that reciprocally they shape the environment, thereby contributing to the triumph of life. But it must be realized that the word "life" encompasses different kinds of relations to nature. At its lowest level, "life" implies, as mentioned above, the deterministic and blind chemical reactions through which an organism—simple or complex as it may be—transmits its distinctive characteristics to its descendants and reacts adaptively to its environment. At its highest, "life" involves man's consciousness and free will and refers to the deep reality of the world within and the affirmation of the individual self, irrespective of the external world.

There is no way at present to link these two extreme and apparently incompatible manifestations of life—biological determinism and human freedom. Yet both are real, and both have been immensely influential in giving the present characteristics to our planet.

The surface of the Earth reflects the activities of countless living things. Even though these operate chiefly through blind, deterministic mechanisms, life introduces on Earth a degree of order, organization, and diversity not found anywhere else in the cosmos, not even in the movement of the celestial bodies. Man emerged, not on the bare planet, but in this orderly and diversified biological world. As soon as he achieved his identity as Homo sapiens, he began to insert his free will into ecological determinism. For good or evil, he has now become the most powerful influence in changing the face of the globe. His conscious choices will determine not only his own fate, but also the fate of life on Earth.
Part Three. Life on Earth

Several points about the relations of Part Three to other parts should be noted. The separation of Part Three from Part One, on matter and energy, and from Part Two, on the Earth, reflects a traditional division of labour among the natural sciences. However, the separation is not rigid. The borderline disciplines of biophysics and biochemistry appear throughout Part Three, especially in Division II, concerned with the molecular basis of vital processes. The effects of the Earth's atmosphere and hydrosphere on living things are reflected throughout Part Three, especially in Division V, which is concerned with the biosphere and with ecosystems.

Some fundamental biological knowledge of humans is involved in the treatment throughout Part Three of what is common to all life and to all animals. And Section 355, the last section of Part Three, deals with mankind's place and activities in the biosphere. However, what is specific to human life, human health, and human behaviour is separately dealt with in Part Four, on human life.

The biological sciences have themselves been the object of historical and analytical studies. Such studies are dealt with in Section 10/34 in Part Ten, which treats the historical development of the biological sciences; the methodology, scope, and conceptual structure of biology as a whole; and the several component disciplines at the different levels of biological research.

The design and operation of observational and experimental instruments are important in the development of the biological sciences. Such scientific instrumentation is dealt with in Section 723 of Part Seven.

Division I. The Nature and Diversity of Living Things

The outlines in the three sections of Division I deal with the nature, the origin and evolution, and the classification of living things.

Section 311. Characteristics of Living Things

A. The concept of life on Earth
   1. Properties of life
      a. Order and form
      b. Metabolism: catabolism and anabolism
      c. Sensory reception
      d. Reproduction, growth, and development
      e. Interaction with the environment
   2. Levels of biotic organization
      a. Molecular: polymers, carbohydrates, lipids, proteins, and nucleic acids
      b. Cellular: procaryotic cells and eucaryotic cells
      c. Organ: tissues, tissue systems, and the whole organism
      d. Population: species and communities

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B. Life beyond the Earth
   1. The concept of extraterrestrial life and its chemistry
   2. The significance of the search for life beyond Earth
   3. Exobiological survey of the solar system: physical environments and biological prospects

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with the characteristics of living things
- Animals
- Bacteria and Other Monerans
- Behaviour, Animal
- Biological Sciences, The
- Biosphere, The
- Cells: Their Structures and Functions
- Coloration, Biological
- Evolution, The Theory of
- Fungi
- Genetics and Heredity, The Principles of

**MICROPAEDIA**: Selected entries of reference information
- apoptosis
- cell
- evolution
- homeostasis
- life
- metabolism
- life cycle

**Biographies**
See Section 10/34 of Part Ten

**INDEX**: See entries under all of the terms above

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**Section 312. The Origin of Life and the Evolution of Living Things**

A. Stages in the emergence of life
   1. Hypotheses about the origin of life
   2. Steps in the production of chemical precursors of life
      a. Formation of the Earth’s primitive reducing atmosphere
      b. Production of simple organic molecules
      c. Production of long-chain molecules consisting of repeating units
      d. Origin of the genetic code
   3. The earliest living systems
      a. Evolution of enzymatic reaction chains
      b. Origin of procaryotic and eucaryotic cells
      c. Evolution of photosynthesis
   4. The antiquity of life: evidence of biological activity in the geological record
      [see also 242 and 243]

B. The theory of evolution
   1. The history of evolutionary theory
      a. Lamarck’s contribution
      b. Darwin’s theory of natural selection
      c. Mendel’s theory of heredity
      d. The synthetic theory of evolution
      e. Molecular and genetic studies
2. The evidence for evolution
   a. The fossil record of gradual change
   b. Structural similarities (homologies) of different species
   c. Vestiges of ancestral forms in embryonic development
   d. Molecular clues to evolutionary history

C. The process of evolution
   1. Genetic variation through gene or chromosomal mutation
   2. Changes in gene frequencies within a population through gene mutation, gene migration, and genetic drift
   3. Natural selection
      a. Adaptation and fitness
      b. Aspects of the process of natural selection: coloration; mimicry; polymorphism
      c. Natural selection in the process of genetic change
      d. Types of selection: stabilizing, directional, diversifying, sexual, and kin

D. The origin of species and the process of speciation
   1. The distinctiveness of species
   2. The criterion of reproductive isolation
   3. The properties of species
   4. Modes of speciation (e.g., geographic speciation, adaptive radiation, quantum speciation)
   5. Genetic differentiation during speciation
   6. Patterns and rates of species evolution
      a. The topology (or configuration) of phylogenies
      b. The rate of morphological change: gradual or punctuational evolution
      c. Molecular evolution
   7. The relationship between species and other taxonomic categories: family, order, class, phylum

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles and a biography dealing with the origin of life and the evolution of living things
- Coloration, Biological
- Darwin
- Evolution, Human
- Evolution, The Theory of
- Mimicry

**MICROPAEDIA:** Selected entries of reference information

**General subjects**
- adaptation
- aggressive mimicry
- analogy
- auxochrome
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- carotene
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**Biographies**
- See Section 10/34 of Part Ten

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B. Monerans: bacteria and other prokaryotes

C. Protists
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   2. Protozoans
   3. Slime molds

D. Fungi

E. Plants
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      b. Liverworts
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   2. Psilotophytes, or whisk ferns
   3. Lycophytes (club mosses and allies)
   4. Sphenophytes, or horsetails
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      a. Ophioglossopsids
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      b. Hyalospongiaens
      c. Demospongiaens
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   4. Cnidarians, or coelenterates
      a. Anthozoans (corals; sea anemones; sea fans and sea whips; sea pens and sea pansies)
      b. Scyphozoans (jellyfish)
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   5. Ctenophores, or comb jellies
   6. Platyhelminthes, or flatworms
      a. Turbellarians
Division I. Section 313

b. Monogeneans
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7. Nemerteans, or ribbon worms
8. Acanthocephalans, or spiny-headed worms
9. Aschelminthes
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   b. Gastrotrichs
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d. Nematodes, or roundworms
e. Nematomorphs, or horsehair worms
10. Priapulids
11. Annelid worms
   a. Polychaetes, or marine worms
   b. Oligochaetes, or terrestrial worms
   c. Hirudineans, or leeches
12. Tardigrades, or water bears
13. Onychophorans, or velvet worms
14. Arthropods
   a. Crustaceans
   b. Uniramians (millipedes, centipedes, pauropods, symphylans, and insects)
c. Chelicerates (sea spiders, horseshoe crabs, and arachnids)
15. Mollusks
   a. Tryblids, or neopilinids
   b. Solenogastres, or narrow-footed gliders
c. Caudofoveatans, or mudmoles
d. Placophorans, or chitons
e. Pelecypods, or bivalves (clams, mussels, oysters, scallops, and cockles)
f. Scaphopods, or tusk shells
g. Gastropods (limpets, snails, and slugs)
h. Cephalopods (nautiluses; cuttlefishes, squids, and octopuses)
16. Bryozoans, or moss animals
   a. Phylactolaemates
   b. Stenolaemates
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18. Brachiopods, or lamp shells
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19. Sipunculid worms, or peanutworms
20. Chaetognaths, or arrowworms
21. Echiurids, or spoonworms
22. Echinoderms
   a. Crinozoans, or sea lilies
   b. Echinozoans (sea urchins, heart urchins, and sand dollars; sea cucumbers)
c. Asterozoans (starfish, brittle stars, and sea daisies)
23. Hemichordates
   a. Enteropneusts, or acorn worms
   b. Pterobranchs
24. Pogonophors, or beardworms
25. Chordates
   a. Tunicates (sea squirts, appendicularians, and thaliaceans)
   b. Cephalochordates, or lancelets
   c. Vertebrates (hagfishes and lampreys; placoderms; sharks,skates,and rays; bony fishes; amphibians; reptiles; birds; mammals)

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with the classification of living things

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**MICROPAEDIA**: Selected entries of reference information

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<td>Capparales</td>
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<td>cauliflower</td>
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<td>charlock</td>
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<td>Chinese cabbage</td>
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collard
cress
kale
Kerguelen cabbage
kohlrabi
marsh cress
mustard
peppergrass
radish
rape
rock cress
rocket
spiderflower
stock
toothwort
turnip
wallflower
whitlow grass
angiosperms—
composite order:
artichoke
Asteraceae
basket-flower
boneset
chamomile
Chrysanthemum
cineraria
coneflower
dandelion
dogwood order:
dandelion
endive
fleabane
goldenrod
groundsel
guayule
Jerusalem
artichoke
lettuce
marigold
pussy-toes
safflower
sunflower
thistle
zinna
angiosperms—
dogwood order:
angelica
anise
Apiaceae
Araliaceae
carrot
Cornales
cow parsnip
dogwood
fatia
ivy
parsnip
poison hemlock
schefflera
tupelo
angiosperms—ebony
and primrose orders:
Bumelia
Ebenales
ebony
persimmon
pimpernel
primrose
Primulales
sapodilla
stax
angiosperms—
euphorbia order:
boxwood
Buxaceae
cassava
castor-oil plant
copperleaf
croton
crown of thorns
Euphorbiaceae
Euphorbias
jatropha
jojoba
manchineel
mercury
Omphalea
Phyllanthus
poinsettia
redbird cactus
sandbox tree
spurge
tung tree
angiosperms—figwort
order:
Acanthaceae
ash
belladonna
Bignoniaceae
bladderwort
bromerape
eggplant
figwort
forsythia
foxglove
Gesneriaceae
henbane
Indian paint brush
jacaranda
jasmine
lilac
mullein
nightshade
Oleaceae
olive
petunia
potato
privet
sausage tree
Scrophulariales
Solanaeae
tea olive
toadflax
tobacco
tomato
witchweed
angiosperms—gentian order:
Apocynaceae
Asclepiadaceae
bedstraw
buckbean
carnation flower
coffee
Gentianales
Indian hemp
Loganiaceae
madder
oleander
partridgeberry
periwinkle
Rubiaeae
angiosperms—
geranium order:
Barbados cherry
flax
Geraniaceae
geranium
Impatiens
lignum vitae
nasturtium
Oxalis
shamrock
wild sorrel
angiosperms—ginger
order:
abaca
arrowroot
banana
bird-of-paradise
flower
Cannaceae
ginger
ginger lily
Marantaceae
Musaceae
plantain
prayer plant
Strelitziaceae
Zingiberaceae
Zingiberales
angiosperms—grass
families:
agrostology
Arundinaria
bamboo
darey
beach grass
bent grass
bluegrass
bluestem
bromegrass
cordgrass
corn
crabgrass
esparto
fescue
foxtail
gras
love grass
millet
muhly
needlegrass
oat grass
oats
panicum
Paspalum
Pennisetum
Poaceae
quack grass
reed
Restionales
rice
rye
ryegrass
sorghum
sugarcane
wheat
wheat
angiosperms—heath
order:
Arbutus
azalea
bilberry
blueberry
Clethra
cranberry
crowberry
Ericaales
gaultheria
heath
heather
huckleberry
Indian pipe
kalma
kiwi
Labrador
tea
leatherleaf
Lyonia
Pieris
pipsissewa
rhododendron
Vaccinium
wintergreen
angiosperms—laurel
order:
avocado
California laurel
greenheart
lambkill
Laureales
laurel
sassafras
sweet shrub
angiosperms—lily
and iris orders:
Agavaceae
Alliaceae
Amaryllidaceae
Asparagus
Part Three. Life on Earth

asphodel
bear grass
bellwort
blue-eyed grass
cantala
chive
Colchicum
Crocus
Dioscoreaceae
Dracaena
elephant’s-foot
Erythronium
fritillary
garlic
Gladiolus
henequen
Iridaceae
Iris
leek
Liliaceae
Lilium
lily
mariposa lily
Mauritius hemp
narcissus
onion
phormium
pickereleweed
Sansevieria
Smilax
ti
tulip
water hyacinth
yam
angiosperms—magnolia order:
Annonaceae
champac
cherimoya
lancewood
magnolia
Magnoliaceae
Magnoliales
Myristicaceae
pawpaw
tulip tree
Winteraceae
ylang-ylang
angiosperms—mallow order:
Abutilon
balsa
baobab
Bombacaceae
cacao
cotton
durian
hibiscus
jute
kapok
kenaf
linden
mallow
Malvaceae
Malvales
okra
roselle
sidal
Sterculiaceae
Tiliaceae
urena
angiosperms—orchid order:
bucket orchid
cattleya
Dendrobium
 Epidendrum
 greenhood
 helioborne
 jewel orchid
 ladies’ tresses
 lady’s slipper
 Odontoglossum
 Oncidium
 Ophrys
 orchid
 Orchis
 Pogonia
twayblade
Vanda
vanilla
angiosperms—palm
and related orders:
Anthurium
Arales
Areceae
Arisaema
Arum
babassu palm
calla
coco de mer
coconut palm
Cyclanthales
date palm
dumb cane
oil palm
palm
Pandanales
Philodendron
skunk cabbage
Typhales
angiosperms—pea order:
acacia
Albizia
bean
bluebonnet
broom
chick-pea
Clanthus
clover
cowpea
crown vetch
Fabales
honey locust
indigo
kudzu vine
laburnum
lentil
lespedeza
locoweed
locust
logwood
mesquite
mimosa
narra
pagoda tree
palo verde
pea
peanut
redbud
rosewood
semma
sensitive plant
smoke tree
soybean
sunn
vetiv
Wisteria
angiosperms—pepper
and birthwort
orders:
birthwort
Peperomia
Piperaceae
Piperales
wild ginger
angiosperms—phlox
order:
alkanet
bindweed
borage
Boraginaceae
bugloss
Convulvulaceae
dodder
forget-me-not
Hydrophyllaceae
Ipomoea
Lancoolaceae
Loasaceae
Mertensia
phlox
Polemoniaceae
Rivea
sweet potato
waterleaf
angiosperms—pomegranate and related orders:
Aechmea
Bromeliaceae
Commelinaceae
Cryptanthus
Dyckia
Ericaulales
Juncales
papycus
pineapple
Puya
Spanish moss
spiderwort
Tillandsia
umbrella plant
Zebrina

angiosperms—pink order:
Amaranthaceae
baby’s breath
beet
Bougainvillea
cactus
campion
carnation
Caryophyllaceae
Caryophyllales
Celosia
card
chickweed
goosefoot
Haloegeton
Lychnis
Nyctaginaceae
pigweed
pink
poke
Portulacaceae
purslane
spinach
sugar beet

angiosperms—poppy order:
blooming heart
bloodroot
bush poppy
California poppy
celandine
Corydalis
Fumariaeae
fumitory
horned poppy
Hypecoaceae
Papaveraceae
Papaverales
poppy
prickly poppy

angiosperms—rose order:
almond
Amelanchier
apple
apricot
Astilbe
blackberry
boysenberry
cherry
chokecherry
cinquefoil
Connaraeae
cotoneaster
crab apple
current
Echeveria
firethorn
gooseberry
hawthorn

houseleek
hydrangea
kalanchoe
loganberry
loquat
medlar
nectarine
peach
pear
Pittosporaceae
plum
prunus
rose
Saxifragaceae
sedum
spirea
strawberry
sweetbrier
angiosperms—sandalwood order:
Australian
Christmas tree
Balanophoraceae
broad toothed
dwarf mistletoe
Loranthaceae
mistletoe
sandalwood
Santalaceae
Santalales
Viscaceae

angiosperms—soapberry order:
Aceraceae
ake
Anacardiaceae
bel fruit
box elder
buckeye
Burseraceae
cashew
citron
grapefruit
guarana
horse chestnut
kumquat
lemon
lime
litchi
mahogany
mango
maple
Melaceae
orange
pili nut
Pistacia
poison ivy
red maple
Rhus
Rutaceae
Simaroubaceae
Sapindales
shaddock
silver maple
Simaroubaceae
tree of heaven

angiosperms—staff-tree and buckthorn orders:
Alder buckthorn
bittersweet
buckthorn
Ceanothus
Celastraceae
celastrales
Euonymus
holy
jujube
Rhamnales
Vitaceae

angiosperms—tamarisk order:
boojum tree
calamita
Tamaricales

angiosperms—tea order:
Camellia
Clusiaceae
Dipterocarpaceae
Elaeocarpaceae
franklinia
gordonia
mammee apple
mangosteen
Ochnaceae
Saint-John’s-wort
stewartia
Theaceae
Theales

angiosperms—teasel order:
Caprifoliaceae
caprifoliaceae
campanulata
cinnamon
cistle
clerodendron
cotoneaster
cotoneaster

angiosperms—violet and related orders:
begonia
bottle gourd
brynosa

cucumber
Cucurbitaceae
dishdoff gourd
Flacourtiaceae
gourd
melon
pansy
papaya
Passifloraceae
passion-flower
pumpkin
rock rose
squash
sun rose
Viola
Violales
watermelon

angiosperms—walnut order:
butternut
hickory
Juglandales
pecan
walnut

angiosperms—water lily order:
fanwort
Nelumbonaceae
Nymphaeales
water lily
water shield

angiosperms—water plantain and related orders:
Alismatales
arrowhead
Elodea
Hydrocharitales
Najadales
pondweed
water plantain

angiosperms—witch-hazel and related orders:
Casuarinales
Didymelales
Fumariaceae
Fothergilia
Hamamelidaceae
Hamamelidae
Hamamelidales
katsura tree
Myrica
plane tree
sweet gum
Trochodendrales
winter hazel

angiosperms—other:
Alismatidae
aspen
Barbeya
buckwheat
buffalo berry
burning bush
carnivorous plant
cobra plant
Commeliniidae
Cyperaceae
Cyperales
Daphne
Diapensiales
dicotyledon
Dilleniales
Dilleniidae
everlasting
Haloragales
hardwood
Illiciales
Leitneriales
lotus
macadamia
Magnoliidae
monocotyledon
Nepenthales
Nepenthes
Paeoniaceae
peony
pitcher plant
Plumbaginaceae
Podostemales
Polygalales
Polyonales
poplar
Proteaales
Rafflesiaceae
rhubarb
Rosidae
Salicales
Sarraceniaceae
Solanales
sundew
taro
Theligonales
Thymelaeales
Triuridales
Venus’s-flytrap
wild flower
willow
arthropods—
archnids:
arachnid
black widow
brown spider
chigger
crab spider
daddy longlegs
false scorpion
funnel weaver
funnel-web spider
garden spider
jumping spider
mite
nursery-web spider
red spider
scorpion
silk spider
spider
sunspider
tarantula
tick
trap-door spider
whip scorpion
wolf spider
arthropods—
wastebasket:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
arthropods—other:
bacteria:
actinomycete
archaeabacterium
bacillus
bacterium
blue-green algae
Clostridium
denitrifying
bacteria
epsome
eubacterium
gliding bacterium
gram stain
Haemophilus
Lactobacillus
Micrococcus
mycoplasma
Pasteurella
pneumococcus
psuedomonad
ricketta
Salmonella
sheathed bacteria
spirillum
spirochete
Staphylococcus
streptococcus
streptomycetes
sulfur bacterium
vibrio
birds—charadriiform
order:
auk
auklet
avoet
charadriiform
courser
curlew
dotterel
dowitcher
godwit
great auk
greenshank
guilemot
gul
jacana
jaeger
killdeer
knot
lapwing
murre
murrelet
oystercatcher
painted snipe
phalarope
plover
pratincole
puffin
redshank
ruff
sandpiper
seedsnipe
sheathbill
skimmer
skua
snipe
stilt
surfbird
Division I. Section 3

birds—extinct:  
Aepyornis
Archaeopteryx
Diatryma
Hesperornis
Ichthyornis

birds—passeriform order:  
accentor
Aegithalidae
antbird
beard
bell-magpie
bellbird
bird-of-paradise
bishop
blackbird
Bombicillidae
bowerbird
broadbill
buffalo weaver
bulbul
bunting
butcherbird
Callaeidae
canary
Carduelidae
cathbird
Certhiidae
chat
chat-thrush
cough
cisticola
cock-of-the-rock
cordon bleu
Cotingidae
creeper
crow
cuckoo-shrike
currawong
Dendrocolaptidae
dipper
drongo
Emberizidae
Estrildidae
fairly bluebird
false sunbird
fantail
flowerpecker
flycatcher
forktail
Furnariidae
Galapagos finch
gnatcatcher
goldfinch
grackle
Grallinidae
grossbeak
green buttongrass
ground thrush
helmet-shrike
Hirundinidae
honeyeater
house sparrow
hypocoly
Icteridae
Irenidae
jay
kingbird
kinglet
kiskadee
lark
laughing thrush
Leiothrix
lyrebird
magpie
maggie-robin
manakin
mannikin
martin
meadowlark
Mimidae
mockingbird
monarch
Musicapidae
mynah
Nectariniidae
nightingale
nightingale thrush
nuthatch
oriole
oropendola
ovenbird
Panuridae
Paridae
Parulidae
pesse
Philepittidae
phoebe
ppit
pitta
Ploceidae
prinia
queue
raven
redstart
Remizidae
robin
rockfowl
rosefinch
scrub-bird
seedeater
sharpbill
shrike
shrike-vireo
silky flycatcher
song-babbler
songbird
sparrow
starling
Sturnidae
sunbird
swallow
Sylviidae
tailorbird
tanager
tapaculo
thickhead
thrush

birds—columbiform and psittaciform orders:  
bristlehead
cockatoo
columbiform
cunure
dodo
domestic pigeon
lovebird
macaw
parakeet
parrot
passenger pigeon
pigeon
psittaciform
sandgrouse
turtledove
wood pigeon

birds—coraciiform and piciform orders:  
barbet
coraciiform
flicker
honey guide
hornbill
ivory-billed
woodpecker
jacamar
kingfisher
kookaburra
motmot
piciform
piculet
puffbird
roller
sapsucker
toucan
woodpecker

birds—cuculiform and owl orders:  
ani
barn owl
coucal
cuckoo
cuculiform
eagle owl
fish owl
ground cuckoo
hawk owl
horned owl
owl
roadrunner
screech owl
short-eared owl
turaco
wood owl
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tit
tityra
towhee
treecreeper
Turdidae
tyrannulet
tyrian flycatcher
umbrellabird
vanga-shrike
vireo
wagtail
warbler
wattle-eye
waxbill
waxwing
weaver
white-eye
whydah
woodcreeder
woodswallow
woodwarbler
wren
Xenicidae

birds—others:
albatross
aviary
aviculature
bird
bittern
booby
 cassowary
casuariiform
ciconiform
coly
Columbiformes
cormorant
diving petrel
egret
emu
flamingo
frigate bird
fulmar
gannet
grebe
hammerhead
heron
ibis
kiwi
loon
moa
ornithology
ostrich
pelecaniform
pelican
penguin
petrel
plumage
prion
procellariiform
rhea
shearwater
shoebill
snakebird

spoonbill
stork
storm petrel
syrix
tinamou
trogon

tropic bird

bryophytes:
bryophyte
bug-on-a-stick
carpet moss
cord moss
cushion moss
granite moss
hair-cap moss
hornwort
leafy liverwort
liverwort
luminous moss
Marchantia
mass
peat moss
tree moss
wind-blown moss
classification:
nomenclature
taximetrics
taxon
taxonomy
tunicata:
acorn worm
amphioxus
arrowworm
beardworm
bèche-de-mer
blastoid
brittle star
cake urchin
carpoid
chordate
crinoid
crown-of-thorns
starfish
echinoderm
echinoid
graptolite
heart urchin
hemichordate
prochordate
pterobranch
sand dollar
sea cucumber
sea lily
sea squirt
sea urchin
starfish
tunicate
fishes—atheriniform
and related orders:
atheriniform
dealfish
dory

fryunion
killifish
lantern-eye fish
live-bearer
molly
oarfish
silversides
spiny-finned
fish

gasterosteiiform order:
corntfish
gasterosteiiform
pipefish
sea horse
shrimpfish
stickleback
swamp eel
trumpet fish

fryes—jawless fish
and placoderms:
Agnatha
antiarch
Arctolepis
arthrodire
Bothriolepis
Cephalaspis
hagfish
lamprey
ostrocoderm
Palaeospondylus
placoderm
spiny shark

fryes—pericorm
order:
angelfish
archer fish
barracuda
bass
bigeye
black bass
blenny
bluegill
bonito
butterfish
butterly fish
caranig
chichlid
crappie
damselshf
darter

dace
electric catfish
electric eel
goldfish
hatchetfish
knifefish
labeo
loach
madtom
minnow
ostariophysan
pencil fish
piranha
roach
sucker
tench
tetra
tigerfish
wels
zebra fish

bryophytes:
bryophyte
bug-on-a-stick
carpet moss
cord moss
cushion moss
granite moss
hair-cap moss
hornwort
leafy liverwort
liverwort
luminous moss
Marchantia
mass
peat moss
tree moss
wind-blown moss
classification:
nomenclature
taximetrics
taxon
taxonomy
tunicata:
Division I. Section 313

fishes—salmoniform order:
- Atlantic salmon
- bristlemouth
- brook trout
- brown trout
- capelin
- char
- coho
- hatchetfish
- king salmon
- lake trout
- mudminnow
- pike
- rainbow trout
- salmon
- salmoniform
- sandfish
- scaleless dragonfish
- smelt
- spookfish
- trout
- viperfish
- whitefish

fishes—scorpaeniform and related orders:
- dragonfish
- flathead
- flying gurnard
- greenling
- lion-fish
- lump sucker
- poacher
- redfish
- scorpaeniform
- scorpionfish
- sculpin
- sea robin
- snailfish
- stonefish
- zebra fish

insects—coleopteran order:
- alfalfa weevil
- bark beetle
- beetle
- bess beetle
- billbug
- blisters beetle
- boll weevil
- branch and twig borer
- carrion beetle
- casebearing beetle
- chafer
- checkered beetle
- click beetle
- coleopteran
- Colorado potato beetle
- cucumber beetle
- darkling beetle
- dermestid beetle
- firefly
- flat bark beetle
- flea beetle
- glowworm
- ground beetle
- ladybird beetle
- leaf-rolling weevil
- long-horned beetle

and tetraodontiform orders:
- boxfish
- dab
- pleuronectiform
- deep-sea fish
- Dipterus
eel
elopiform
Eusthenopteron
fish
gar
gulper
herring
holostean
ladyfish
lungfish
menhaden
moray
mormyrid
notopterid
osteoglossomorph
paddlefish
Rhipidistia
sardine
shad
sturgeon
tarpon
teleost
wolf herring

fungi:
- Agaricales
- Amanita
- Armillaria
- Ascomycetes
- Basidiomycetes
- Boletaceae
- cup fungus
- Deuteromycetes
- fungus
- Lycoperdales
- mushroom
- mycorrhiza
- Oomycetes
- Polyporales
- stinkhorn
- yeast
- Zygomycetes

gymnosperms:
- alerce
- American arborvitae
- Araucaria
- arborvitae
- bald cypress
- big tree
- California nutmeg
cedar
conifer
Cordaitales
Cupressales
cycad
Cycadeoidales
Cycas
cypress
cypress pine
metallic
wood-boring
beetle
plum curculio
potato beetle
predaceous
diving beetle
primitive weevil
rhinoceros beetle
rove beetle
scarab beetle
seed beetle
soldier beetle
spider beetle
stag beetle
strepisipteran
tiger beetle
tortoise beetle
tumbling flower
beetle
unicorn beetle
water scavenger
beetle
weevil
whirling beetle
insects — fly order:
anthomyiid fly
bee fly
biting midge
black fly
blow fly
bot fly
crane fly
dipteran
flesh fly
fly
fruit fly
fungus gnat
gall midge
Hessian fly
horse fly
housefly
hover fly
leaf miner
louse fly
midge
mosquito
robber fly
tachinid fly
tsetse fly
vinegar fly
warble fly
insects — hymenopteran order:
ant
Apocrita
beetle
braconid
bumblebee
chalcid
cuckoo wasp
fig wasp
gall wasp
honey ant
honeybee
hornet
hymenopteran
ichneumon
leaf-cutter bee
sand wasp
crawly
spider wasp
Symphyta
thread-waisted
wasp
velvet ant
wasp
wood wasp
tussock moth
white butterfly
yucca moth
zebra swallowtail
butterfly
insects — others:
elderly
ambush bug
ant lion
aphid
apterygote
assassin bug
back swimmer
bedbug
bristletail
bug
burrower bug
caddisfly
chewing louse
chin ch bug
cicada
cockroach
cone-headed
garden
coreid bug
cottony-cushion scale
cricket
dipluran
dobsonfly
dragonfly
earwig
ephemeropteran
flea
flower bug
frog hopper
giant water bug
grape phylloxera
gardener
harlequin
cabbage bug
heteropteran
cabbage bug
human louse
jumping plant
loose
katydid
lace bug
lace wing
leaf insect
leaf hopper
locust
long-horned
gardener
louse
lygaid bug
mantis
mantid
mantispid
marsh treater
mayfly
meadow
grasshopper
mealy bug
mole cricket
neuroptirant
odore
orthopteran
plant bug
proturan
psocid
pygmy grasshopper
red bug
San Jose scale
scale insect
scorpionfly
shield-backed
katydid
short-horned
grasshopper
smaller water
strider
snakefly
springtail
stinkbug
stonefly
sucking louse
termite
thrips
tree hopper
walking stick
water boatman
water scorpion
water strider
web spinner
whitefly
lophophorates:
Atypa
horseshoe worm
lamp shell
lingulid
moss animal
lower invertebrates:
archaeocyathid
Ascaris
aschelminth
Aurelia
bread crumb
sponge
Cassiopea
Chrysora
clionid
cnidarian
coral
ctenophore
eelworm
entoproct
eye worm
filarial worm
flatworm
fluke
freshwater
tunnelfish
gastrotrich
Gonionemus
guinea worm
horn coral
horny sponge
Hydra
Division I. Section 313

Hydractinia
generouk

giraffe
gnu
goat

guanaco
hartebeest
hippopotamus
ibex
impala
Kobus
kudu
llama
moose

mountain goat
mule deer
muntjac
musk deer
musk-ox
nyala
okapi
oryx
peccary
Père David's deer
pig
pronghorn
red deer
reindeer
roe deer
ruminant
saiga
saxony
sheep
sika
springbok
tahr
vicuña
wapti
warthog
water buffalo
white-tailed deer
yak

mammals—bat order:
bat
brown bat
bulldog bat
disk bat
false vampire bat
free-tailed bat
Hipposideridae
horseshoe bat
Jamaican fruit bat
New Zealand
short-tailed bat
Phyllostomatidae
Pteropodidae
sheath-tailed bat
spear bat
Vespertilionidae

mammals—carnivore order:
aardwolf

African hunting dog
Artic fox
Asiatic black bear
badger
bat-eared fox
bear
bearded seal
binturong
black bear
bobcat
brown bear
bush dog
cacomistle
Caffre cat
canine
caracal
carnivore
cat
cheetah
eivet
cloven-footed leopard
coati
coyote
crab-eater seal
dhole
dingo
dog
elephant seal
ermine
tenrec
tinamou
tiger
typhonus
viper

mammals—cetacean order:
baleen whale
beaked whale
beluga
blue whale
bottlenose whale
cetacean
dolphin
fin whale
grey whale
humpback whale
killer whale
narwhal
pilot whale
porpoise
right whale
sei whale
sperm whale

mammals—extinct:
Barylambda
brontothere
Camelops
cave bear
Chalicotherium
Condylarthra
Coryphodon
Crescocity
dawn horse
Dinohyus
Dryopithecus
Elasmotherium
 Glyptodon
Indricotherium
 Irish elk
 lioptern
 mammoth
 mastodon
 Merychippus
 Miacis
 Mocritherium
 Moropus
 multituberculate
 Notoungulata
 Orohippus
 Phenacodus
 sabre-toothed cat
taeniodont
 Thylacosmilus
titanothere
 Toxodon
 Triconodon
 Uintatherium
 woolly rhinoceros
*mammals—
insectivore and
edentate orders:
anteater
 armadillo
edentate
elephant shrew
golden mole
 hedgehog
 insectivore
 mole
 otter shrew
 short-tailed shrew
 shrew
 sloth
 solenodon
tenrec
*mammals—
 monotremes and
 marsupials:
 bandicoot
cuscus
echidna
glider
 kangaroo
 koala
 marsupial
 marsupial mole
 marsupial mouse
 monotreme
 native cat
 numbat
 opossum
 phalanger
 platypus
 rat kangaroo
 rat opossum
 Tasmanian devil
 Tasmanian wolf
 wallaby
 wombat
*mammals—
 perissodactyl
 order:
 ass
donkey
 equine
 horse
 mule
 perissodactyl
 Przewalski’s horse
 rhinoceros
 tapir
 zebra
*mammals—
 primate
 order:
ap
 avahi
 aye-aye
 baboon
 bonobo
 capuchin monkey
 Celebes black ape
 chimpanzee
 colobus
 diana monkey
drill
 durukuli
 galago
 gelada
 gibbon
 gorilla
 guenon
 hamadryas
 howler monkey
 indri
 langur
 lemur
 loris
 macaque
 mandrill
 mangabe
 marmoset
 monkey
 orangutan
 patas monkey
 potto
 primate
 proboscis monkey
 rhesus monkey
 saki
 siamang
 siíaka
 spider monkey
 squirrel monkey
 tarsier
 titi
 tree shrew
 uakari
 woolly monkey
 woolly spider
 monkey
*mammals—
 rodent
 order:
 agouti
 bamboo rat
 bandicoot rat
 beaver
 cane rat
 capybara
cavy
 chinchilla
 chipmunk
 cloud rat
cotton rat
dormouse
 field mouse
 flying squirrel
gerbil
 gopher
 grasshopper
 mouse
 ground squirrel
 guinea pig
 gundi
 hamster
 harvest mouse
 huitia
 jerboa
 jumping mouse
 kangaroo rat
 lemming
 maned rat
 marmot
 mole rat
 mouse
 muskrat
 nutria
 paca
 pocket mouse
 porcupine
 pouched rat
 prairie dog
 rat
 rice rat
 rock rat
 rodent
 sewel
 spiny rat
 springhare
 squirrel
 tuco-tuco
 viscacha
 vole
 water rat
 white-footed
 mouse
 wood rat
 woodchuck
*mammals—
 others:
aardvark
colugo
dugong
elephant
 hare
 hyrax
 lagomorph
 mammal
 manatee
 pangolin
 pika
 proboscidean
 rabbit
 sea cow
 sirenian
 ungulate
*protists—
algae:
 Acetabularia
 alga
 algology
 brown algae
 Chlorella
 desmid
 diatom
 dulse
 Fucus
 green algae
 Irish moss
 kelp
 laver
 Nostoc
 Oedogonium
 phytoplankton
 Pleurococcus
 red algae
 Sargassum
 sea lettuce
 seaweed
 spirigra
 stenocyst
 Ulothrix
 Vaucheria
 water bloom
 water net
*protists—
 protozoans:
 actinomyxidian
 amoeboidea
 apicomplexan
 astome
 Balantidiidium
 Ceratium
 Chlamydomonas
 chloromonad
 chrysomonad
 ciliate
 coccolith
 cryptomonad
 dinoflagellate
 Entamoeba
 entodiniomorph
 Euglena
 flagellate
 foraminifera
 fusulinid
 gregarine
 Gymnodinium
 gymnophore
haplosporidian
haplosporidian
helioflagellate
heliozoan
heterochlorid
heterotrich
Holomastigotoides
hymenostome
hypermastigote
hypotrich
mesosporidian
myxosporidian
Nosema
odontostome
oligotrich
opalinid
Paramecium
peritrich
Plasmodium
protonad
protozan
pseudopodium
radiolarian
rhizomastigote
Sarcocystis
sarcodine
sucoridian
testacean
tintinnid
trichocyst
trichomonad
trichostome
tolvocid
Volvox
Vorticella
protists—others:
beard lichen
Iceland moss
lichen
manna
Myxomycetes
oak moss
Parmelia
Plasmodio-
phoromycetes
protist
slime mold
reptiles—
protists—others:
croco-
alligator
caiman
crocodile
gavial
reptiles—
turtles:
Albertosaurus
Allosaurus
Anatotitans
Ankylosaurus
Apatosaurus
brachiosaur
Bradytitan
Camptosaurus
carnosaur
ceratopsian
Ceratosaurus
Clidastes
Coelophysis
cynodont
Cynognathus
Dicyonodon
Dimetrodon
Dimorphodon
dinosaur
Displodocus
dromaecosaur
Edaphosaurus
Euparkeria
Hypsilophodon
ichthyosaur
iguanodon
Lambeosaurus
Limnoscelis
Maiasaura
megalosaur
Mesosaurus
mosasaur
Moschops
Nothosaurus
ornithischian
Ornitholestes
Ornithomimus
ornithopod
Oviraptor
Pachycephalo-
saurus
Pentaceratops
phytosaur
Plateosaurus
pleiosauro
Protoceratops
Psittacosaurus
Pteranodon
pterodactyl
pterosaur
Rhamphorhyn-
cus
saurischian
sauropod
sauropterygian
Stegosaurus
Struthiomimus
thecodont
therapsid
theropod
triceratops
tritylodont
tyrannosaur
reptiles—lizards:
Agamidae
anole
chameleon
dcko
Gila monster
glass snake
horned toad
iguana
Komodo dragon
lizard
monitor lizard
racerunner
skink
reptiles—snakes:
adder
anaconda
black snake
blind snake
boa
boomslang
brown snake
bull snake
bushmaster
Cerastes
cochlear
coast
colubrid
copperhead
coral snake
egg-eating snake
elapid
fer-de-lance
flying snake
garter snake
green snake
hognose snake
indigo snake
king snake
krait
mamba
mangrove snake
moccasin
python
racer
rat snake
rattlesnake
sea snake
shielddail snake
sidewinder
snake
taipan
tree snake
vine snake
viper
wart snake
water snake
reptiles—
turtles:
Blanding's turtle
box turtle
Emydidae
mud turtle
musk turtle
pentadactyl
turtle
pond turtle
sea turtle
side-necked
turtle
snake-necked
turtle
snapping turtle
softshell turtle
terrapin
tortoise
turtle
wood turtle
archosaur
reptile
tutara
schizocoelomates—
annelids:
annelid
earthworm
fanworm
feather-duster
worm
fireworm
leech
lugworm
oligochaete
palolo worm
peacock worm
polychaete
rag worm
sea mouse
mollusks:
ammonoid
ark shell
belemnoid
bivalve
bubble shell
cephalopod
chiton
cockle
conch
cone shell
coonina clam
cowrie
cuttlefish
ear shell
gaper clam
gastropod
geoduck
jingle shell
land snail
mollusk
monoplaco-
phorans
murex
mussel
nautilus
nudibranch
octopus
olive shell
opisthobranch
oyster
periwinkle
piddock
prosobranch
pteropod
pulmonate
Division II. The Molecular Basis of Vital Processes

[For Part Three headnote see page 95.]

The outlines in the three sections of Division II deal with the molecular level of biotic organization and set forth theories of the chemical transformations and the exchanges of energy that occur in the distinctly vital processes treated in Section 311 of Division I.

Section 321. Chemicals and the Vital Processes

A. The inorganic milieu of living systems

B. Organic chemicals participating naturally in the life processes

1. Carbohydrates
2. Lipids
3. Proteins and peptides
4. The major carrier of chemical energy: ATP
5. Nucleic acids
   a. General features
   b. Deoxyribonucleic acid (DNA)
   c. Ribonucleic acid (RNA)
6. Biological pigments and coloration
7. Enzymes
8. Vitamins
9. Hormones
   a. General features of hormones: relationship between endocrine regulation and neural regulation, the evolution of hormones
   b. The hormones of vertebrates
   c. The hormones and hormonelike substances of invertebrates: neurohormones, molting hormones, pheromones
   d. The hormones of plants
10. Other natural products: alkaloids, steroids and sterols, isoprenoids and terpenes

C. Drugs: chemicals administered to an organism to change its physiological state or to combat pathogens
   1. Sources and development of drugs
   2. General aspects of drug action
   3. Absorption, distribution, metabolism, and excretion of drugs
   4. Classification of drugs by organ or organ system of principal effect
      a. Drugs affecting the cardiovascular system
      b. Drugs affecting smooth and skeletal muscle systems
      c. Drugs affecting the central nervous system
      d. Drugs affecting the autonomic nervous system and the eyes
      e. Drugs affecting the excretory system
      f. Drugs affecting the digestive system
      g. Drugs affecting the reproductive systems
      h. Drugs affecting the immune response system
      i. Drugs affecting the histamine response system
   5. Drugs directed against disease organisms
      a. Drugs derived from living microorganisms: antibiotics
      b. Chemical compounds used to treat infectious diseases: chemotherapeutic drugs
   6. Drugs directed at the suppression of cancer
   7. Drug use and abuse: the nature of drug addiction and dependence
      [see 522.C.9.]

D. Ethyl alcohol, alcohol consumption
   [see 522.C.9.]

E. Biocides and biorepellents
   1. Antiseptics and disinfectants
   2. Biocides directed by mankind against animal and plant pests
   3. Biotoxins produced by microorganisms, plants, and animals: microbial toxins, phytotoxins, zootoxins
   4. Biological and chemical warfare agents
      [see 736.A.6.]

F. The selective concentration of chemicals by organisms

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with chemicals and the vital processes

- Biochemical Components of Organisms
- Cells: Their Structures and Functions
- Chemical Compounds
- Drugs and Drug Action
- Poisons and Poisoning

MICROPAEDIA: Selected entries of reference information

General subjects

- biocides: Agent Orange aldrin chemosterilant chloral chlor dane DDT dichlorobenzene dimethoate fumigant fungicide herbicide insecticide Malathion parathion phorate rodenticide Toxaphene bentoxins: lambkill mycotoxin poison toxin venom carbohydrates: carbohydrate cellulose disaccharide glucose glycoside monosaccharide pectin polysaccharide starch sugar drugs affecting the autonomic nervous system adrenergic drug anticholinesterase

Other natural products: alkaloids, steroids and sterols, isoprenoids and terpenes

C. Drugs: chemicals administered to an organism to change its physiological state or to combat pathogens
   1. Sources and development of drugs
   2. General aspects of drug action
   3. Absorption, distribution, metabolism, and excretion of drugs
   4. Classification of drugs by organ or organ system of principal effect
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      b. Drugs affecting smooth and skeletal muscle systems
      c. Drugs affecting the central nervous system
      d. Drugs affecting the autonomic nervous system and the eyes
      e. Drugs affecting the excretory system
      f. Drugs affecting the digestive system
      g. Drugs affecting the reproductive systems
      h. Drugs affecting the immune response system
      i. Drugs affecting the histamine response system
   5. Drugs directed against disease organisms
      a. Drugs derived from living microorganisms: antibiotics
      b. Chemical compounds used to treat infectious diseases: chemotherapeutic drugs
   6. Drugs directed at the suppression of cancer
   7. Drug use and abuse: the nature of drug addiction and dependence
      [see 522.C.9.]

D. Ethyl alcohol, alcohol consumption
   [see 522.C.9.]

E. Biocides and biorepellents
   1. Antiseptics and disinfectants
   2. Biocides directed by mankind against animal and plant pests
   3. Biotoxins produced by microorganisms, plants, and animals: microbial toxins, phytotoxins, zootoxins
   4. Biological and chemical warfare agents
      [see 736.A.6.]

F. The selective concentration of chemicals by organisms

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MACROPAEDIA: Major articles dealing with chemicals and the vital processes

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MICROPAEDIA: Selected entries of reference information

General subjects

- biocides: Agent Orange aldrin chemosterilant chloral chlor dane DDT dichlorobenzene dimethoate fumigant fungicide herbicide insecticide Malathion parathion phorate rodenticide Toxaphene mycotoxin poison toxin venom carbohydrates: carbohydrate cellulose disaccharide glucose glycoside monosaccharide pectin polysaccharide starch sugar drugs affecting the autonomic nervous system adrenergic drug anticholinesterase
Part Three. Life on Earth

Drugs affecting the cardiovascular system:
- Digitalis
- Heparin
- Nitroglycerin
- Drugs—analgesics:
  - Acetaminophen
  - Acetanilide
  - Analgesic
  - Antipyrine
  - Aspirin
- Drugs—antibiotics:
  - Ampicillin
  - Antibiotic
  - Cephalosporin
  - Erythromycin
  - Penicillin
- Drugs—anesthetics:
  - Anesthetic
  - Chloroform
  - Cocaine
  - Curare
  - Cyclopropane
  - Procaine
  - Hydrochloride
- Drugs—anxiolytics:
  - Alprazolam
  - Benzodiazepine
  - Diazepam
  - Sedative-hypnotic
  - Tranquilizer
- Drugs—hallucinogens:
  - DMT
  - Hallucinogen
  - Hashish
  - Ibogaine
  - LSD
  - Marijuana
  - Mesaline
- Drugs—intravenous:
  - Anticoagulant
  - Antitussive
  - Cimetidine
  - Morphine
  - Reserpine
- Drugs—local:
  - Procaine
  - Procainamide
  - Quinidine
- Drugs—narcotics:
  - Codeine
  - Fentanyl
  - Heroin
  - Methadone
  - Morphine
  - Narcotic
- Drugs—sedatives:
  - Barbiturate
  - Chloral hydrate
  - Paraldehyde
  - Sedative-hypnotic
  - Sedative-hypnotic
- Drugs—stimulants:
  - Amphetamine
  - Caffeine
  - Catecholamine
  - Dopamine
  - Phenylalanine
- Drugs—tranquilizers:
  - Chlordiazepoxide
  - Chlorpromazine
  - Diazepam
  - Lithium carbonate
  - Meprobamate
  - Reserpine
- Drugs—other drugs and drug action:
  - Antacid
  - Antagonist
  - Antihistamine
  - Antimicrobial
  - Agent
  - Astringent
  - Colchicine
  - Cytoxic drug
  - Diuretic
  - Drug
  - Ephedrine
  - Laxative
  - Phenol
  - Coefficient
  - Promethazine
  - Quinidine
  - Scopolamine
  - Theophylline
  - Urethane
  - Enzymes and enzyme action:
    - Allosteric control
    - Amylase
    - Cofactor
    - Cooperator
    - Enzyme
    - Feedback inhibition
    - Hydrolyase
    - Induction
    - Inhibition
    - Ligase
    - Lipase
    - Michaelis–Menten hypothesis
    - Nuclease
    - Pepsin
    - Proteolytic enzyme
    - Renin
    - Serotonin
    - Transaminase
    - Zymogen
  - Hormones:
    - Aldosterone
    - Androgen
    - Corticoid
    - Cortisol
    - Enterogastrone
    - Epinephrine and norepinephrine
    - Estrogen
    - Growth hormone
    - Insulin
    - Luteinizing hormone
    - Melatonin
    - Neurohormone
    - Progesterone
    - Testosterone
    - Isoprenoids and terpenes:
      - Abietic acid
      - Camphor
      - Isoprene
      - Limonene
      - Menthol
      - Pinene
      - Terpene
  - Vitamins:
    - Biotin
    - Carnitine
    - Choline
    - Folic acid
    - Nicacin
    - Pantothenic acid
    - Para-aminobenzoic acid
    - Vitamin
    - Vitamin A
    - Vitamin B complex
    - Vitamin B1
    - Vitamin B2
    - Vitamin B3
    - Vitamin B5
    - Vitamin B6
Section 322. Metabolism: Bioenergetics and Biosynthesis

A. Photosynthesis: the initiation of energy conversion in the biosphere
   [see also 335.B.]
   1. The biological importance of photosynthesis
   2. Factors that influence the rate of photosynthesis and the energy efficiency of photosynthesis
   3. Determination of the mechanism of photosynthesis
   4. The site of the photosynthetic process in green plants: the chloroplast
   5. The photosynthetic pigments
   6. The energetics of photosynthesis: photoelectron transfer, photophosphorylation
   7. The metabolic path of carbon in photosynthesis: the carbon reduction cycle

B. Metabolism: the totality of all chemical processes in the living organism
   1. The fragmentation of complex molecules: catabolism
   2. The combustion of food materials and the conservation of part of the energy in them: cellular respiration, oxidation and transduction
   3. The biosynthesis of cell components: anabolism
   4. Regulation of metabolism

C. The nitrogen cycle: nitrogen fixation, nitrification and denitrification

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with metabolism: bioenergetics and biosynthesis
   - Cells: Their Structures and Functions
   - Metabolism
   - Photosynthesis

MICROPAEDIA: Selected entries of reference information

General subjects

| vitamin C | other: | denaturation | sapogenin |
| vitamin D | adenosine | histamine | secretion |
| vitamin E | triphosphate | piperine |
| vitamin K | |

Biographies
   See Section 10/34 of Part Ten

INDEX: See entries under all of the terms above
Section 323. Vital Processes at the Molecular Level

A. The cell membrane
   1. The nature of membranes
   2. Compartmentalization of the cell
   3. Movement of water across cell membranes: osmosis
   4. Movement of solutes through membranes in response to a concentration gradient
   5. Movement of solutes through membranes independent of concentration gradients: active transport, pinocytosis

B. Bioelectricity

C. The nerve impulse
   1. The structure of the neuron
   2. Characteristics of artificially stimulated nerve fibres
   3. Nature of the nerve impulse
   4. Transmission of the nerve impulse: the synapse

D. Muscle contraction
   1. Contractile or motile activity of some type as a characteristic of all living things
   2. Striated, or skeletal, muscle in higher animals
   3. Cardiac muscle
   4. Smooth muscle

E. Bioluminescence
   1. The significance of bioluminescence in behaviour, metabolism, and research
   2. The range and variety of bioluminescent organisms
   3. The biochemical events of light emission: enzymic and nonenzymic systems

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with vital processes at the molecular level
   Cells: Their Structures and Functions
   Electricity and Magnetism
   Muscles and Muscle Systems
   Nerves and Nervous Systems

MICROPAEDIA: Selected entries of reference information

General subjects
   acetylcholine  bioluminescence  membrane  osmosis
   actin  end-plate potential  muscle  pinocytosis
   action potential  excitatory  nervous system  resting potential
   adrenaline and  postsynaptic  neuromuscular  sodium pump
   noradrenaline  potential  junction  synapse
   all-or-none law  marine  neuron  neurotransmitter
   bioelectricity  phosphorescence

Biographies
   See Section 10/34 of Part Ten

INDEX: See entries under all of the terms above
Division III. The Structures and Functions of Organisms

Division I deals with the nature, origin, evolution, distinctive properties, and classification of living things. Division II deals with the molecular level of biotic organization. The outlines in the nine sections of Division III deal with life at the cellular level and at the organismic level.

Section 331. The Cellular Basis of Form and Function

A. Cell theory and classification
   1. The cell theory
      a. Historical background
      b. Challenges to and revisions of the cell theory in the light of later knowledge
   2. Classification of cells
      a. General features: comparisons between cells and viruses and between procaryotic and eucaryotic cells, tissues as providing a functional classification of cells
      b. Cells and tissues of animals: absorptive cells, secretory cells, nerve cells, sensory cells, muscle cells, cells in supporting tissues, circulating cells, reproductive cells
      c. Cells and tissues of higher plants: outstanding features of the plant cell; meristematic, epidermal, and other types of plant cells
      d. Comparison between animal cells and plant cells

B. Cell design and cell organization
   1. The cell as a molecular system
      a. Macromolecules in cells: nucleic acids, proteins, polysaccharides
      b. Small molecules in cells: lipids, nucleotides, amino acids, fatty acids
   2. Form and structure of the cell
      a. Sizes and shapes of cells
      b. Morphological elements: parts of cells—cell membrane, extracellular matrix, mitochondria, ribosomes, cytoskeleton, nuclear envelope, chromosomes, nucleolus
      c. Procaryotic and eucaryotic cells
         [see also 312.A.3.b.]

C. Functional aspects of cells
   1. The internal environment and the cell matrix: the concept of the cell as a "protoplasm," the concept of the cell as a "bag" containing a water solution of molecules
   2. Cell membranes
      [see 323.A.]
   3. Interplay of nucleus and cytoplasm
   4. Cell movement: ciliary, flagellar, and amoeboid
   5. Cells in combination: cohesion and communication to form tissues and multicellular organisms

D. The cell cycle
   1. Cell growth: doubling of size, genetic replication, preparation for division
2. Cell division
   a. Mitosis: condensation of chromosomes and dissolution of nuclear envelope; splitting of chromosomes; formation of new nuclear envelopes
   b. Cytokinesis: constriction of animal cell into halves by contractile ring of actin filaments; division of plant cell by formation of cell plate and new cell wall
   c. Meiosis: division of germ cell into gametes, or reproductive cells, each with one-half of the genetic material of parent cell

E. Fertilization
   1. Characteristics of the mature egg
   2. Events of fertilization
   3. Biochemical analysis of the events of fertilization
   4. Mechanisms that aid in the union of gametes

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major article dealing with the cellular basis of form and function
   Cells: Their Structures and Functions

MICROPAEDIA: Selected entries of reference information

General subjects

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<td></td>
</tr>
</tbody>
</table>

Biographies
   See Section 10/34 of Part Ten

INDEX: See entries under all of the terms above

Section 332. The Relation of Form and Function in Organisms

A. Biological form and function

B. Plant tissues and fluids: classification, organization, main functions
   1. Relatively undifferentiated tissues of nonvascular plants
   2. Well-differentiated tissues in vascular plants
      a. Meristematic (cell-producing) tissues: apical, lateral, intercalary
      b. Mature tissues
         i. Dermal (protective) tissues: the epidermis of the primary plant body, the periderm of the secondary plant body
         ii. Vascular (conducting) tissues: the xylem, the phloem
         iii. Fundamental (ground) tissues: the parenchyma, the supportive collenchyma and sclerenchyma, the endodermis
   3. Cells of plant tissues
      [see 331.A.2.c.]

C. Organs of plants: tissue organization, functions, and types
   1. Development of organs in vascular plants: internal and external morphology, tissue organization, functions, types, and modifications; the stem; the leaf; the root
   2. Physiology of organs in vascular plants
3. Diverse sizes and forms of organ systems in vascular plants: potential for unlimited growth
   a. Varieties of shoot systems
   b. Varieties of root systems
   c. Varieties of reproductive organs and organ systems
4. Organs of nonvascular plants: analogues of stem, leaf, and root
5. Evolution of plant organs and organ systems into the complex, multicellular state

D. Animal tissues and fluids: classification, organization, and main functions
   1. Classification of tissues: anatomical, embryological, functional
   2. Tissues for assimilation, storage, transport, and excretion: alimentary, liver, kidney, and lung tissues: blood and lymph
   3. Tissues for coordination: nervous and sensory tissues, endocrine tissues
   4. Tissues for support and movement: connective tissues, cartilage, bone, muscle
   5. Other tissues: reproductive tissues, hemopoietic tissues, tissue fluids
   6. Cells of animal tissues

E. Animal organs and organ systems
   1. Specialized organ systems
      a. Relating to the environment primarily: integumentary, skeletal, muscular, nervous, and endocrine systems
      [see also 333.C. and D.: 334.A., B., and C.]
      b. Serving cell metabolism primarily: digestive, respiratory, circulatory, and excretory systems
      [see also 335.C.: 336.A., B., and C.]
      c. Serving genetic continuity primarily: the reproductive system
   2. Interrelationships between organ systems: functional interdependence, feedback mechanisms
   3. Development of organ systems
      [see also 338.D.]
   4. Evolution of organ systems

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with the relation of form and function in organisms

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A. Maintenance of steady states in biological systems: homeostasis
   1. The nature of homeostatic systems
   2. Homeostatic processes
   3. Homeostatic control hierarchies: homeostatic subsystems that serve either organisms or natural communities
   4. Origin and evolution of homeostasis
   5. Individual adjustments to gradual changes in the physical environment: acclimatization
   6. Inactive states accompanied by a lower than normal rate of metabolism: dormancy

B. Information reception and processing: sensory reception
   1. Classification of sensory systems
      a. According to location of receptors: exteroceptors, interoceptors
      b. According to type of stimulus: photoreceptors, thermoreceptors, chemoreceptors, mechanoreceptors, electroreceptors, sound receptors
   2. Evolution of sensory systems: specialized organs and information-processing structures
   3. Sensory information: interactions between adjacent sense cells and sensory neurons

C. Endocrine systems in animals
   1. General features of hormonal coordination: the relationships between endocrine and neural regulation
   2. Vertebrate endocrine systems
      a. Relationships of endocrine glands to each other and to the blood
      b. Structure and function
   3. Invertebrate endocrine systems: insects, crustaceans, annelid worms
   4. Comparative, adaptive, and evolutionary aspects of endocrine systems: the neurosecretory cell, hypothalamus-pituitary control systems
   5. The human endocrine system
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D. Nervous systems in animals
   1. Comparison of chemical and nervous regulation: control mechanisms located between the stimulus and the response
   2. Nervous coordination
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      b. Organelle systems: the channeling of responsiveness at the subcellular level within more complex protozoans
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         i. The neuron, or nerve cell
         ii. The transmission of the nerve impulse and the synapse
            [see 323.C.]
   3. Invertebrate nervous systems
      a. Theories of the evolutionary origin of the nervous system
      b. Diffuse nervous systems
      c. Centralized nervous systems
   4. Vertebrate nervous systems
      a. The central nervous system: the brain and its components; the spinal cord; the brain coverings (meninges), cavities, cerebrospinal fluid, and neuroglia (nonnervous tissue)
b. The peripheral nervous system
c. Embryonic development of the vertebrate nervous system
d. Evolution of the vertebrate nervous system
e. Biodynamics of the vertebrate nervous system

5. The human nervous system
[see 421.J.]

E. The biological clock: periodicity

1. Rhythms without apparent external correlates: brain waves, breathing, heartbeat
2. Rhythms correlated with natural geophysical cycles: solar-day rhythms, lunar-tidal rhythms, monthly rhythms, annual or seasonal rhythms, epochal rhythms
3. The mechanism of the biological clock
4. Factors affecting biological periodicities
5. The amplification and superimposition of individual rhythms in communities
[see 352.C.1.b.]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the coordination of vital processes: regulation and integration
   Endocrine Systems
   Nerves and Nervous Systems
   Sensory Reception

MICROPAEDIA: Selected entries of reference information

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   2. Invertebrate integuments: organization and function
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      b. Noncellular coatings of the integument
   3. Vertebrate integuments: cellular components and their derivatives
      a. Skin layers: the epidermis, the dermis
      b. Skin derivatives and appendages: skin glands and pigment; epidermal scales; claws, nails, and hoofs; horns and antlers; feathers and hair; dermal derivatives
   4. Skin variations among vertebrates
   5. Embryology and evolution of the vertebrate skin
   6. The biodynamics of vertebrate skin
   7. Human integument and derivatives: skin, hair, nails, sebaceous glands, sweat glands

B. The body skeleton
   1. The roles of the body skeleton
   2. Description and composition of the skeletal elements
      a. Cuticular structures: bone, crystals, cuticle, ossicles, spicules
      b. Semirigid structures: flexible cuticular structures, calcareous spicules that are not tightly packed, keratin, notochord, cartilage
      c. Other elements: connective tissue, the hydrostatic skeleton, elastic structures, buoyancy devices
   3. The invertebrate skeleton: organization and function
   4. The vertebrate skeleton: structure and function
      a. General features
      b. Embryology of vertebrate skeletons
      c. Vertebral column and thoracic skeleton
      d. Appendicular skeleton: pectoral girdle, pelvic girdle, limbs
   5. Joints in vertebrates and invertebrates permitting various types of movement
   6. Properties of bone and its development
   7. The human skeletal system

C. The body musculature
   1. General features of muscle tissue: its role in movement, support, colour changes, temperature regulation, and discharge of certain glands; arrangement and gross function
   2. Muscle contractile systems
      a. Simple contractile systems: simple contractile fibrils and epithelio-muscular cells
      b. Complex contractile tissues: striated muscle, smooth muscle
   3. Muscle contraction
      [see 323.D.]
   4. Invertebrate muscle systems
   5. Vertebrate muscle systems
      a. Embryonic development and divisions of the muscular system
      b. Evolution of the vertebrate musculatory system
c. Function and regulation of muscle action
d. Electric organs in certain fishes
6. The human musculatory system
[see 421.H.6. and 7.]

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with covering and support: integumentary, skeletal, and musculatory systems
- Integumentary Systems
- Muscles and Muscle Systems
- Supportive and Connective Tissues

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**Section 335. Nutrition: the Procurement and Processing of Nutrients**

A. The basic features of nutrition
1. The various nutritional patterns; *e.g.*, autotrophism and heterotrophism, phototrophism and chemotrophism
2. Methods of ingestion or penetration
[see C. below]
3. The essential nutrients: compounds that cannot be synthesized by an organism and must be supplied in food; the nutritional needs of organisms
4. Syntrophism: nutritional interrelationships in which the immediate or end products of metabolism of one organism may provide essential nutrients for another

B. Photosynthesis: the production of food in green plants
[see also 322.A.]

C. Digestion and digestive systems
1. The contrast between autotrophs and heterotrophs
2. The alimentary system in animals other than humans
   a. Invertebrate digestive systems: vacuolar systems, channel-network systems, saccular systems, tubular systems
   b. Vertebrate digestive systems: oral cavity, teeth, and pharynx; esophagus and stomach; small intestine, pancreas, and liver; the large intestine
   c. Embryology and evolutionary development of the vertebrate digestive system
   d. Biodynamics of the vertebrate digestive system: control of secretions and intestinal movements
3. The human alimentary system
   [see 421.D.]

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with nutrition: the procurement and processing of nutrients

*Digestion and Digestive Systems*

*Nutrition*

**MICROPAEDIA:** Selected entries of reference information

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1. The process of extracting oxygen and releasing carbon dioxide
2. Gases in the environment: the range of respiratory problems faced by aquatic and terrestrial animals
3. Basic types of respiratory structures
   a. Respiratory organs of invertebrates: tracheae and gills
   b. Respiratory organs of vertebrates: gills and lungs
4. Dynamics of respiratory mechanisms
5. The control of respiration: neural reflexes, muscular feedback, chemically sensitive controls
6. Adaptation to special environmental conditions
Division III. Section 336

7. The human respiratory system
   [see 421.C.]

B. Circulation and circulatory systems

1. Circulation and transport patterns: general aspects common to all circulatory systems
   a. Circulation in single cells: streaming movements within the protoplasm
   b. Circulation in multicellular animals

2. The fluid media involved in circulation: blood and lymph
   a. Evolutionary origins of circulating fluids
   b. Plasma
   c. Formed elements of the circulating fluid: red cells, white cells, platelets, thrombocytes
   d. Lymphocytes and lymph in vertebrates

3. Transport systems in animals
   a. Invertebrate circulatory systems
   b. Vertebrate circulatory systems
   c. Coronary circulation
   d. Embryonic development of the circulatory system
   e. Biodynamics of vertebrate circulation
   f. The human cardiovascular system
      [see 421.A.]

4. Plant internal transport

C. Elimination: the disposal of wastes

1. General features of elimination

2. Excretion and excretory systems
   a. Excretory mechanisms
   b. Invertebrate excretory systems
   c. Vertebrate excretory systems
   d. The evolution of the vertebrate excretory system
   e. The human excretory system
      [see 421.G.]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with gas exchange, internal transport, and elimination

Cells: Their Structures and Functions
Circulation and Circulatory Systems
Excretion and Excretory Systems
Respiration and Respiratory Systems

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      a. Molecular replication and reproduction
      b. Cell reproduction: binary and multiple fission
      c. Reproduction of organisms
         [see A.2., below]
      d. Life cycles of plants and animals
   2. Reproduction of organisms: sexual and asexual reproduction
   3. Natural selection and reproduction: the evolution of reproduction and variation control
      [see also 312.C.]

B. Sex and sexuality
   1. The distinctions between sex, sexuality, and reproduction
   2. Transduction and transformation as sexlike recombination in viruses and bacteria
   3. The adaptive significance of sex: establishment of genetic diversity
   4. The origin of sex and sexuality
   5. Sex patterns
   6. Determination of the sex of individuals
      a. The sex chromosomes
      b. Abnormal chromosome effects
      c. The effect of parthenogenetic development
      d. Environmental and hormonal influences

C. The reproductive system in plants: its organization and function
   1. General features: asexual systems that create new plants identical to the parent plant, sexual
      systems that create new plants different from either of the two parents
   2. The sex organs of bryophytes
      a. In liverworts and hornworts
      b. In mosses
   3. The variations of sex organs in tracheophytes
      a. In spore plants
      b. In seed plants
   4. Variations in reproductive cycles: apogamy and apospory (apparent secondary loss of capacity
      for sexual reproduction)
5. The physiology of reproduction: the influence of internal and environmental factors on the maturation of sporophytes and gametophytes as manifested by their ability to produce spores and gametes

D. The reproductive system in animals: its organization and function
   1. General features
   2. Reproductive systems of invertebrates
      a. Gonads, associated structures, and products in monoecious and dioecious types
      b. Mechanisms that aid in the union of gametes
      c. Specializations associated with parthenogenesis
      d. Provisions for the developing embryo
         [see 338.D.2.b.]
   3. Reproductive systems of vertebrates
      a. Gonads, associated structures, and products
      b. Adaptations for internal fertilization; e.g., the cloaca, intromittent (copulatory) organs, accessory structures
      c. Role of gonads in hormone cycles
      d. Provision for the developing embryo
         [see 338.D.2.b.]
      e. The human reproductive system
         [see 421.F.]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with reproduction and sex
   Behaviour, Animal
   Reproduction and Reproductive Systems
   Sex and Sexuality

MICROPAEDIA: Selected entries of reference information

General subjects

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Section 338. Development: Growth, Differentiation, and Morphogenesis

A. The nature and scope of biological development

B. The constituent processes of development and their control
   1. Growth
   2. Morphogenesis
   3. Differentiation
   4. Control and integration of development

C. Development of plants
   1. General features: types of life cycles, alternation of generations as independent phases of the life cycle
   2. Preparatory events
      a. Formation of sex cells
      b. Pollination
      c. Fertilization
   3. Early development: from fertilized egg (zygote) to seedling
      a. Embryo formation
      b. Independent dormant stages and germination of the seeds and fruits of higher plants, dispersal
   4. Later development: the sporophyte plant body

D. Development of animals
   1. Preparatory events: the egg and its activation by normal fertilization or by parthenogenesis
   2. Early development
      a. Embryo formation: cleavage, gastrulation
      b. Embryonic adaptations for the maintenance of the developing embryo: shell, yolk stores, membranous sacs, placenta
   3. Organ formation
   4. Postembryonic development: transformation of the newborn into the adult

E. Aging and decline in animals: life span, death
   [for aging in humans, see 422.A.]
   1. Senescence in mammals
   2. Causes of aging
   3. The duration of life

F. Specialized patterns of development
   1. Biological regeneration
   2. The healing processes and scar tissue formation
   3. Biological malformation
   4. Twinning: multiple births
   5. Development in vitro: cell and tissue cultures
   6. Development of transplanted tissues and organs

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with development: growth, differentiation, and morphogenesis

Death
Growth and Development, Biological
**Section 339. Heredity: the Transmission of Traits**

**A. Basic features of heredity**
1. Early speculations on the nature of heredity
2. Mendelian genetics: Mendel's experiments and their significance, the universality of Mendel's laws, interactions among genes and their variant forms (alleles)
3. The combined action of heredity and environment in producing an organism

**B. The physical basis of heredity**
1. Chromosomes and genes: the cellular basis of heredity
2. Molecular genetics: the chemical and molecular nature of genes, the genetic code and its mutations, the expression and regulation of genes, applications of molecular genetics

**C. Heredity and evolution**
[see also 312.C.]
1. Population genetics: the gene pool, the Hardy-Weinberg principle, changes in gene frequencies
2. Natural selection as an agent of evolutionary change
3. Artificial selection for genetic improvements of selected organisms: domesticated animals, cultivated plants, humankind
[see also 355.B.3.]
4. Outbreeding and inbreeding: the effects of consanguinity on the vigour of offspring

**Suggested reading in the Encyclopaedia Britannica:**

- Genetics and Heredity, The Principles of...
Division IV. Behavioral Responses of Organisms

Several of the sections in Division III deal with the structure and internal functioning of organisms. The outlines in the two sections of Division IV deal with the external actions and reactions of living things in relation to changes in their environment.

Section 341. Nature and Patterns of Behavioral Responses 130

Section 341. Nature and Patterns of Behavioral Responses

A. Diverse conceptions of animal behaviour
   1. The variety of animal behaviour
   2. Classification of animal behaviour
   3. Components of animal behaviour

B. Patterns of stereotyped response: unlearned behavioral reactions of organisms to some environmental stimulus
   1. Plant movements: tropic and nastic movements, nutation, other autonomous movements
   2. Animal movements: reflex and reflexlike activities, taxes, fixed action patterns and instinct
   3. Photoperiodism

C. Hormonal and nervous control of behaviour
   1. Interaction of endocrine and nervous systems
   2. Hormonal influences on behaviour; e.g., by sex hormones
   3. The nervous system and behaviour: the role of the nervous system in receiving information, processing it in the brain and spinal cord, and initiating the appropriate response

D. Evolution of behaviour
   1. Evidence of the genetic determination of behaviour
   2. The influence of experience on behaviour: phyletic patterns in the evolution of learning
   3. Evolutionary origins and evolutionary consequences of behaviour patterns

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major article dealing with the nature and patterns of behavioral responses

Behaviour, Animal

MICROPAEDIA: Selected entries of reference information

General subjects

animal behaviour
behaviour genetics
instinct
photoperiodism
play
reflex
tropism

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Section 342. Development and Range of Behavioral Capacities: Individual and Group Behaviour

A. Basic behavioral activities of individuals
1. Food getting
2. Locomotion
3. Avoidance behaviour
4. Aggressive behaviour: attack and defensive threats
5. Behaviour related to habitat
6. Behaviour related to reproduction

B. Higher behavioral characteristics of individual animals
1. Simple nonassociative learning; e.g., habituation, sensitization
2. Associative learning; e.g., classical and instrumental, or operant, conditioning
3. Spatial learning; e.g., maze learning, navigation
4. Perceptual learning: imitation and observational learning; e.g., song learning, imprinting
5. Complex problem solving
   a. Discriminations of relational and abstract stimuli
   b. Generalized rule learning
   c. Insight and reasoning
   d. Language learning

C. The behaviour of animals in groups
1. Distinctions between groups of social animals and groups of nonsocial ones
2. Animal communication
3. The range of social behaviour among social and nonsocial animals
4. Dynamics of social behaviour

D. Evolution of behaviour
[see 341.D.]

Suggested reading in the *Encyclopaedia Britannica:*

MACROPAEDIA: Major articles dealing with the development and range of behavioral capacities: individual and group behaviour
- Behaviour, Animal
- Learning, Animal

MICROPAEDIA: Selected entries of reference information

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Division V. The Biosphere: the World of Living Things
[For Part Three headnote see page 95.]

Division I of Part Three deals with the nature, origin, evolution, distinctive properties, and classification of living things. Divisions II, III, and IV deal with life at the molecular, cellular, organismal, and behavioral levels.

The outlines in the five sections of Division V deal with the world of living things taken as a single system of biotic and environmental interactions and interdependencies.

Section 351. Basic Features of the Biosphere 132

352. Biological Populations and Communities 133
353. Hazards of Life in the Biosphere: Disease and Death 135
354. Biogeographic Distribution of Organisms: Ecosystems 136
355. The Place of Humans in the Biosphere 137

Section 351. Basic Features of the Biosphere

A. The extent of the biosphere

1. Preconditions of the biosphere: the Earth as an ideal medium for life
   [see 312.A.2.]

2. The levels of organization within the biosphere: the biocycle, the ecosystem, the community, the population
   [see 352.A. and C.: 354]

3. Energy flow in the biosphere

4. Cycling of matter in the biosphere
   a. The general pattern of chemical cycles in nature
      [see also 214.C.]
   b. The carbon and oxygen cycles
   c. The nitrogen cycle
   d. The sulfur cycle
   e. The water cycle
      [see also 222.D.]
   f. The sedimentary cycles of essential minerals

5. The concept of the noosphere: mankind’s place in the biosphere
   [see 355.B.]

B. The ecosystem: a collection of integrated communities and their environment

1. Definition of an ecosystem

2. The biotic components of the ecosystem
   a. Producers
   b. Consumers
   c. Decomposers

3. The abiotic components of the ecosystem
   a. Pressure and temperature
      [see 223.E.1.]
   b. Radiation
   c. Illumination
d. Water and soil characteristics, salts

e. Wave action: wind and water

f. Fire as a limiting factor

4. The conditioning of the abiotic environment by living organisms

5. The effect of microenvironments on the ecosystem

6. Processes that determine the nature and productivity of the ecosystem

7. Types of ecosystems

[see 354]

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major article dealing with the basic features of the biosphere

Biosphere, The

MICROPAEDIA: Selected entries of reference information

General subjects

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Section 352. Biological Populations and Communities

A. Biological populations

1. The study of populations

[see 10/34.B.4.]

2. The measurable characteristics of biological populations

a. Age, sex, and genetic differences and their distribution

b. Numbers and density: the effects of natality and mortality, the reproductive rate and death rate

3. Growth of populations: growth form and carrying capacity

4. Fluctuations in stable populations: variations in population size

5. Movements: migration; emigration; dispersion; dispersal; the influence of topographical, climatic, and biological barriers

6. Interactions of populations

[see B., below]

7. Factors affecting the structure of human populations

[see 524.A.]

B. Biotic interactions

1. Intraspecific interactions: positive and negative interactions of individuals within a species

2. Interspecific interactions: interactions among members of different species

a. The range of interspecies associations

b. Negative interactions, in which one or both populations are harmed: consumption, parasitic interactions, amensalism and antagonism
c. Positive interactions, in which one or both populations are benefited: commensalism, mutualism

d. Neutralistic interactions

3. Interactions between populations of different species and the ecological, evolutionary, and biogeographical aspects of interaction on the population level

C. Biological communities

1. Community structure

a. Vertical and horizontal patterns: the influence of variations in environmental conditions on the stratification and zonation of organisms

b. Time relations: periodicity and population changes in the community

c. Interactions in the community: heterotrophic nutrition, predation, symbiosis

d. Niches and species diversity

e. Ecotones and the "edge effect"

2. Community function: energy flow

3. Community succession: growth toward a stable, mature condition

4. Communities in space

a. Landscape patterns: the habitats of a landscape as forming a pattern of environmental gradients

b. Climax interpretation: monoclimax theory, polyclimax theory, and climax pattern hypothesis

c. Community gradients: coenclines

5. Community classification and its bases

a. The association as the unit of classification

b. The biome or formation as the unit of classification

c. Other bases for classification: e.g., ecological succession, habitat, community metabolism

6. Community structure in past ages: biogeographical succession
[see 242.B. and 243]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with biological populations and communities

Behaviour, Animal
Biosphere, The

MICROPAEDIA: Selected entries of reference information

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A. Disease as a departure from the "normal" state, or a disruption of homeostasis; death as the irreparable disruption of life processes

1. The nature of noncommunicable disease: metabolic defects, environmental hazards
2. The nature of communicable, or contagious, disease
   a. The multifactorial concept of contagious disease
   b. Endemic disease and epidemic disease
3. Immunity
   [see also 422C.2.]
4. Control of disease: prevention, treatment

B. Plant diseases

C. Animal diseases

D. Human diseases
   [see 423]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with hazards of life in the biosphere: disease and death
   Death
   Disease
   Immunity

MICROPAEDIA: Selected entries of reference information

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      a. Land as a medium for life and the comparison of the terrestrial and aquatic ecosystems
      b. Limiting factors to living on land
      c. Major terrestrial biomes: the tundra, the coniferous forest, the middle-latitude forest, the tropical rain forest, the grassland and savanna, the scrublands, the desert
      d. Specialized biomes: polar biomes, subterranean biomes
   2. Major life-forms
      a. Growth habits and indicator organisms
      b. Classification by habitat: soil organisms, trees and other rooted plants, epiphytes and periphytes, permeants
      c. Classification by niche: producers, consumers, decomposers
   3. Productivity in terrestrial ecosystems

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   2. The ocean and its communities: communities of the open sea
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      b. Character of oceanic populations: benthos, plankton, nekton
      c. Adaptations to marine conditions
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   3. Inland waters and their communities: freshwater communities
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   4. Boundary ecosystems: between waters or between water and land
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      a. Holarctic region: the nontropical parts of Eurasia, northern Africa, and North America
      b. Ethiopian region: Africa south of the Sahara, southwestern Arabia, Madagascar
      c. Oriental region: tropical southern and southeastern Asia
   2. The Notogaean realm: Australia, New Guinea, New Zealand, tropical Pacific islands
   3. The Neogaean realm: Central and South America
   4. The Antarctic realm: Antarctica and most of the sub-Antarctic islands
Suggested reading in the *Encyclopedia Britannica*:

**MACROPAEDIA:** Major articles dealing with biogeographic distribution of organisms: ecosystems

- Biosphere and Concepts of Ecology, The
- Lakes
- Oceans

**MICROPAEDIA:** Selected entries of reference information

### General subjects

- **biogeographic regions:**
  - Australian region: prairie
  - Ethiopian region: savanna
  - faunal region: ecosystems—
    - floristic region: biome
    - Holartic region: desert
    - Neotropical region: ecosystem
  - ecosystems—forests:
    - cloud forest: estuary
    - coniferous forest: lacustrine
    - deciduous forest: ecosystem
    - forest: polar
    - rainforest: biome
  - ecosystems—
    - grasslands: rangeland
    - grassland: riverine ecosystem

- **ocean layers:**
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  - air-sea interface
  - bathyal zone
  - bottom water
  - halocline
  - littoral zone
  - pelagic zone
  - photic zone
  - ocean populations:
    - benthos
    - nekton
    - plankton
    - zooplankton

- **vegetation:**
  - Mediterranean
  - scrubland
  - thorn forest
  - other:
    - dispersion
    - land bridge
    - Marine
    - Biological Laboratory
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### Section 355. The Place of Humans in the Biosphere

**A.** The qualities that set human beings apart in the biosphere

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2. Physiological characteristics underlying the unique behaviour of humans: lack of a definite breeding season, long life span with slow development and lengthy dependency to maturity

3. Behavioral capacity as the basis of the unique culture of humans: communication through propositional speech, intellect and conceptualization

**B.** The effects of human action upon the biosphere

1. The influence of the human species on the modification of the environment

2. The influence of the environment on the modification of the human species

3. The attempts to change genetic endowments through deliberate selective measures: eugenics

**C.** The utilization of organisms by humans

1. Domestication of plants and animals: distribution and development

2. The cultivation of plants: plant breeding and growing

3. The uses of plants
   [see also 724.C.8. and 731]

4. The cultivation of animals: animal breeding and raising

5. Major uses of animals
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   a. Museums of natural history
   b. Zoological gardens and aviaries
   c. Institutional and private aquariums
   d. Botanical gardens and arboretums

D. The conservation and management of natural resources
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   2. Types of natural resources
   3. Management of natural resources
   4. Management of the world’s food supply
      a. The problem of food supply: special difficulties facing the developing countries
      b. Attempts to increase the production and utilization of food supplies: the quest for new sources of food and food additives

Suggested reading in the *Encyclopædia Britannica*:

**Macropaedia:** Major articles dealing with the place of humans in the biosphere

- Biosphere and Concepts of Ecology, The
- Conservation of Natural Resources
- Dogs
- Farmers and Agricultural Technology
- Forestry and Wood Production
- Gardening and Horticulture
- Horses and Horsemanship

**Microopaedia:** Selected entries of reference information

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**Biographies**

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Introduction to Part Four: The Cosmic Orphan

by Loren Eiseley

When I was a young lad of that indefinite but important age when one begins to ask, Who am I? Why am I here? What is the nature of my kind? What is growing up? What is the world? How long shall I live in it? Where shall I be replaced? I laid the turtle down in the water and gave it a little shove. It entered the current and began to drift away. "Let's go home," I said to my companion. From that moment I think I began to grow up.

"Papa," I said in the evening by the oil lamp in our kitchen. "Tell me how men got here." Papa paused. Like many fathers of that time, he was worn from long hours, he was not highly educated, but he had a beautiful resonant voice and he had been born on a frontier homestead. He knew the ritual way the Plains Indians opened a story. "Son," he said, taking the pattern of another people for his own, "once there was a poor orphan." He said it in such a way that I sat down at his feet. "Once there was a poor orphan with no one to teach him either his way, or his manners. Sometimes animals helped him, sometimes supernatural beings. But above all, one thing was evident. Unlike other occupants of Earth he had to be helped. He did not know his place, he had to find it. Sometimes he was arrogant and had to learn humility, sometimes he was a coward and had to be taught bravery. Sometimes he did not understand his Mother Earth and suffered for it. The old ones who starved and sought visions on hilltops had known these things. They were all gone now and the magic had departed with them. The orphan was alone; he had to learn by himself; it was a hard school."

My father tousled my head; he gently touched my heart. "You will learn in time there is much pain here," he said. "Men will give it to you, time will give it to you, and you must learn to bear it all, not bear it alone, but be better for the wisdom that may come to you if you watch and listen and learn. Do not forget the turtle, nor the ways of men. They are all orphans and they go astray; they do wrong things. Try to see better."

"Yes, papa," I said, and that was how I believe I came to study men, not the men of written history but the ancestors beyond, beyond all writing, beyond time as we know it, beyond human form as it is known today. Papa was right when he told me men were orphans, eternal seekers. They had little in the way of instinct to instruct them, they had come a strange far road in the universe, passed more than one black, threatening bridge. There were even more to pass, and each one became more dangerous as our knowledge grew. Because man was truly an orphan and confined to no single way of life, he was, in essence, a prison breaker. But in ignorance his very knowledge sometimes led from one terrible prison to another. Was the final problem then, to escape himself, or, if not that, to reconcile his devastating intellect with his heart? All of the knowledge set down in great books directly or indirectly affects this problem. It is the problem of every man, for even the indifferent man is making, unknown to himself, his own callous judgment.

Long ago, however, in one of the Dead Sea Scrolls hidden in the Judaean Desert, an unknown scribe had written: "None there be, can rehearse the whole tale." That phrase, too, contains the warning that man is an orphan of uncertain beginnings and an indefinite ending. All that the archaeological and anthropological sciences can do is to place a somewhat flawed crystal before man and say: This is the way you came, these are your present dangers; somewhere, seen dimly beyond, lies your destiny. God help you, you are a cosmic orphan, a symbol-shifting magician, mostly immature and inattentive to your own dangers. Read, think, study, but do not expect this to save you without humility of heart. This the old ones knew long ago in the great deserts under the stars. This they sought to learn and pass on. It is the only hope of men.

What have we observed that might be buried as the Dead Sea Scrolls were buried for 2,000 years, and been broken out of a jar for human benefit, brief words that might be encompassed on a copper scroll or a ragged sheet of vellum? Only these thoughts, I think, we might reasonably set down as true, now and hereafter. For a long time, for many, many centuries, Western man believed in what we might call the existent world of nature; form as form was
seen as constant in both animal and human guise. He believed in the instantaneous creation of his world by the Deity; he believed its duration to be very short, a stage upon which the short drama of a human fall from divine estate and a redemption was in progress.

Worldly time was a small parenthesis in eternity. Man lived with that belief, his cosmos small and man-centred. Then, beginning about 350 years ago, thoughts unventured upon since the time of the Greek philosophers began to enter the human consciousness. They may be summed up in Francis Bacon's dictum: "This is the foundation of all. We are not to imagine or suppose, but to discover, what nature does or may be made to do."

When in following years scientific experiment and observation became current, a vast change began to pass over Western thought. Man's conception of himself and his salvation became current, a vast change began to pass over nature does or may be made to do."

"But how can I?" wept the Orphan, hiding his head. "This is magic. I do not know what I am. I have been too many things."

"You have indeed," said all the scientists together. "Your body and your nerves have been dragged about and twisted in the long effort of your ancestors to stay alive, but now, small orphan that you are, you must know a secret, a secret magic that nature has given to you. No other creature on the planet possesses it. You use language. You are a symbol-shifter. All this is hidden in your brain and transmitted from one generation to another. You are a time-binder, in your head the symbols that mean things in the world outside can fly about unrammed. You can combine them differently into a new world of thought or you can also hold them tenaciously throughout a lifetime and pass them on to others."

Thus out of words, a puff of air, really, is made all that is uniquely human, all that is new from one human generation to another. But remember what was said of the wounds of evolution. The brain, parts of it at least, is very old, the parts laid down in sequence like geological strata. Buried deep beneath the brain with which we reason are ancient defense centres quick to anger, quick to aggression, quick to violence, over which the neocortex, the new brain, strives to exert control. Thus there are times when the Orphan is a divided being striving against himself. Evil men know this. Sometimes they can play upon it for their own political advantage. Men crowded together, subjected to the same stimuli, are quick to respond to emotion that in the quiet of their own homes they might analyze more causiously.

Scientists have found that the very symbols which crowd our brains may possess their own dangers. It is convenient for the thinker to classify an idea with a word. This can sometimes lead to a process called hypostatization or reification. Take the word "Man," for example. There are times when it is useful to categorize the creature briefly, his history, his embracing characteristics. From this, if we are not careful of our meanings, it becomes easy to speak of all men as though they were one person. In reality men have been seeking this unreal man for thousands of years. They have found him bathed in blood, they have found him in the hermit's cell, he has been glimpsed among innumerable messiahs, or in meditation under the sacred bō tree; he has been found in the physician's study or lit by the satanic fires of the first atomic explosion.

In reality he has never been found at all. The reason is very simple: men have been seeking Man capitalized, an imaginary creature constructed out of disparate parts in
the laboratory of the human imagination. Some men may thus perceive him and see him as either totally beneficent or wholly evil. They would be wrong. They are wrong so long as they have vitalized this creation and call it “Man.” There is no Man; there are only men: good, evil, inconceivable mixtures marred by their genetic makeup, scarred or improved by their societal surroundings. So long as they live they are men, multitudinous and unspent potential for action. Men are great objects of study, but the moment we say “Man” we are in danger of wandering into a swamp of abstraction.

Surveying our fossil history perhaps we are not even justified as yet in calling ourselves true men. The word could the mysterious alphabet we carry in our bodies be abstract symbols in its brain from which skyscrapers rise, and complicated than 19th-century biologists had imagined; the tiny building blocks constantly reshuffled in every mating had both an amazing stability and paradoxically, over long time periods, a power to alter the living structure of a species beyond recall. The thing called man had once been a tree shrew on a forest branch; now it manipulates marvels of abstraction.

Molecular biologists have begun to consider whether the marvelous living alphabet which lies at the roof of evolution can be manipulated for human benefit. Already some varieties of domesticated plants and animals have been improved. Now at last man has begun to eye his own possible road into the future. By delicate excisions and intrusions could the mysterious alphabet we carry in our bodies be made to hasten our advancement into the future? Already our urban concentrations, with all their aberrations and faults, are future-oriented. Why not ourselves? It is in our power to perpetuate great minds ad infinitum? But who is to judge? Who is to select this future man? There is the problem. Which of us poor orphans by the roadside, even those peering learnedly through the electron microscope, can be confident of the way into the future? Could the fish unaided by nature have found the road to the reptile, the reptile to the mammal, the mammal to man? And how was man endowed with speech? Could men choose their way? Suddenly before us towers the blackest, most formidable bridge of our experience. Across what chasm does it run?

Biologists tell us that in the fullness of time more than ninety percent of the world’s past species have perished. The mammalian ones in particular are not noted for longevity. If the scalpel, the excising laser ray in the laboratory, were placed in the hands of some one person, some one poor orphan, what would he do? If assured, would he reproduce himself alone? If cruel, would he by indirection succeed in abolishing the living world? If doubtful of the road, would he reproduce the doubt? “Nothing is more shameful than assertion without knowledge,” the great Roman statesman and orator Cicero once pronounced as though he had foreseen this final bridge of human pride—the pride of a god without foresight.

After the disasters of the second World War when the dream of perpetual progress died from men’s minds, an orphan of this violent century wrote a poem about the great extinctions revealed in the rocks of the planet. It concludes as follows:

I am not sure I love
the cruelties found in our blood from some lost evil tree in our beginnings.
May the powers forgive and seal us deep when we lie down.
May harmless dormice creep and red leaves fall over the prisons where we wreaked our will.
Dachau, Auschwitz, those places everywhere.
If I could pray, I would pray long for this.

One may conclude that the poet was a man of doubt. He did not regret man; he was confident that leaves, rabbits, and songbirds would continue life, as long ago, a tree shrew had happily forgotten the ruling reptiles. The poet was an orphan in shabby circumstances pausing by the roadside to pray, for he did pray despite his denial: God forgive us all. He was a man in doubt upon the way. He was the eternal orphan of my father’s story. Let us then, as similar orphans who have come this long way through time, be willing to assume the risks of the uncompleted journey. We must know, as that forlorn band of men in Judaea knew when they buried the jar, that man’s road is to be sought beyond himself. No man there is who can tell the whole tale. After the small passage of 2,000 years who would deny this truth?
Part Four. Human Life

The outlines in the three divisions and fifteen sections of Part Four treat stages in the development of human life on Earth; human health and diseases; and human behaviour and experience.

Several points should be noted about the relations of Part Four to preceding and subsequent parts.

The fundamental physical and chemical properties of matter are dealt with in Part One. The treatment of the Earth in Part Two encompasses those properties of the Earth that are supportive of human life. Much fundamental biological knowledge concerning human life is involved in the treatment—in Part Three, Life on Earth—of what is common to all animal life; the last section of Part Three deals with mankind's place in the biosphere.

Knowledge of the biomedical and psychological aspects of human life is not wholly separable from, and is germane to, the subjects covered in Parts Five through Ten, which treat human society, the fine arts, technology, religion, the history of peoples and civilizations, and man as logician, mathematician, scientist, historian, and philosopher.

The biological, medical, and psychological sciences have been themselves the object of historical and analytical studies concerned with their nature, methods, and interrelations. These studies are set forth in Sections 10/34, 10/35, and 10/36 of Part Ten. The instrumentation involved in these sciences is dealt with in Section 723 of Part Seven.

Division I. Stages in the Development of Human Life on Earth

Division I. Stages in the Development of Human Life on Earth

The outlines in the two sections of Division I present studies in historical comparative anatomy that place *Homo sapiens* within a general taxonomy; the theory of human evolution; and studies, in genetics and physical anthropology, of human heredity and the races of mankind.

Section 411. Human Evolution

A. The evolutionary process

B. Human evolutionary relationships with living and fossil primates

1. The primates
   a. Distinguishing characteristics of the primates
   b. The natural history of primate life
   c. Evolution and paleontology
   d. Classification of the primates: the two main groups or suborders, the prosimians (principally lemurs, lorises, and tarsiers) and the anthropoids (monkeys, apes, and man)
      [see also 313.F.25.c.]

2. Distinguishing characteristics of the Hominidae
   a. Morphological characteristics
   b. Inferred behavioral characteristics
   c. Contrasting adaptations of Hominidae and Pongidae

C. The fossil record of the Hominidae

1. The discovery and recognition of the hominid fossil record
2. Classification of the Hominidae
   a. *Australopithecus*
   b. *Homo habilis*
   c. *Homo erectus*
   d. *Homo sapiens*
      i. Fossil remains of early *Homo sapiens*: e.g., Vértesszöllős man, Ngoloba man, Border Cave man, Swanscombe man, Omo hominids
      ii. The Neanderthals
      iii. The Cro-Magnons
      iv. *Homo sapiens* of Africa
      v. *Homo sapiens* of Asia and Australasia

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with human evolution

Evolution, Human
Life

**MICROPAEDIA**: Selected entries of reference information

General subjects

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Human Heredity

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   2. Inheritance of behavioral traits
      a. Fraternal and identical twins and the inferences that can be made from twin studies
      b. Genetic explanations for abnormalities: chromosome variations, mutation
   3. Applications of human genetics
   4. Specific behavioral traits affected by inheritance
   5. Consanguinity and its effects

B. The nature and origin of human physical variation
   1. Aspects of human diversity
   2. Measures of “race”
      a. Old measures; e.g., colour, hair form, body measurements, features such as eyes and nose
      b. Modern measures; e.g., blood groups and genetic evidence

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with human heredity: the races of mankind
   Evolution, Human
   Genetics and Heredity, The Principles of
   Life

MICROPAEDIA: Selected entries of reference information

General subjects

human heredity: consanguinity founder principle pedigree
assortative mating dominance genetic drift recessiveness
character eugenics heterospecific mating
climatic adaptation

Biographies
   See Sections 10/34 and 10/36 of Part Ten

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Division II. The Human Organism: Health and Disease

The outlines in the four sections of Division II treat the structures and functions of the human body; human health; the manifestation, recognition, and treatment of human disease; and the practice of medicine.

The outline referred to in Section 421 deals with the structures and the functions of the several organ systems, the proper coordination and regulation of which constitute the health of the human body.

The outline in Section 422 begins with an enumeration of the stages in human life and the definitions of normality in human health. It then treats of the various ways that the body maintains itself and recovers from injury. The Section concludes with a listing of other significant influences on human health.

The outline in Section 423 first treats the general characteristics, causes, and classifications of human disease. It then treats the concepts, principles, and methods of the medical art, in the two stages of diagnosis and therapy. The outline encompasses the symptoms, diagnosis, and treatment of diseases that affect the body as a whole, and of diseases that affect each of the organ systems dealt with in their healthy state in Section 421.

The outline in Section 424 deals with issues relating to the professionalization of the practice of medicine—not only those internal to the profession but also those arising from the educational, economic, social, political, and legal dimensions of institutionalized medicine.

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Section 421. The Structures and Functions of the Human Body

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      b. Blood groups
      c. Bleeding and blood clotting
   4. Blood circulation: the central pump, the systemic circulation, the pulmonary circulation

B. The structures and functions of the lymphatic system: lymphocytes, lymphatic vessels, lymph nodes, and the lymph

C. The structures and functions of the respiratory system
   1. The upper portion of the respiratory tract: nasal cavity, pharynx, larynx, and trachea
   2. The lungs and bronchi
   3. The regulation, control, and dynamics of breathing

D. The structures and functions of the digestive system
   1. Structure of the components of the digestive tract
      a. Mouth and related structures
      b. Pharynx and esophagus
      c. Stomach
      d. The small intestine and the small bowel mucosa
      e. Large intestine, rectum, and anus
      f. Associated glands and structures: pancreas, liver, gallbladder, and bile ducts
   2. The digestive process

E. The structures and functions of the endocrine system
Principal Parts of

THE HUMAN BODY
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Suggested reading in the *Encyclopædia Britannica*:

MACROPAEDIA: Major articles dealing with the structures and functions of the human body

- Biochemical Components of Organisms
- Blood
- Circulation and Circulatory Systems
- Digestion and Digestive Systems
- Endocrine Systems
- Excretion and Excretory Systems
- Integumentary Systems
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      b. Physiological responses to exercise and the effects of physical conditioning
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      b. Psychophysiological variations in sleep; e.g., REM, NREM, light and deep sleep, dreaming
      c. Effects of general and selective sleep deprivation
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with human health

- Death
- Exercise and Physical Conditioning
- Immunity
- Nutrition

**MICROPAEDIA**: Selected entries of reference information

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   c. Disorders of the spinal cord and autonomic nervous system
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   e. Other disorders of the general nervous system
   f. Disorders of the eye and vision
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with human diseases

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General subjects

diagnosis—laboratory tests:
amniocentesis basal metabolic rate blood analysis blood count Bromsulphalein test cardiac catheterization electrocardiography electroencephalography electromyography endoscopy enzyme analysis glucose tolerance test kidney function test liver function test Pap smear patch test Rubin’s test serological test skin test thyroid function test tuberculin test ur analysis
diagnosis—radiography and ultrasound:
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diagnosis—other:
atopsy diagnosis gynecological examination knee-jerk reflex lumbar puncture sphygmanometer stethoscope
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AIDS allergy anaphylaxis angioedema asthma autoallergic disease autoantibody autoimmunity drug allergy hay fever hypersensitivity reagin serum sickness disorders—blood diseases:
agranulocytosis anemia aplastic anemia erythroblastosis fetalis folic-acid-deficiency anemia hemoglobinopathy hemophilia hereditary spherocytosis iron-deficiency anemia leukemia leukocytosis leukopenia methemoglobinemia pernicious anemia polycythemia purpura septicemia sickle-cell anemia thalassemia thrombocytopathy uremia disorders—cancers:
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disease
diverticulum
edema
empyema
fetal alcohol syndrome
fever
gangrene
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hernia
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hypophosphatemia
Kawasaki syndrome
lesion
potassium deficiency
progeria
prolapse
Reye’s syndrome
sarcoidosis
Sjögren’s syndrome
sodium deficiency
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infectious agents:
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treatments—
prosthetic devices:
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artificial heart
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Section 424. The Practice of Medicine and the Care of Health

A. Medical education

B. Fields of specialized medical research: the related disciplines of osteopathy, dentistry, and nursing [see 10/35.C.]

C. The practice of medicine
1. The kinds of medical practice in various countries
   a. General practice and first-contact care: the general practitioner versus the specialist, clinic and health centre practice
   b. Hospital and specialist practice: general surgery, pediatrics, anesthetics, pathology, teaching practice
   c. Governmental practice: public health service, military practice, space medicine
   d. Research
2. Maintenance of professional standards
   a. The ethical basis of medical practice: e.g., the Hippocratic oath, problems relating to euthanasia and abortion
   b. Licensure requirements for practice: the wide variation among countries
   c. Legal restrictions on practice
   d. Professional organizations and the maintenance of standards

D. Public health services and administration

E. Hospital services and facilities

F. Environmental sanitation and health: the control of air, water, and soil pollution [see 737.C.1.]

G. Efforts directed toward the prevention of malnutrition: the recognition and attempted solution of problems relating to nutrient requirements, world food supply, and world population

H. The prevention and control of infection
   1. Vaccination and immunization
   2. The quarantine and isolation of infected victims
   3. Destruction of infectious agent or carrier: e.g., aseptic and antiseptic precautions, control of disease carriers, disinfection
   4. The use of therapeutic agents and prophylactic medication
   5. The prevention and control of epidemics
I. Industrial and social medicine

1. The scope of industrial and occupational medicine

2. Health and safety laws: the regulation of working hours; restrictions on female and child labour; the elimination of health, safety, and fire hazards; the control of foods and drugs; pollution control [see 552.D.]

J. The economics of health and disease

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the practice of medicine and the care of health

- Birth Control
- Medicine
- Occupational Diseases and Disorders

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

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**Division III. Human Behaviour and Experience**

[For Part Four headnote see page 143.]

The outlines in the six sections of Division III set forth the discoveries and theories in the psychological sciences concerning human capacities, human behaviour, and human experience.

Section 431 is concerned with the questions of the definition and origins of human behaviour and experience. It also indicates the stages in the development of a person’s behaviour and experience.

The outline in Section 432 deals with the capacities by which humans receive, organize, and interpret information about the current environment that influences behaviour. It treats the following subjects: attention; sensation; perception; the perception of time, of space, and of movement; perceptual illusions and hallucinations; and parapsychological phenomena.

Section 433 is concerned with current internal states that affect behaviour and conscious experience. It treats the determinants and manifestations of activation level; motivational states; emotional states; and transient states affecting behaviour and experience, such as sleep, dreams, hypnosis, fatigue, and intoxication.

Section 434 is concerned with persisting capacities that influence human behaviour and conscious experience. The outline treats the nature and assessment of human abilities and attitudes; sensorimotor abilities; intellectual abilities; and the distribution of intelligence.

Section 435 is concerned with the development of a person’s potentials by learning and thinking. The outline treats diverse general theories of learning; deals separately with psychomotor, perceptual, and conceptual learning; and then treats memory and forgetting and the theories about and the types of the higher thought processes.
The outline in Section 436 sets forth those parts of psychology, psychopathology, and psychotherapy that consider the functioning, the integration, and the disintegration of the person as a whole. It treats diverse definitions and theories of personality and the self; theories of personality adjustment and maladjustment; and the kinds of mental disorders and their psychiatric treatment.

Section 431. Human Nature and Experience: General Considerations 160

A. The relative contribution of opposing factors in human behaviour and conscious experience, the degree to which these factors interact to produce human behaviour and conscious experience

1. Mankind as radically distinct from nature and mankind as homogeneous and continuous with the rest of nature
   a. Behavioral capacities and performances that humans have in common with other primates and higher mammals
   b. Behavioral capacities and performances held to be distinctive of humans; e.g., propositional language, cumulative transmission of culture
   c. The explanation of allegedly distinctive human traits in accordance with the principle of phylogenetic continuity: the evolutionary development of mankind [see also 341 and 411]

2. The relative weights of genetic and environmental factors: the nature—nurture controversy
   a. Elements of genetic endowment; e.g., physiological and psychological characteristics, reflexes and instincts
   b. Environmental conditions; e.g., ecological factors, cultural conditioning, personal socialization experiences

3. Cognitive, conative, and affective dimensions of behaviour and experience
   a. The cognitive dimension: sensation and perception; memory and imagination; concept formation, ideation, and reasoning
   b. The conative dimension: desires, needs, cravings, drives; motivation and purpose; the voluntary and the involuntary
   c. The affective dimension: the emotions, the pleasant and the unpleasant; the sentiments

4. The observed elements of behaviour and the inferred dispositional tendencies: actions and powers; habits, inclinations, and capacities

5. Emergent problems in the study of human behaviour and experience: the data and hypotheses of parapsychology; the comparison of human and artificial, machine-created intelligence

B. Stages in the development of human behaviour

1. General aspects of human development
2. Prenatal growth and development
3. Birth: effects of the birth experience on the person’s subsequent history
4. Infancy: the first 18 months
5. Early childhood and childhood: one to 12 years
6. Adolescence: puberty to adulthood
7. Young adulthood and maturity
8. Old age and death [see also 338.E.]
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major article dealing with human nature and experience: general considerations

- Behaviour, The Development of Human

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- adolescence  
- adulthood  
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- creativity  
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**Section 432. Influence of the Current Environment on a Person’s Behaviour and Conscious Experience: Attention, Sensation, and Perception**

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3. Theories of perceptual and of nonperceptual parapsychological phenomena: physical theories, field theories, and theories of the collective unconscious; projection hypothesis

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the influence of the current environment on a person's behaviour and conscious experience: attention, sensation, and perception

- Attention
- Perception, Human

**MICROPAEDIA:** Selected entries of reference information

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[see also 321.C.4.c]
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with the current internal states affecting a person's behaviour and conscious experience

- Emotion, Human
- Motivation, Human
- Sex and Sexuality
- Sleep and Dreams

**MICROPAEDIA**: Selected entries of reference information

- Emotional states:
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H. Persuasion and change of attitude

**Suggested reading in the *Encyclopædia Britannica*:**

**MACROPAEDIA:** Major articles dealing with the persisting capacities and inclinations that influence human behaviour and conscious experience
- Intelligence, Human
- Psychological Tests and Measurement

**MICROPAEDIA:** Selected entries of reference information

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**Suggested reading in the *Encyclopædia Britannica*:**

**MACROPAEDIA:** Major articles dealing with the development of a person’s potentials: learning and thinking
- Learning and Cognition, Human
- Memory
- Thought and Thought Processes
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2. Prevalence of mental disorders: epidemiology
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Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with personality and the self: integration and disintegration of the person as a whole

Freud
Mental Disorders and Their Treatment
Personality

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Introduction to Part Five:  
Man the Social Animal  
by Harold D. Lasswell

We are part of society when we share in comprehensive arrangements for living with one another and for managing the environment. The simplest societies are the primitive bands who to this day live in jungles and deserts, and on isolated mountains and beaches around the globe. The most complex technological societies bind the world’s cities together as part of an evolution that, barring catastrophe, is forming a planetary society of mankind.

Whether primitive or civilized, all societies must cope with the parallel problems that are generated by the urgencies of human nature and the necessities of a common life. Arrangements are made for kinship and procreation; for safety, health, and comfort; for producing and consuming commodities and services. Arrangements also develop latent talent into skills of communication, body movement, and environmental management. Institutions specialize in the gathering and dissemination of news and images of the natural and social environment. Some institutions give respect or disrespect to individuals and groups on a temporary or permanent basis, and distinguish between what is considered to be responsible or irresponsible conduct. Government, law, and politics seek to resolve the conflicting demands that arise within or among communities.

At first glance we are less likely to be impressed by the parallels than by the differences among societies. The differences are conspicuous, if we consider, say, a horde of big-city commuters as compared with a band of technologically handicapped people who are continually in search of the next meal. An anthropologist who lived with such a band a few years ago in the rain forests of eastern Bolivia reported that apart from the hammocks they slept in, three-foot digging sticks, and cumbersome long bows and arrows, these naked seminomads carried no material objects with them. Modern urban dwellers usually feel some contempt for these bearers of an Old Stone Age culture and speculate on a possible weakness of the brain to account for their lack of technological progress. Such speculations are dismissed by modern anthropologists as without foundation. As we get acquainted with primitive societies it dawns upon us that they have met some of the same problems that we have by adopting solutions whose ingenuity equals or even excels our own. This may apply, for instance, to arrangements for transmitting political authority from one generation to the next, or for preventing violently aggressive behaviour.

Societies do indeed differ from one another in the degree that they encourage specialization. In the simplest societies everybody does everything, with exceptions that are closely linked to differences of sex and age. On the other hand, many tribes use professional specialists, such as warriors, medicine men, blacksmiths, potters, weavers, musicians, and carvers. The world that we call civilized appeared with the invention of writing. Literacy provides a means of storing and retrieving information without relying exclusively on the memory of the old. Records and education multiply the number of learned professions. Urban civilization marks the emergence of such institutions as the territorial state, formal legislative codes of law, regular taxes, bureaucratized civil and military services, monumental public works, complex systems of taxation, and official records.

One way to bring out the degrees of likeness and difference among societies, whether primitive or civilized, is to compare the priorities that are given to institutions of the same kind. No one doubts that every society must concern itself to some extent with food. It is only in bands of the kind mentioned above that near-total preoccupation with hunger deemphasizes, although without abolishing, all other interests. Where existence is less hard the accumulation of wealth may become the principal value sought, as among some merchant cities and trading tribes. War and preparation for war may take top priority as it did for millennia among the shepherds of Inner Asia and the river-valley agriculturalists who were conquered by herdsmen-warriors. Some agricultural societies emphasize worship and encourage forms of knowledge, like astronomy, that enhance religion. In some societies, notably in East India, the accent is on ritual purity or impurity, and every kin group is assigned a position in the respect system of caste and class.

While priorities may remain stable for generations in a given society, this is not necessarily the case. At one time the peoples of Scandinavia were warriors and brigands. Today we perceive them as among those who are most involved with the values of civil society. In the United States, the early colonizers of New England were heavily involved with the values of civil society. In the United States, the early colonizers of New England were heavily oriented toward religion, morality, and political freedom. More recently, the most general trend has been toward secular activities, especially those connected with wealth. Throughout the contemporary world, “development” often carries the connotations of economic modernization, political independence, scientific education and research, personal freedom, and social justice.

Besides allocating priorities, every society strikes a temporary or durable balance between the accumulation and the immediate enjoyment of every value. The modes of accumulation depend on the value in question. Investment in wealth production, for instance, may involve adding fertilizers to the soil, or building an infrastructure of roads and bridges, or inculcating the values of saving and investment. Expanded educational opportunity implies that more per capita hours of teaching and learning, and more physical equipment, are made available, and that the importance of education is successfully communicated. If health opportunities are to be multiplied, it is necessary to add facilities and to spread the practice of personal hygiene. A society cultivates public enlightenment with installations for scienti-
tific and scholarly purposes, and for mass communication. Human relations improve as the roles of love, friendship, and loyalty expand in "an era of good feeling," and as social discrimination wanes. Levels of responsible conduct typically rise as opportunities become more available for worship and more people join in formulating and applying moral standards. During a given period the institutions of government, law, and politics sometimes accumulate more support.

The examples mentioned above refer to the "positive" accumulation of a valued outcome. Accumulations may be "negative," as when disasters destroy property, spread epidemics, or interfere with education.

All societies necessarily make arrangements for the sharing of wealth, power, and other values. Among individuals and groups these arrangements exhibit all degrees of equality and inequality. Wealth and income are sometimes widely distributed. By contrast, they may be monopolized in the hands of a few. Political participation may be dispersed or concentrated. Opportunities may be equalized or monopolized for health, education, and information; or for respect, affection, and responsible conduct.

Characteristic of every society is the attempt to maintain itself by controlling the minds of young and old. People not only hunt or plow, trade or fight. They are also likely to believe in what they do and how they do it. It is not necessarily true that in a system of inequality those who occupy any particular station, however exalted or lowly, entertain any doubts about the justification of the system. A stable society carries on within the framework of a common map of perception, belief, and identity. In such a setting the individual learns from earliest infancy to think, feel, and act in ways that bring positive rather than negative consequences from the social and natural environment.

Socialization is the process by which private motivations are channeled into acceptable public acts.

In civilized societies reliance on the results of early education is heavily supplemented by government, law, and politics. The legal system is made up of several sets of authoritative and controlling prescriptions. One set is constitutive. It prescribes "who decides what and how." It centralizes or decentralizes formal and effective power, and it separates power among agencies and groups. Structures may be differentiated to plan, to promote, to legislate, to execute, or to review and appraise. Regulation defines the degree of protection given to the fundamental institutions of every sector of society. Tradition alleges that a legal order is blind to values and practices that lie outside the established beliefs, faiths, and loyalties ("ideologies") of the society with which it is involved. In consequence, legal systems may defend widely different balances between value accumulation and enjoyment, and sharply contrasting patterns of equality and inequality in the sharing of political power, wealth, respect, or any other value. The legal order may protect economic systems whose structures are capitalistic, socialistic, or cooperative; family systems that permit one or more members of the sexes to marry and raise children; religious faiths that exalt monotheism and polytheism; and so on through the infinite variety of human practices.

One set of prescriptive norms is supervisory. Individuals and groups may be given wide latitude to make private contractual agreements or to seek redress of private wrongs. Nonetheless, the decision makers of the community are prepared to play a supervisory role by enforcing common norms if an unsettled private controversy is brought to their notice by the parties. Prescriptions also lay down the principles and procedures to be followed if the body politic organizes and administers a continuing enterprise, of which services of transportation, communication, banking, insurance, and housing are examples. A legal system includes correctional or sanctioning measures to obtain compliance with prescribed norms. Value deprivations are imposed on those who have failed or are expected to fail to comply. Deprivations range in severity from capital punishment, confiscation of property, or life imprisonment, to a light fine or reprimand.

A legal system is stabilized when the effective elements in society perceive themselves as relatively better off by continuing the system than by adopting alternative arrangements. To some extent a legal order may exhibit cyclical fluctuations, as when deviations are tolerated within limits which, if exceeded, generate reform activities that restore the former situation with little change. In a capitalist economy "creeping monopoly" may invade trade unions, employers' associations, or natural resource and industrial enterprises. In a socialist economy "black markets" may introduce "creeping competition." In either case, cyclical movements may restore the original relationship before they have quietly stabilized a structural innovation, or prepared the way for violent revolutionary change.

If the view is correct that worldwide interdependence is increasing, the traditional blindfold of legal systems must be put aside long enough to give explicit consideration to competing value goals and practices around the globe. Interdependence implies that whether they like it or not, the members of an emerging planetary society must take one another into account. Being taken into account implies that beliefs, faiths, and loyalties, as well as overt behaviours, are examined by public and private decision makers. The demand to be better informed about the social environment creates an enormous opportunity and responsibility for those who study society.

We expect anthropologists to provide us with knowledge of primitive societies and other specialists to focus on the processes and institutions of civilized society. Political scientists and legal scholars concentrate on government, law, and politics. Economists specialize in the production and distribution of wealth. The role of educators is relatively clear. So, too, is the role of sociologists who concern themselves with a sector of society, such as the family, social class and caste, professions and occupations, communication, public health, or comparative morals and religion.

Social scientists are continually under pressure to provide a map of the past and probable future impact of the forces that shape society. They are asked, for instance, to explain the causes of war and other forms of violence, and to suggest strategies that lead to "victory" in a specific conflict or to show how war itself may be eliminated as an instrument of public policy. Social scientists are asked for explanations of why an economy experiences inflation, or how it generates changing levels of employment and unemployment. Specialists are expected to discover the sources of alienation that separate young and old or threaten the
unity of a family, a school, a church, a political party, or a national state. These examples suggest the wide-ranging demands that confirm the importance of adding to our knowledge of society.

We recognize the existence of a problem when we perceive that our goals are inconsistent with one another or when there are discrepancies between what we want and what we have or expect. In public policymaking, the first step is to answer the question, "Whose values are to be realized?" The social scientist who participates in tackling a policy problem has an option: he may adopt the criteria of a "client" or he may rely on his own values.

The study of social institutions is sometimes affected by diverging norms of professional responsibility. No conflict need arise if a social scientist is personally committed to a line of research that happens to be popular with influential members of the body politic. No anxiety or guilt is felt if the findings are applied by current decision makers. A frequent example is the study of administrative agencies according to their "dollar efficiency" or according to the accuracy and speed of communication between central offices and field stations.

In contrast to this harmonious relationship is the inner and perhaps visible turmoil of social scientists whose research interests are unacceptable to many members of the current establishment. The researchers may want to study the effect of military expenditures on society. The problem may be to find how a given level of military outlay modifies the structure of the civilian economy and influences both the production and delivery of services specialized for health, education, public information, family welfare, and other social outcomes. If the information gathered in the course of a given project is classified as secret, no scientist can lawfully report his findings. Perhaps the investigator will violate the letter of the law in the hope of mobilizing an effective demand for change. But it may be that such a strategy will backfire. Instead of arousing community protest against authority, the revelations may result in established leaders successfully taking advantage of an alleged "breach of security" to suppress inquiry and discussion.

Another complication affecting the social investigator is the degree of genuine consent that he must obtain from those whom he proposes to study. Physicians, surgeons, and biologists confront similar questions when they plan to give a test, run an experiment, administer a drug, or perform an operation. Is it always necessary to explain to a prospective subject the risks he will run? Is the investigator professionally or legally bound to make sure that the language of explanation can be understood by the individual concerned? If a social scientist plans to study the facts of life in a prison or a mental hospital, should he reveal his purpose, even when it would be easier to gain confidence by posing as a fellow prisoner or a fellow patient? Similar issues rise in connection with field studies of primitive tribes, of peasant communities, of foreign societies, and of many other social settings.

In recent times, professional opinion has emphasized the importance of obtaining "shared participation" in the pursuit of knowledge. Many investigators willingly accept the challenge of cultivating group demand for a project and for a hand in data gathering and analysis. At every stage, arrangements are made for laymen to work side by side with professional sociologists, social psychologists, political scientists, and other investigators. As a result, some communities have learned to study themselves, assessing the degree to which they are involved in ethnic and other forms of discrimination. Unusual groups have joined in self-study. For instance, murderers and persons who have survived as targets of murderous assault have cooperated in scientific research on the causes and consequences of murder, and on possible strategies of prevention. Instead of resenting the role of "guinea pig" in science, it is typical for those who choose to participate in programs of self-observation to improve their individual insight while contributing to the enhancement of society's stock of knowledge.

Whether the client or the investigator is the source of the value criteria adopted for a policy problem, questions of value priority are bound to arise. The relative importance of political, economic, and other aims cannot be satisfactorily settled in programs of national or regional development unless the full range of possible goals is considered. It is essential to take timing into account. When a new nation-state first secedes from an empire, political power has top priority. The "ex-colony" tries to ensure its independence of external control, to obtain support from outside powers, and to unify its people. Economic development occupies a high priority position. Other targets, such as health, education, the expressive arts, and environmental protection, seem to be less urgent. The allocation of manpower and facilities to various institutions depends on the priority of the specific outcomes in which these institutions specialize.

Social scientists have an indirect influence on priorities by asking questions about them, and also by presenting a factual map of past trends, causes, and future contingencies. Scientists often devise small-scale pretests in order to try out solutions that may eventually be applied on a larger scale.

In adapting to the needs of this interdependent world, the scientists of society require of themselves that they measure the direction and intensity of the value demands of political, economic, ethnic, and all other identifiable groups anywhere on the globe. Acknowledging the perils of a divided and militant world, the most compelling task is to discern and make public the conditions under which a world public order of government and law could become a more perfect instrument of human dignity, security, and welfare. Many small-scale programs show how to reduce the human cost of transforming today's inadequate institutions into more effective systems of communication and organization.

For the first time in history it can be truly asserted that the scientists of society have been provided with technological instruments of sufficient sophistication to assist in meeting the demands that are made upon them. Retrieval and dissemination make it possible to map past, present, and future events. Social analysts know that the key question for the future is to resolve whether or not the spectacularly changing technology of knowledge, and especially knowledge of society, will be in the hands of a limited class or caste that seeks to serve its own advantage. The alternative is to share the control of information widely among all territorial and pluralistic groups. Unless individuals and groups are able to obtain access to com-
prehensive stocks of information, they will be blind judges of public policy. Without adequate access, their criticism will be dismissed as exercises in ignorance and bias. Critics will be in no position to develop realistic alternatives to the plans of governmental or private monopolists of knowledge. "Knowledge is power"; if there is to be self-control, there must be prompt and total access to information.

The chief novelty about the computer and other technically advanced means of processing and transmitting information is that, in principle, everyone can be given prompt access to a selective "map of the whole." An image of the total deployment of man in space or of the total activities of a corporate enterprise can be made available to everyone from the highest official to the humblest worker. The salient facts can be made vivid, concise, and substantially accurate in images that may be supplemented in whatever detail is desired. The range of possible expenditures for any political, economic, or social program can be summarized and related to its potential impact on society.

Human society has attained an unparalleled height of danger and opportunity. The study of society shares in both. The unprecedented accumulation of knowledge enables us to recognize that the scale of our problems is also without precedent.
Part Five. Human Society

All studies of mankind take account of the effect of the social nature of humans. This is true of the treatment in Part Four of human evolution, health, and general nature and behaviour. It is also true of the treatments, in subsequent parts, of art, technology, religion, history, and the sciences and philosophy.

A special set of interrelated sciences, however, takes society and social behaviour as its direct subject of inquiry. The outlines in the six divisions and the twenty-five sections of Part Five are concerned with the complementary work of these social sciences.

The social sciences have themselves been the object of historical and analytical study. These studies are presented in the articles referred to in Section 10/36 of Part Ten. The outline in that section covers the history of the social sciences generally, and the nature, scope, methods, and interrelations of anthropology, sociology, economics, and political science.

The social sciences have become increasingly interdependent and interpenetrating, and no regulative agreement exists about how their distinction should be understood. Nevertheless, the diverse domains are, in practice, distinguishable. The breakdown of Part Five into six divisions reflects the currently operative distinction between cultural and social anthropology, the several branches of sociology, economics, political science, jurisprudence and law, and educational philosophy and science.

Division I. Social Groups: Peoples and Cultures

The outlines in the four sections of Division I set forth anthropological accounts of the development and the variety of sociocultural forms.

Section 511. Peoples and Cultures of the World

A. In the Arctic
   1. In the eastern Arctic
   2. In the western Arctic

B. In North America
   1. In the sub-Arctic
   2. On the Northwest Coast
   3. In California
   4. On the Plateau
   5. In the Great Basin
   6. In the Southwest
   7. On the Plains
   8. In the eastern woodlands
   9. In the Southeast
C. In Middle America
   1. In northern Mexico
   2. In Mesoamerica
   3. In Central America and the northern Andes
   4. In the Caribbean

D. In South America
   1. In the central and southern Andes
   2. In the tropical forest
   3. Among the South American nomads

E. In Europe
   1. On the Atlantic fringe
   2. On the plain
   3. Along the Mediterranean
   4. On the Alpine climax

F. In the Middle East and North Africa
   1. In the Maghrib: northwestern Africa
   2. In the Mashriq: northeastern Africa and southwest Asia
   3. In Iran
   4. In Turkey

G. In Asia
   1. In Siberia
   2. In Central Asia
   3. In East Asia
   4. In South Asia
   5. In Southeast Asia

H. In sub-Saharan Africa
   1. In the western Sudan
   2. In the eastern Sudan
   3. On the Guinea coast
   4. In the Congo
   5. In central and lower East Africa
   6. In the East African Horn
   7. In southern Africa

I. In Oceania
   1. In Australia
   2. In Melanesia
   3. In Polynesia
   4. In Micronesia
Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with the peoples and cultures of the world

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**MICROPAEDIA:** Selected entries of reference information

**General subjects**

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{**Middle America and northern Andes:**}

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South America—

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    - Araucanian
  - Atacama
  - Aymara
  - Chavín
  - Chimú
  - Diaguita
  - Inca
  - Mapuche
  - Quechua

South America—

- Nomadic:
  - Abipó
  - Chono
  - Guató
  - Makú
  - Mataco
  - Mbayá
  - Ona
  - Puelche
  - Puri and
  - Coroado
  - Querandi
  - Sirionó
  - Tehuelche
  - Warrau
  - Yámana
  - Yaruro

- Tropical forest:
  - Apapocuva
  - Bororo
  - Botocudo
Section 512. The Development of Human Culture

A. Diverse theories of culture: conceptions involved in the analysis of culture
   1. Definitions of culture
   2. Culture and personality
   3. Cultural comparisons: ethnocentrism, cultural relativism
   4. Cultural adaptation and change
   5. Cultural patterns
   6. Cultural institutions

B. Types of cultures
   1. Cultures of primitive and nonurban societies
      a. Cultures of nomadic and settled hunters and gatherers
      b. Horticultural societies: societies in which primitive agriculture is supplemental to hunting and gathering
      c. Cultures of pastoralists and herders: distribution and characteristics
      d. Cultures of peasants and settled agriculturists
   2. Cultures of civilized societies: theories of their origin and evolution
   3. The development of modern industrial civilization: mass society

C. Processes of cultural change
   [see Division II, below]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the development of human culture
- Culture, The Concept and Components of Modernization and Industrialization
- Social Sciences, The Social Structure and Change

MICROPAEDIA: Selected entries of reference information

General subjects
- acculturation
- age-area hypothesis
- cultural evolution
- culture
- culture-and-personality studies
- culture area
- environmentalism
- folk society
- Gemeinschaft and Gesellschaft
- hunting and gathering society
- hydraulic civilization
- industrialization
- Kulturkreis
- Mesolithic Period modernization
- Neolithic Period nomadism
- Paleolithic Period
- peasant
- primitive culture region
- social Darwinism
- survival
- transhumance
- urban revolution

Biographies
- See Section 10/36 of Part Ten

INDEX: See entries under all of the terms above
Section 513. Major Cultural Components and Institutions of Human Societies

A. Systems of relationship based upon marriage and descent: kinship
   1. General aspects of kinship
   2. Laws and customs regarding mate selection, sexual behaviour, marriage and divorce, legitimacy
      [see also 553.B.]
   3. Rules of residence; e.g., virilocal, uxorilocal, neolocal
   4. Descent systems: unilineal, cognatic, and variant forms
   5. Control of resources, inheritance, and succession: the family as a centre for transmission of
      economic, religious, political, and other powers and goods
   6. Kinship and social change: kinship as an evolving social institution

B. Other social structures
   1. The varieties of groups and other associations within societies
   2. Organization by status: class systems, caste systems, systems characterized by slavery or serfdom

C. Types of economic systems
   1. The economic systems of primitive or nonurban peoples
      a. Production, division of labour, role differentiation
      b. Exchange of goods, distribution of wealth
      c. Property and property rights
   2. The economic systems of developed nations
      [see Division III, below]

D. Other elements common to all cultures but differing in expression or practice between cultures
   1. Education and socialization: formal and informal enculturation
   2. Religious belief, folklore
      [for religious belief, see 811]
   3. Legal systems
      [see 551.B.]
   4. Artistic expression: literature, visual arts, performing arts; crafts
      [see 611, 612, and 613]
   5. Linguistic systems
      [see 514]
   6. Recreation, sports and games
   7. Passage and purification rites: birth, puberty, marriage, death

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with major cultural components and institutions of human societies
   Culture, The Concept and Components of
   Family and Kinship
   Inheritance and Succession
   Social Sciences, The
   Sports, Major Team and Individual

MICROPAEDIA: Selected entries of reference information

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<td>gens</td>
<td>matriarchy</td>
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### Section 514. Language and Communication

A. Communication as a foundation of human culture and as the essential element in social and cultural interaction, the role of communication in the modification of human behaviour

B. Nonverbal communication

1. Communication by means of bodily gestures and posture, by facial expression
2. Laughter and nonword sounds as communication
3. The use of signals, signs, symbols, icons, and cultural artifacts
4. Cybernetic communication: computer languages, human language–computer interfaces, and artificial intelligence and expert systems
5. Parapsychological forms of communication: telepathy

[see 432.H.1]

C. The nature of language

1. Definitions of language
2. Ways of studying language: phonetics, grammar, semantics
3. Language variants: dialects, slang, and specialized variants *(e.g., jargon, pidgins, creoles)*
4. Speech: the psychological and physiological bases
5. Meaning and style in language: structural and lexical meanings; semantic flexibility; language and conceptualization; style
6. Language and culture: transmission of language; language and social differentiation; control of language for cultural ends; language learning and literacy; written language and spoken language
7. Linguistic change and language typology
8. Cryptology: codes, ciphers, and other means of encrypting language

D. The structure of speech and language

1. The phonetics of speech *(articulatory, acoustic, linguistic)*; phonetic transcription; experimental phonetics
2. The physiology of speech: regulators *(respiratory and brain functions)*; the larynx; voice production *(including synthetic voice production)*
3. Speech disorders

E. Written language: systems of notation

1. The nature, origin, and evolution of writing: from pictures to the alphabet
2. Types of writing systems: logographic, syllabic, consonantal, alphabetic, featural
3. Systems of writing: hieroglyphic, cuneiform, alphabetic, ideographic
4. Adjuncts to writing: punctuation, shorthand
5. Calligraphy and the art of handwriting: early Semitic, Arabic, Greek, Latin, Indic, East Asian

F. Linguistics: the scientific study of language and language development
[see also 10/36 H.]
1. The development of linguistic theory
2. Synchronic linguistics: structural, transformational-generative grammar, tagmemics, stratificational grammar, the Prague school
3. Diachronic linguistics: linguistic change, comparative method, language classification
4. Dialectology and the study of linguistic geography
5. Semantics: the study of language and meaning
6. The study of writing
7. The classification of language

G. Language and society
1. Attitudes toward language: taboos in language use, myths about the origin of language, the relation of language and thought
2. The connection of language with history, the role of language in the transmission of culture
3. The role of language in cross-cultural relations
4. The use of language as a political instrument
5. The role of language in unifying social and occupational groups

H. Languages of the world
1. Indo-European languages
   a. Anatolian
   b. Indo-Iranian
   c. Greek
   d. Italic
   e. Romance
   f. Germanic
   g. Armenian
   h. Tocharian
   i. Celtic
   j. Baltic
   k. Slavic
   l. Albanian
2. Uralic languages
   a. Finno-Ugric
   b. Samoyedic
3. Altaic languages
   a. Turkic
   b. Mongolian
   c. Manchu-Tungus
4. Dravidian languages
   a. South Dravidian
b. Central Dravidian
c. North Dravidian

5. Austroasiatic languages
   a. Mon-Khmer
   b. Munda

6. Sino-Tibetan languages
   a. Chinese
   b. Tibetic
   c. Burmic
d. Baric
e. Karenic

7. Hmong-Mien (Miao-Yao) language

8. Tai languages
   a. Southwestern Tai
   b. Central Tai
c. Northern Tai

9. Paleo-Siberian languages
   a. Nivkh
   b. Yukaghir
c. Chukchi
d. Koryak
e. Itelmen
f. Ket

10. Caucasian languages
    a. South Caucasian
    b. North Caucasian

11. Afro-Asiatic languages
    a. Semitic
    b. Egyptian
c. Berber
d. Cushitic
e. Chadic

12. Korean language

13. Japanese language

14. Austronesian languages
    a. Formosan
    b. Western Malayo-Polynesian
c. Central Malayo-Polynesian
d. South Halmahera-West New Guinea
e. Oceanic

15. Papuan languages

16. Australian Aboriginal languages

17. African languages
    a. Niger-Congo
    b. Chari-Nile and Nilo-Saharan
c. Khoisan
18. Indian languages of North America
   a. Eskimo-Aleut
   b. Na-Dené
   c. Macro-Algonquian
   d. Macro-Siouan
   e. Hokan
   f. Penutian
   g. Aztec-Tanoan

19. Indian languages of Meso-America
   a. Uto-Aztecan
   b. Tequistlatec
   c. Tlapa
   d. Oto-Pamean
   e. Popolocán
   f. Mixtecan
   g. Zapotecan
   h. Chinantecan
   i. Mixe-Zoque
   j. Totonacan
   k. Mayan
   l. Misumalpan

20. Indian languages of South America and the Caribbean
   a. Arawakan
   b. Cariban
   c. Macro-Chibchan
   d. Macro-Ge
   e. Macro-Pano-Tacanan
   f. Quechumaran
   g. Tucanoan
   h. Tupian

21. Language isolates
   a. Sumerian
   b. Etruscan
   c. Basque

22. Pidgins and creoles

23. Constructed languages
   a. Special international or universal languages, including Esperanto and Interlingua; Basic English
   b. Machine languages: e.g., Fortran, Algol
      [see 735.D.3.]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with language and communication

Communication
Cryptology
Humour and Wit
Language
Languages of the World

Linguistics
Names
Speech
Writing
### MICROPÆDIA: Selected entries of reference information

#### General subjects

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- Danish language
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- Demotic Greek language
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Division II. Social Organization and Social Change
[For Part Five headnote see page 173.]

The outlines in the four sections of Division II present general sociological theories of social order and social change, and sociological studies of basic social institutions, social processes, and social problems.

Section 521. Social Structure and Change 186
Section 522. The Group Structure of Society 188
Section 523. Social Status 189
Section 524. Human Populations: Urban and Rural Communities 190

Section 521. Social Structure and Change
A. The structure of society: diverse theories of social structure and organization, various types of social structure
B. The social effects of bureaucratic and industrial specialization
   1. The social effects of industrialization and modernization
   2. The social effects of organizational specialization: bureaucracy
   3. The social effects of industrial specialization and automation
      [see also 712.C.]

C. Social control
   1. The process of socialization: the transmission of patterns of normative behaviour by family, peer groups, and education
   2. Theories of alienation: definitions, causes, manifestations, and proposed solutions
   3. The regulation of behaviour that departs from social norms
      a. By punishment, rehabilitation, and reform of criminals
      b. By psychological therapy
      c. By persuasion

D. Factors operative in social change
   1. The role of ideology in social change
   2. Contact with other cultures as a factor in social change
   3. The influence of environment as a factor in social change
   4. The role of demographic factors in social change
   5. The role of art in social change: art as an ideological instrument
   6. Religion as a factor for and against social change
   7. The role of intellectual factors in social change
   8. The relationship of economic factors to social stability
   9. Technological factors in social change
   10. The role of collective behaviour in social change
   11. The role of public opinion in social behaviour

E. Social movements and social change
   1. Characteristics of social movements
   2. Selected types of social movements
      a. Movements centred on religious concepts or personalities
      b. Humanitarian and reform movements
      c. Interest group movements
      d. Revolutionary movements
      e. Nationalist movements
      [see also 541.C.3.b.vii.]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with social structure and change
   Collective Behaviour
   Crime and Punishment
   Modernization and Industrialization
   Propaganda
   Public Opinion
   Social Sciences, The
   Social Structure and Change
   Work and Employment

MICROPAEDIA: Selected entries of reference information

General subjects
   punishment and rehabilitation:
      amnesty
      Auburn system
      Baumes Laws
      Borstal system
      commutation
      deportation
      Elmira system
      exile and 
      banishment


Part Five. Human Society

indeterminate punishment social change collective
sentence recidivism social Darwinism behaviour
mark system reformatory social movement temperance
parole workhouse movement
penal colony social change: social norms phenomena: penal colony
Pennsylvania civil disobedience and associated
system social structure
prison probation

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Section 522. The Group Structure of Society

A. The various types of groups: patterns of group relations
   1. Classifications of groups
   2. The modern family: its organization and functions
   3. Special-interest groups
      [see also 541.B.3.]
   4. Minorities and ethnic groups

B. The social effects of racial and ethnic prejudice

C. Special social concerns
   1. Adolescence
   2. Old age
   3. Women’s social and legal status
   4. Cultural minorities
      [see A.4., above]
   5. Poverty
   6. Criminality and delinquency
   7. Sexual orientation
   8. Prostitution
   9. Drug and alcohol abuse
  10. Suicide

D. Social service: organized public and private activities to alleviate human wants and needs
   1. The background of social and welfare services: modern and historical influences
   2. Fields of service
      a. Family welfare
      b. Child welfare
      c. Youth welfare
      d. Group welfare
      e. Disaster relief
      f. Community development
      g. Medical and psychiatric social services
      h. School social services
         [see also 561.C.4.]
      i. Correctional services: probation, parole, and delinquency control
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the group structure of society

- Alcohol and Drug Consumption
- Crime and Punishment
- Family and Kinship
- Sex and Sexuality
- Social Sciences, The
- Social Welfare

**MICROPAEDIA:** Selected entries of reference information

### General subjects

- **family and marriage:**
  - adoption
  - betrothal
  - bridewealth
  - divorce
  - dowry
  - exchange marriage
  - exogamy and endogamy
  - family
  - group marriage
  - hagiology
  - joint family
  - levirate
  - marriage
  - nuclear family
  - parent

- **social legislation and social services:**
  - crime
  - delinquency
  - drug abuse
  - habitual offender
  - old age
  - organized crime
  - poverty
  - prostitution
  - racial segregation
  - racism
  - suicide
  - white-collar crime

### Other:

- **social problems:**
  - alcoholism
  - child abuse

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## Section 523. Social Status

### A. Social differentiation and stratification

1. The concepts of differentiation and stratification: distinctions and interrelationships
2. Factors producing social, economic, and cultural differences: sex differentiation, age differentiation, racial differentiation, intellectual differentiation, social and cultural factors [see 521.D.]
3. The process of stratification: its relationship to differentiation
   a. Economic differentiation: the basis of stratification
   b. Class, status, and power as forms of stratification
   c. The relation of the individual to society: the effects of differentiation and stratification

### B. Varieties of social stratification and social mobility

1. The relation of social class to caste, status, elites, and other concepts
2. Theories of social class: divergent conceptions of the importance of classes in social structures and of the nature of class relationships
3. Types and characteristics of and comparisons among modern social classes: upper class, working class, and middle class; the special case of the peasant class
4. Social mobility
5. The idea of a classless society: approximations to an equality of conditions
6. Social immobility: slavery, serfdom, and forced labour
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with social status

- Slavery
- Social Sciences, The

**MICROPAEDIA**: Selected entries of reference information

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A. The composition and change of human populations

1. Determinants of population
   a. Human fertility and its control
   b. Mortality: death rates and longevity
   c. Migration and refugee movements

2. Historical changes in population

3. Theories of population
   a. Premodern beliefs: pronatalism versus birth control
   b. Mercantilist theory
   c. Laissez-faire theory
   d. Malthusian theory
   e. Marxist theory
   f. Modern theories of population; *e.g.*, optimum population size, optimum rate of population growth, relationship between population and demographic movements
   g. Ecological theories concerning the relationship between human population growth and the conservation of natural resources

4. Governmental policies influencing population growth and composition

5. The future of the world’s population: population projections and problems of the population explosion

B. Development of modern cities

1. Characteristics of urbanization

2. History of urbanization

3. Patterns of urban planning
   a. Methods and materials of urban planning and redevelopment
   b. Social aspects of urban planning and redevelopment

4. Trends in urbanization
   a. Megalopolis: the coalescence of several metropolitan areas into a contiguous agglomeration of people and activity
b. Suburbanization: the growth of politically separate but economically dependent residential communities surrounding large cities

c. Regional integration: economic and cultural interaction between the city and its hinterland

d. The role of technology in extending the dominance and influence of urban concentrations

e. Problems of urban growth and population control

f. Problems of environmental change: pollution, climatic change

C. Development of modern rural societies

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with human populations: urban and rural communities
- Birth Control
- Cities
- Climate and Weather
- Modernization and Industrialization
- Population
- Social Sciences, The

**MICROPAEDIA:** Selected entries of reference information
- General subjects
  - age distribution
  - birth control
  - census
  - city
  - contraception
  - demography
  - human migration
  - metropolitan area
  - mortality
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  - parenthood
  - pollution
  - population
  - refuge
  - rural society
  - urban climate
  - urban planning

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**Division III. The Production, Distribution, and Utilization of Wealth**

[For Part Five headnote see page 173.]

The outlines in the seven sections of Division III deal with the economic order in human society.

Section 531. Economic Concepts, Issues, and Systems 191


533. The Organization of Production and Distribution 194

534. The Distribution of Income and Wealth 198

535. Macroeconomics 199

536. Economic Growth and Planning 201

**Section 531. Economic Concepts, Issues, and Systems**

A. Some basic concepts of economics
   1. The concept of economic activity as a process of choosing among scarce resources
   2. The concept of division of labour
   3. The concepts of diminishing returns and optimization
   4. The concept of marginality
   5. The concept of capital
   6. The concept of competition
   7. The concept of comparative advantage
   8. The concepts of growth and development

B. Levels of economic analysis
   1. Microeconomics: the economic decisions of individuals, households, and firms
2. Sectoral economics: the economic arrangements of industries, groups, and regions
3. Macroeconomics: the economy as a whole

C. The comparison of different economic systems
1. Archetypal economic systems
   a. The pure private enterprise economy: a theoretical model
   b. The centrally planned economy: the pure socialist model
   c. The mixed economy with various degrees of economic planning
2. Western-type market economies
3. Soviet- and socialist-type economic systems
4. Mixed economies in developing countries
5. Other economic systems
   a. Primitive economic systems
   b. Feudal economic systems

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with economic concepts, issues, and systems
   Economic Systems
   Economic Theory

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B. The satisfaction of material wants: the behaviour of consumers
   1. National consumption levels in the private sector: trends in expenditures for goods and services
   2. Factors influencing consumers' tastes and spending
   3. The protection of consumer interests

C. Markets as an economic institution in a mixed economy
   1. Markets classified by reference to competition and monopoly
      a. Purely competitive markets as distinguished from markets of imperfect competition: monopoly, oligopoly, and monopolistic competition
      b. Influences affecting the behaviour of sellers under various competitive conditions
      c. The concept of workable competition
      d. Government regulation of monopolistic practices
2. Major types of markets
   a. Markets for primary commodities
   b. Markets for manufactured goods
   c. Markets for money and capital: the market for short-term loans, the securities market
   d. The market for labour and services
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3. The counterpart of the market under full-scale economic planning: markets under socialism

4. The historical development of markets: the market in economic theory, the relationship of the market to social welfare and politics

5. Markets in international trade
   [see 533.F.]

6. The function of the market in the establishment of equilibrium between supply and effective demand

D. The price system in capitalist economies

1. The price system as a means of organizing economic activity: the determination of what is to be produced, how goods are to be produced, and who gets the product

2. Limitations on and failures of the price system: areas in which the price system does not function
   a. Control of prices by business: price-fixing
      [see C.1.a., above]
   b. Government-established price controls and subsidies: regulations concerning public utilities and bank interest rates
      [see 534.B.4.b., and 534.B.6.b.]
   c. Economic relationships not susceptible to control by prices: "externalities," such as air pollution and highway congestion
      [see also 737.C.1.]
   d. Imperfect knowledge on the part of buyers as to alternative uses of their buying power
      [see B.2., above]

3. The role of the public sector in the distribution of goods and services: government budgets
   [see 534.B.1.]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the consumer and the market: pricing and the mechanisms for distributing goods

<table>
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<tr>
<th>Economic Theory</th>
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</tbody>
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MICROPAEDIA: Selected entries of reference information

General subjects

| consumer protection: antitrust law | credit card demand curve | bazaar black market |
| nature Business Bureau | indifference curve marginal utility | cartel |
| consumerism | producer goods propensity to consume | cobweb cycle commodity |
| fair-trade law | supply and demand | exchange commodity |
| consumption: consumer good | market organization and pricing | trade futures |
| consumer's surplus | auction | hedging marginal-cost pricing |
| consumption function | | market marketing board |

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INDEX: See entries under all of the terms above
Section 533. The Organization of Production and Distribution

A. The organization of the production of goods
   1. Analysis of costs and output in the short run: the production function, substitution, the relationship of marginal cost to market price, marginal product
   2. Analysis of costs and output in the long run for profit maximization and cost minimization

B. The organization of the distribution of goods
   1. The relation between the productive process and the incomes derived from it [see also 534.A.2. and A.3.b.]
   2. The earnings of land, labour, and capital employed in the productive process

C. The inputs of the productive process
   1. Labour as an input in the productive process
      a. The labour force: size, quality, and deployment of work force
      b. Methods of fixing rates of pay
      c. The structure of pay: differences in the earnings of various occupations
      d. Changes in the general level of pay
      e. Employment and unemployment
      f. The economic and social status of temporary, seasonal migrant labourers
      g. The organization of unions
      h. The influence of the union on the supply of labour, wages, and output
      i. Capital elements in labour: education and training
      j. The economic role of managers and entrepreneurs
   2. Land and raw materials as inputs
   3. Energy as an input
   4. Capital as an input in the productive process

D. Institutional arrangements that facilitate production and output
   1. The nature and characteristics of money
      a. The basic functions of money
      b. The various forms of money
      c. The quantity theory of money: views of classical and neoclassical monetary theorists, views of Keynesian income theorists
   2. The monetary functions of commercial banks and central banks
      a. Historical development of banking systems
      b. The structure of modern national banking systems
      c. Principles and functions of commercial banking systems
      d. Principles and functions of central banking systems
      e. The money market: various national and international markets for short-term funds
      f. International monetary institutions: proposals for future monetary cooperation and an international currency unit [see also 535.B.2.]
      g. The market for long-term funds: savings institutions, the stock and bond markets, credit unions, mortgage institutions, farm cooperative banks, insurance institutions, mutual funds, pension funds
      h. The nature and functions of government credit agencies
   3. The use of economic statistics in the determination of production and output
      a. National income statistics
b. Price statistics: the use and construction of indexes of retail and wholesale prices
c. Economic forecasting
4. The business corporation

E. Agricultural economics
1. The relationship between agricultural and economic development
2. Efforts to control prices and production in agriculture: government price supports, subsidies, and acreage limitations
3. The behaviour of farm prices and the consequences for the incomes of farmers
4. The effect of technology on world agriculture: the increase in acreage and in crop yields
5. The organization of farming: types of farms

F. The geographical distribution of resources and markets: international trade
1. Classical and contemporary theories of international and interregional trade
2. National and regional factors influencing trade
   a. Tariffs, embargoes, and quotas imposed to obtain revenue, protect domestic industry, and secure a favourable balance of payments
   b. Changes in the conditions of production: costs, labour, and technology
   c. Price movements
   d. National domestic taxes and subsidies
      [see also 534.B.4.]
3. International trade arrangements

G. The role of government in production and distribution
1. The theory of public expenditures: the role of taxation in the budgetary process and problems of effective tax administration
2. The justification of the government’s claim to share in resource use: problems of balancing resource consumption between the public and private sectors
3. The growth in government spending in the 19th and 20th centuries: the rise in military and social welfare expenditures
4. Government operation of basic industries

H. Methods of business organization
1. The keeping of accounts
   a. Accounting as an information system
   b. Various types of company financial statements; e.g., the balance sheet, the income statement
   c. Principles of accounting measurement: asset and cost measurement
   d. Cost accounting: formulation of budgetary plans, performance reports, profit analyses
2. The management of business funds
   a. Short-term and intermediate-term financial operations: planning and control, the cash budget, accounts receivable, inventories
   b. Long-term financial operations: the design of capital structure and the issuance of securities
   c. Consolidations and mergers
3. The management of human resources: personnel administration
   a. Personnel departments: their functions and services
   b. Manpower planning, recruitment, and placement
   c. Employee training and development
   d. Methods of maintaining employee incentive and commitment
4. The administration and control of production
   a. The flow channels of information and materials
   b. The control function: maintaining conformity between operations and the plan
c. Production scheduling

d. Inventory adjustment

5. The distribution of goods
   a. The functions of a marketing department in a large firm
   b. Retailing
   c. Wholesaling
   d. Marketing goods to industry, marketing farm products
   e. The application of market research techniques to merchandising

I. Advertising

J. The distribution of risk
   1. The nature of insurance
   2. Fire and marine insurance
   3. Casualty and surety insurance: liability insurance, theft insurance, aviation insurance, workmen's compensation or industrial injury insurance, credit insurance, title insurance, suretyship
   4. Private life and health insurance
   5. Government-sponsored and/or government-administered health insurance
      [see 534.13.4.c.]
   6. Underwriting of risks: rate making
   7. Legal aspects of insurance

K. Consumer credit
   1. Types of consumer credit: installment loans and noninstallment, or single-payment, loans
   2. Historical development of consumer credit in industrialized countries
      a. Lending institutions and the question of interest rates
      b. Costs and hazards of consumer credit
   3. Efforts to protect the consumer: the dimensions of consumer credit

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the organization of production and distribution

| Accounting | Coins and Coinage | Insurane | International Trade | Social Sciences, The Work and Employment |
| Banks and Banking | Economic Growth and Planning | International Trade | Marketing and Merchandising | Markets |
| Business Organization | Economic Theory | Government Finance | Money |

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General subjects

agricultural economics: bank development bank investment trust
agricultural economics bond discount rate liquidity preference
extensive capital dividend marginal efficiency
agriculture central bank exchange, bill of investment of investment
intensive commercial bank Federal Deposit insurance money market
agriculture consumer credit Corporation money order
kolkhoz credit central bank Federal Reserve mutual fund
tenant farming credit, letter of System national bank
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advertising and public relations:
Markowitz, Harry M.
Mellon, Andrew W.
Miller, Merton H.
Modigliani, Franco
Morgan, John Pierpont
Rothschild family
Sage, Russell
industry:
Carnegie, Andrew
du Pont family
Field, Marshall
Ford, Henry
Getty, J. Paul
Guggenheim,
Meyer and Daniel
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Hughes, Howard
Hunt, H.L.
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Byoir, Carl
Lasker, Albert

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Belmont family
Fugger family

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consumer price index
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Dow Jones average econometrics

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Section 534. The Distribution of Income and Wealth

A. The distribution of wealth and income by categories of the population
   1. The nature and measurement of wealth and income
   2. Methods of classifying the distribution of wealth and income
      a. Distribution by factor shares: wages, profits, interest, and rent
      b. Distribution according to the number of persons in various classes of wealth and income
   3. Patterns of wealth and income distribution among various countries and among persons within a country
      a. Frequency distributions
      b. Comparisons among wealth and income groups

B. The routes by which government affects the distribution of wealth and income
   1. The national budget as the program of the government’s revenues and expenditures
   2. The nature and purposes of taxation
      a. Principles of taxation; e.g., adequacy, adaptability, universality, ability to pay
      b. The effect of taxes on the distribution of income: progressive and regressive taxes
      c. The burden of taxation: the problem of shifting and incidence
      d. Characteristics of national tax systems: comparisons of tax burdens
   3. Kinds of taxes
      a. Taxes on real and personal property
      b. Sales and excise taxes
      c. Tariffs and export taxes
      d. Taxes on personal income and capital gains
      e. Taxes on corporate income and excess profits
      f. Death and gift taxes
      g. Social security and payroll taxes
   4. Transfers and subsidies
      a. Interest payments on the public debt
         [see B.5., below]
      b. Subsidies and tax concessions
      c. Government-sponsored and government-administered welfare programs
   5. The financing of budgetary deficits and surpluses
   6. Direct controls over the private sector
      a. Price, wage, and profit control
      b. Control of restrictive practices: antitrust legislation, regulations imposed upon public utilities, labour legislation imposed on unions
         [see also 532.C.1.d.]
      c. Economic mobilization for war
   7. Land reform: the redistribution of land tenure
Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the distribution of income and wealth

- Economic Theory
- Government Finance
- International Trade
- Land Reform and Tenure

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- government revenue and spending
- ad valorem tax
- aid
- assessment
- capital-gains tax
- capital levy
- death tax
- depletion
- allowance
- estate tax
- excess-profits tax
- gift tax
- government budget
- guaranteed minimum income
- income tax
- indexation

- inheritance tax
- likin
- luxury tax
- poll tax
- progressive tax
- property tax
- public debt
- regressive tax
- relief
- revenue bond
- sales tax
- single tax
- social insurance
- social security
- social welfare
- program
- subsidy
- tariff

- taxation
- toll
- treasury bill
- unemployment insurance
- use tax
- value-added tax
- war finance
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- antitrust law
- fair-trade law
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- allodium
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**Section 535. Macroeconomics**

A. National income and employment theory

1. The concern of income and employment theory with changes in aggregate output, employment, and prices
   a. The classical law of markets contrasted with the Keynesian theory of effective demand
   b. The classical and Keynesian theories of unemployment

2. The circular flow of income and expenditure: national product as goods and as earnings

3. Analyses of fluctuations in national income

B. International economic and financial equilibrium and disequilibrium

1. Foreign exchange markets: problems of alternative monetary standards and fixed and fluctuating exchange rates
   a. Equilibrating movements in the balance of payments and the mechanisms of adjustment: arbitrage, short-term movements, interest rates, and forward exchange
   b. Disequilibrating movements as a response to currency devaluation: covering, hedging, and speculation
   c. Balance of payments accounting
   d. Methods for adjusting to fundamental disequilibrium: fiscal and monetary policy, incomes policy, devaluation and revaluation, and restrictions on capital movements

2. International monetary and financial institutions: the International Monetary Fund, the Group of Ten, and other attempts at international cooperation

[see also 533.D.2.f.]
a. Problems of maintaining adequate gold and currency reserves: gold crises, special drawing rights
b. The aftermath of major wars: economic and financial crises, economic nationalism

C. Business cycles
   1. The statistical study of cycles: the identification and measurement of business cycles, various cyclical theories
   2. Theories of the business cycle and business cycle models
   3. Countercyclical monetary and fiscal policy

D. Inflation and deflation

**Suggested reading in the *Encyclopædia Britannica*:**

**MACROPAEDIA:** Major articles dealing with macroeconomics
   - Economic Theory
   - Government Finance
   - International Trade
   - Social Sciences, The

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

| Economic cycles: | monetarism | monetary policy | International Development
| business cycle | national income | Association
| depression | accounting | International Finance
| inflation | nationalization | Corporation
| panic | open-market | International Monetary Fund
| Phillips curve | operation | trade:
| recession | parity | comparative advantage
| fiscal and monetary policy: | regional development | customs union
| bimetallism | program | embargo
| bullionism | silver standard | exchange rate
| deficit financing | sterling area | free trade
| economic stabilizer | two-tier gold | free-trade zone
| fiscal policy | system | General
| fractional reserve system | international | Agreement on
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| | and Development | international trade

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Section 536. Economic Growth and Planning

A. The nature and causes of economic growth
1. Various factors influencing economic growth: e.g., technology, markets, the supply of capital, the labour force, governmental fiscal policies

2. The theory of economic growth and models of growth
   a. Various models of economic growth: supply-determined models, demand-determined models, and target-instrument models
   b. The practical functions of growth theory and mathematical growth models

3. Social costs and benefits of economic growth

4. Economic growth in developing countries
   a. The relationship between economic underdevelopment and low per capita income: the rate of increase of gross domestic product (GDP) as compared to population growth
   b. Various theories of national economic development and economic retardation

5. Changes in economic efficiency as measured by changes in output per unit of input: economic productivity

B. Planning for economic growth and stability
1. The nature of economic planning

2. Economic planning in Communist countries

3. Economic planning in developed non-Communist countries

4. Economic planning in developing countries

Suggested reading in the Encyclopædia Britannica:

**MACROPAEDIA:** Major articles dealing with economic growth and planning

- Economic Growth and Planning
- Economic Theory
- Government Finance
- International Trade
- Social Sciences, The

**MICROPAEDIA:** Selected entries of reference information

General subjects

<table>
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Division IV. Politics and Government

[For Part Five headnote see page 173.]

The outlines in the four sections of Division IV treat general theories of the state and of government; the structure, branches, and offices of government; the functioning of government; and international relations in peace and war.

Section 541. Political Theory 202

542. Political Institutions: the Structure, Branches, and Offices of Government 204

543. The Functioning of Government: the Dynamics of the Political Process 205

544. International Relations: Peace and War 206

Section 541. Political Theory

A. The national state as viewed in political theory

1. Properties of statehood: sovereignty
2. The state and the individual
3. The national state in the international community
[see also 552.B.]
4. Various conceptions of the bases of legitimacy and authority of government
   a. Continuing consent of the governed: popular sovereignty
   b. The social contract
   c. Venerable sanction: hereditary monarchy, constitutional succession
   d. Divine right: God as the source of political authority
5. Theories of constitutionalism, modern constitutional governments
[see also 551.B.4.]
   a. Origins and theories of constitutional government
   b. Features of constitutional government
   c. Methods of constitutional growth: evolution and substantive replacement

B. Patterns of political action as viewed in political theory

1. Political action within small groups, villages, or communities
2. Political action by organized parties
3. Political action by special-interest groups
4. The political influence of public opinion

C. Political concepts, ideologies, and problems

1. The concept of political power
2. The concept of human rights
3. Modern ideologies
   a. The importance of ideology to a political system or movement: the relationship between ideological and civil politics
   b. Current political ideologies and tendencies
      i. Anarchism
      ii. Communism
      iii. Conservatism
      iv. Fascism
      v. Liberalism
      vi. Marxism
      vii. Nationalism
      viii. Socialism
4. Contemporary political issues and problems
   a. The problem of church and state: its background and contemporary form
   b. The urban problem: the administration of cities and metropolitan areas
      [see also 524.B. and 542.A.1.c.]
   c. The problem of international cooperation and integration
      [see also 544.A.]
   d. The issue of centralization of power versus decentralization
   e. The problem of adapting traditional political forms to changing conditions
   f. Bureaucracy: the issue of responsive government
      [see 542.C.]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with political theory

<table>
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Section 542. Political Institutions: the Structure, Branches, and Offices of Government

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1. Levels and structures of various systems of government
   a. Supranational political systems: empires; leagues, confederations, and commonwealths; regional federations; world congresses
   [see 544.A.]
   b. National political systems: the unitary nation-state system, the federal state system
   c. Urban governments
   d. Other subnational political systems: tribal community governments, rural community governments, regional community governments
   [see also 521.A.]

2. Types and models of political systems

B. The branches of government

1. The concentration of legislative and executive functions: parliamentary rule
2. The legislature
3. The executive
4. The judiciary
   [see also 552.F.1.]

C. Public administration: the planning, organization, and coordination of governmental bureaucratic operations; civil service

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with political institutions: the structure, branches and offices of government

Cities
Government. The Forms of:
Their Historical Development

Political Systems
Public Administration
Social Sciences, The

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A. The ways in which political power is exercised
   1. Internal and external security functions of government
   2. The conduct of foreign relations: the function of government in relation to other sovereign states, its own dependencies, and international organizations [see 544]
   3. Supervisory functions of government: the resolution of conflicts through mediation and the adjudication of suits [see also 552.F.1. and 3.]
   4. Regulatory functions of government: the establishment and active enforcement of standards
   5. Law enforcement and the corrective functions of government: sanctions, inducements, and penalties [see also 522.C.6. and D.2.1.]

B. Government’s role in production and consumption

C. Methods of changing the form of government
   1. Peaceful changes: by electoral process (plebiscite), by constitutional mandate
   2. Violent changes: revolution, civil war, conquest by a foreign power

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the functioning of government: the dynamics of the political process
- Censorship
- Crime and Punishment
- Police
- Political Parties and Interest Groups
- Political Systems
- Social Sciences, The

**MICROPAEDIA:** Selected entries of reference information

General subjects
- *censorship*: banning, censorship, censorship, obscenity, pornography, *electoral constituencies*: gerrymandering, legislative, apportionment, pocket borough, proportional representation
- *electoral process*: absentee voting, Australian ballot, election, electoral college, plebiscite, plurality system, political, convention, political party, primary election, referendum and initiative, suffrage
- *law enforcement*: capital punishment, constable, criminal, investigation, Federal Bureau of Investigation, Interpol, KGB, police, posse comitatus, punishment, ranger, Royal Canadian Mounted Police
- *sheriff*
- *torture*
- *legislative procedure*: cloture, filibuster, legislative, investigative, powers, parliamentary, procedure
- *other*: revolution, sabotage, terrorism

Biographies
- See Section 541

INDEX: See entries under all of the terms above
Section 544. International Relations: Peace and War

A. The politics of international relations
   1. Transnational political parties and movements, e.g., Pan-Africanism, Pan-Arabism, Pan-Slavism, European federalism
   2. International and nonnational organizations and agencies, e.g., the United Nations, Red Cross and Red Crescent

B. International treaties and agreements
   1. Nonaggression treaties: collective security
   2. Treaties terminating wars
   3. Arms limitation and disarmament treaties
   4. Territorial treaties regarding the sale or transfer of land; treaties granting rights of access and other uses of territory; treaties settling border disputes
   5. Economic and commercial treaties
      [see 533.F.3.]
   6. Communications and transportation treaties
   7. Cultural exchange treaties

C. Foreign policy and diplomacy
   1. Foreign policy: its aims and compatibility with national and humanitarian interests
   2. The use of diplomacy in the negotiation of international disputes; public international conferences, arbitration, and mediation; secret diplomacy
   3. Foreign aid; government-sponsored organizations that affect internal relations in nonpolitical spheres, e.g., economic, cultural, technological organizations

D. The use of intelligence and counterintelligence activities in the preservation of national security and the conduct of international affairs

E. War among states
   1. Degrees and kinds of war: limited war; total war; ethnic or tribal wars; religious wars; national, regional, and worldwide wars; civil wars and insurrections; guerrilla warfare
   2. The conduct of war
      a. Military strategy
      b. Military tactics
      c. Military logistics
      d. Effects of psychological warfare on troops and civilians during wartime
      e. International law relating to the treatment of persons during wartime
         [see also 552.B.4.]
      f. The management of military expenditures
   3. Armed forces: military organizations designed for conquest or defense
      a. Types of soldiers: e.g., professional, volunteer, conscripted, and mercenary
      b. Historical development of organized military forces
      c. Establishment and maintenance of various branches of the armed forces
         i. Ground forces
         ii. Naval and amphibious forces
         iii. Air forces
         iv. Various auxiliary branches: e.g., police, intelligence, logistics, communications, medical, and legal corps
   4. The consequences of war
Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with international relations: peace and war

- Diplomacy
- Intelligence and Counterintelligence
- Social Sciences, The

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Division V. Law

[For Part Five headnote see page 173.]

The outlines in the three sections of Division V treat philosophies and systems of law, and the practice of law; the branches of public law; and the branches of private law.

Section 551. Philosophies and Systems of Law; the Practice of Law 208

552. Branches of Public Law, Substantive and Procedural 210

553. Branches of Private Law, Substantive and Procedural 212

Section 551. Philosophies and Systems of Law; the Practice of Law

A. Western and non-Western philosophies of law

1. Western philosophy of law
   a. The scope of the Western philosophy of law and its relationship to other branches of philosophy
   b. Problems of the philosophy of law, various approaches to a theory of law or jurisprudence
   c. The relationship between law and morality: the influence of the principles of natural law
   d. Historical survey of legal theories from the ancient world to the 20th century

2. Non-Western philosophies of law: Islamic, Chinese, and other non-Western philosophies of law

B. Ancient and modern legal systems

1. Primitive law: the legal systems of nonliterate peoples

2. Ancient systems of law
   a. Egyptian law
   b. Cuneiform law
   c. Chinese law
   d. Greek law
   e. Hellenistic law
   f. Roman law
   g. Germanic law

3. Medieval European law
   a. Origins and development of medieval European law
   b. Sources and institutions of medieval constitutional law
   c. Institutions of private law in medieval Europe
   d. Development of canon law

4. Modern systems of law
   a. Anglo-American common law
   b. Continental civil law
   c. Soviet and socialist law
C. The study of the distinctions and parallels among diverse legal systems

D. The profession and practice of law
   1. The profession of law
   2. Legal ethics
   3. Educational requirements for the legal profession

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with the philosophies and systems of law; the practice of law

- Law, The Profession and Practice of
- Legal Systems, The Evolution of Modern Western

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- ancient legal codes, principles and institutions:
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3. The attempt to create a supranational judicial authority
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5. The attempt to limit and punish war crimes and crimes against peace and humanity
6. The attempt to preserve the peaceful uses and exploration of outer space

#### C. Laws governing acts viewed as crimes

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   [see also 543.A.5.]
2. Laws governing offenses committed by military forces and other persons subject to military discipline

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2. Methods and procedures of the law
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3. Methods of adjudicating litigious disputes: the jury system, systems of arbitration
Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with branches of public law, substantive and procedural

- Constitutional Law
- Criminal Law
- International Law
- Judicial and Arbitral Systems
- Public Administration
- Taxation
- United Nations
- War, The Theory and Conduct of

**MICROPAEDIA**: Selected entries of reference information

**General subjects**

*constitutional law:*
- advisory opinion
- attainder
- commerce clause
- constitution
- due process
- equal protection
- ex post facto law
- interstate commerce
- judicial review
- police power
- powers of delegation
- privacy, rights of standing to sue
- states' rights

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- Appeal, Court of
- assigned counsel
- attorney general
- bailiff
- Chancery, Court of
- Common Pleas, Court of
- coroner
- Conseil d'État
- Cour de Cassation
- court
- court-martial
- Crown Court
- family court
- Federal
- Constitutional Court
- grand jury
- High Court of Justice
- juge d'instruction
- jury
- justice of the peace
- juvenile court
- lord chancellor
- lord chief justice
- lord high steward
- lord steward
- magistrates' court
- ministère public

*criminal law:*
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- prosecutor
- public defender
- Queen's Bench, Court of
- rapporteur
- Supreme Court of Japan
- Supreme Court of the United States
- Tax Court
- United States Claims Court
- United States Court of Appeals
- United States Court of Military Appeals
- United States District Court

*criminal procedure:*
- accomplice
- arson
- assault and battery
- bribery
- child abuse
- confidence game
- conspiracy
- contempt
- counterfeiting
- crime, délit, and contravention
- criminal law
- delinquency
- diminished responsibility
- disorderly conduct
- disturbing the peace
- embezzlement
- entrapment
- extortion
- felony and misdemeanor
- forgery
- fraud
- hijacking
- homicide
- infamy
- insanity

*general procedural law:*
- kidnapping
- lynching
- mayhem
- mens rea
- mutiny
- obscenity
- pardon
- perjury
- poaching
- rape
- riot
- sedition
- seduction
- self-defense
- smuggling
- solicitation
- theft
- treason
- unlawful assembly
- usury
- vagrancy

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- armistice
- asylum
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   b. Laws concerning children: legitimacy, adoption, and guardianship; parental obligations and rights
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   b. The employer's liability and the master–servant relationship
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   b. Interference with economic relationships: deceptive practices, unfair competition, infringement

D. Laws governing economic transactions
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         ii. Transfer of negotiable instruments: e.g., promissory notes, checks, drafts or bills of exchange
         iii. Issuance of documents of title; e.g., bills of lading, warehouse receipts
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2. The conduct of civil trials: the law of evidence

3. The rendering of judgment in civil cases: assessment of damages, res judicata, collateral estoppel

4. Post-trial appeals and other methods of review

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with branches of private law, substantive and procedural

- Business Law
- Family Law
- Inheritance and Succession
- Procedural Law

**MICROPAEDIA**: Selected entries of reference information

**General subjects**

- *Business law:* attorney, power of attorney, concubinage, power of consensual union
- *Agency:* damages, divorce, guardian
- *Air law:* declaratory judgment, illegitimacy
- *Antitrust law:* escrow, marriage law
- *Bankruptcy:* judgment, minor
- *Business law:* forgery, morganatic marriage
- *Caveat emptor:* joinder and impleader, separation
- *Composition:* liability, property
- *Consideration:* lien, remainder
- *Contract:* mandamus, writ of replevin, resurrection
- *Copyright:* settlement, ancient lights
- *Debtor and Creditor:* writ, rent, use
- *Guaranty and Suretyship:* estate law, usufruct
- *Hypothec:* executor, abandonment
- *Insolvency:* gift, adverse possession
- *Labour law:* heir, ancient lights
- *Lading, Bill of Lading,* gift
- *Liquidation:* inheritance, replevin
- *Maritime law:* intestate succession, settlement
- *Marriage Law:* settlement, separation
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Section 561. The Aims and Organization of Education

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   c. Higher education: colleges, universities, and professional schools
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2. The preparation and performance of teachers

   a. The education of teachers
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3. The economics of education

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Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with the aims and organization of education

Philosophies of the Branches of Knowledge

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   b. Decentralized systems: systems in which control is exercised at the regional or local level
   c. Joint national and local systems
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   e. Sectarian systems: national and regional sectarian systems. Sectarian education as an alternative system to public education

#### B. History of education: philosophies, practices, and institutions

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   b. Byzantine education: influences of Greek Christian and humanistic culture; development of primary, secondary, and higher educational institutions
   c. Kiev and Muscovy: Russian education to the period of the early Romanovs
   d. Islamic education
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b. The cultural revival under Charlemagne and his successors
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c. Japanese education from ancient times to 1867

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d. Education during the Reformation and Counter-Reformation

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b. Educational theories and practices
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7. Western education in the 19th century
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b. The early reform movements: the new pedagogy and psychology
c. Development of national systems of education
d. Spread of Western educational practices to Asian countries

8. Education in the 20th century
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b. Traditional and experimental educational movements in the West
c. The modernization of education in Asia and Africa
d. Education in colonies and newly emerging nations in Africa, Asia, and Latin America

C. International educational activities

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with education around the world

- Education, History of
- Teaching

**MICROPAEDIA:** Selected entries of reference information

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**INDEX:** See entries under all of the terms above
Let us imagine if we can a world entirely without art: without story, image, edifice, or significant sound. If we could see it, hear it, feel it, we would not know we did, at least as men know things. Without the earliest of all arts, language, we would scarcely know of what we were deprived: the privilege, namely, of expressing our satisfaction or dissatisfaction with what had taken place before our eyes. Without the arts of speaking, listening, thinking, counting, and measuring—without the intellectual arts—we could not assess or repossess the experience we had undergone. Without the useful arts we could make nothing, build nothing worthy to contain and shelter our bodies, to be a home wherein our thought might rest. And then without the fine arts—the arts that serve only themselves, that are ends, not means, that justify themselves when they give us nothing but pleasure—we would be shallow and poor of mind, with little or no sense of the world's depth and colour, or of ourselves as creatures for whom the present moment is also past and future. We call these arts fine not because they are better than the others but because they are different, as beauty is different from use—beauty that is its own excuse for being.

None of them is more intimately ours than story. The art of literature is the art of story; there are songs and there are essays long and short, there are histories, there are biographies, there are treatises, sermons, and discussions of everything under the sun, but story is our first and last entertainment—when we are children and when we are too old to care any more what truth is unless it comes in the past tense, with persons reflecting in their lives the peculiar radiance that attends the accidents of time and character. Stories may vary in length from the anecdote to the epic, from the fairy tale to the novel, the imaginary biography, the romance. And they may reach us in many forms: in the theatre, for instance, where they may employ flesh-and-blood actors to convey their meaning or where they may be only flickers of light and shade upon a screen that has no depth save what we give it in our imaginations; where, in other words, they call themselves plays or motion pictures or where, if music also sounds and dancers whirl and pose, they call themselves ballets.

Nature does not tell stories: only artists do, and in the process they work transformations that measure the distance between matter and mind. In nature, so far as we can know it, there are no beginnings and no ends in the sense familiar to both writers and readers of fiction and drama, or for that matter history, which likewise imposes form upon a welter of events. No matter how simple a tale is, or how complex, how few the words in it or how many, it is a human construction that no animal or plant, and of course no stone, would find in the least degree interesting; whereas human beings hold their breaths until an end is reached. Ends are intelligible as the raw materials of life seem not to be; if life itself does not become intelligible through story, it becomes in some mysterious way both beautiful and clear, and for the time being that suffices.

Each of the fine arts flourishes both in large and in little forms. Just as story has a choice between the brevity of folk tales and the elaboration of epics and romances, so statements about life may be as compendious as a proverb—the wisdom of many and the wit of one—or as bulky as the longest book in numberless volumes. So music—the sound of other worlds—reaches our ears either as simple song or as opera and symphony and other complex forms. There are those who say that the song, like the anonymous fable or tale, is more lasting and important than compositions of great complexity can ever be; and they also say that the lyric poem, at least when it is perfect, as in truth it seldom is, has more to tell us, or at least deeper ways of touching us, than the most tremendous tragedy in five acts or the subllest comic novel in a thousand pages. When a memorable melody attaches itself to a lyric or a ballad, something indeed does come into existence and hang there as if for perpetuity. Music is the most ineffable of all the arts. It has its own language and it listens to itself; we do not so much hear it as overhear it, nor can we speak very sensibly about what we have overheard. Successful music, powerful music, has an effect upon us that many have tried in vain to describe; it takes us out of ourselves, they say, and perhaps they need to say no more than that. Even then they may be speaking only of the music that is native to them; Eastern music sounds like mere noise to untrained Western ears, and Western music has a monotony, say the Chinese, that Europeans of course deny is there. The same thing is true, though in lesser measure, of all the arts. East and West have different eyes as well as ears, and different thoughts.

The arts of drawing and painting, ofetching and lithography, of engraving and decorative design, have covered many surfaces—canvas, plaster, parchment, paper—which no longer show where the artist's hand once worked: for the materials of these arts are perishable, as the marble of sculptors has been, as the bronze, as the wood. Much remains, but more does not. Even the cave paintings of prehistoric France and Africa, hailed by modern man when he discovered them as miracles of survival, may not survive the visits that living people rushed to pay them. Ancient Greek music has failed to survive for a further reason: we do not know how it was written or how it sounded; we are told that it had almost magical powers over those who heard it in its time, but that time is gone, along with the time when paintings adorned the walls and columns of Greek temples and houses. Painting has been for centuries the queen of the arts in Europe. Belgium.
The Netherlands, France, Germany, Spain, Italy, and England—each of them in its turn, and sometimes in more than one turn, has enriched the world with shapes and colours that only genius could have foretold, only passion could have brought into being. And that is but half the story; in China long before, in India, in Persia, in Japan, in Russia, the brushes of painters, sometimes tipped with gold, beautified and glorified the palaces of emperors, the tombs of princes, and the dwelling places of great gods. In Egypt for millennia the order of the world was registered in stone and gold, and the written word itself was pictures.

Sculpture, that once was solid and now is full of spaces—or may be—left open by the ingenuity of workers in metal, has changed as architecture has changed. Both arts now cultivate openness: buildings are closed, but the exterior is glass; so that space plays games with itself inside, and the effect is of a lightness that winds might blow away, except of course that the buildings look lean and strong enough to remain just where they are. It has always been true that architects desired the effect of lightness, as all art does, heaviness being a quality that no mind admires; any building weighs tons, but we are not supposed to think of that; rather indeed we are expected to imagine that brick and stone for once have learned to lie lightly on the earth, which they do not seem to press at all. So with Classical sculpture, from Greek days on; the charm of it was its poise, its grace, its management of idea in marble. So too with Classical architecture; the Parthenon is both massive and weightless, like a ship that might sail yet does not. And always in China and Japan there have been those curled and tapered roofs that still look as if at this very instant in time they are taking wing. The open revolution, then, was only a restatement of what had long been understood though some of its secrets were forgotten.

Abstraction in all the arts, for there is no art from which it is absent, is again a restatement of what has always been true, however feebly it was recognized by schools of artists who had lost contact with reality. Great painting, great music, great poetry, great architecture—great landscape architecture too—have never been strangers to abstraction, just as they have never been slaves to an incomplete understanding of what is meant when we say that art is imitation. It is imitation, but of what? Of essences, not accidents; of the truth that is hard to see; of beauty that is basic; of shapes that will not change; of colours that will not fade. And if, say, the great painters of the past, comprehending this, still "copied nature," they did not do so inanely. They did so, on the contrary, with huge effort aimed at the verities that underlie verisimilitude, so that in one sense they were not copying at all; they were extracting essences, they were reducing appearances to the ideas that informed them; they were, in a word, abstracting truth from vessels that contained it. But they did not say they were doing this. They said they were copying nature. And when later on they were taken at their word by painters with inadequate aspiration, the result was woeful insipidity, was mediocrity and flatness. The heroic remedy was warfare against representation as such, was a shortcut to abstraction that could have its weakness too, was a loss, in all but the great revolutionaries, of the contact with Earth which no art ever can be without. Abstract painting at its best—and the worst does not matter—imitates nature at nature’s best; is "like" nature after all, for nature is brilliant and strong, and abstract painting convinces us of this even though it dispenses with the particulars with which we used to be fascinated and of which we were quite properly fond.

A world entirely without art would be worse than invisible, inaudible, ineffable, and intangible. It would be a world without temporal dimension, it would be a world that human minds could not remember. Human memory is unique in its capacity not only to recall but also to utilize the past, and to apply it; and better still, to re-create it so that it becomes a part of the present moment, which is more like eternity than anything else we shall ever experience. Human memory is nothing less than the origin of human art.

"The Greeks fabled not unwisely," said Sir Thomas Browne, "in making Memory the mother of the Muses." The memory of man is indeed a wonderful thing, and his richest possession. Not only is it the source of all our arts, it is their record too, stored in the mind of the beholder, the listener. Plato even asked us to conceive "in the mind of man a block of wax, the gift of Memory, and when we wish to remember anything which we have seen, or heard, or thought in our own minds, we hold the wax to the perceptions and thoughts, and in that material receive the impression of them as from the seal of a ring; and we remember and know what is imprinted as long as the image lasts." An artist whose poems or pictures or musical ideas have great power is certainly, we feel, the possessor of a memory that is always at his command, bringing to him at any moment whatever detail he needs, and reminding him too of the knowledge he has, and never forgets, of the way the world is put together, so that he does not misrepresent things as they are. The human race itself can be said to be such an artist, for it has its myths which it keeps alive, its stories that are "so true," someone has said, "that they couldn’t have happened." There is such a thing as folk memory, the mother perhaps of all our thoughts and feelings, and the guardian of such wisdom as we have.

A story that cannot be remembered, a song that fades out of the mind, a hero whose name escapes us, a sentence we thought we would never forget but somehow do—such works of art must be defective at the core. But there are others that we could not forget if we tried, and it is those we live with in the company of friends who remember them too. Perhaps the final justification of art is the two-fold pleasure it gives: the pleasure of remembering great and beautiful things that we cannot lose, and the pleasure of sharing them with others who possess them in the same fashion.

There is a limited number of such things, of these greatest of human works of art; by definition there can be no superfluous masterpieces. The ones we have are numerous after all, and no single person can claim to have done justice to every one of them, or can claim to know what further ones are still unborn, Mnemosyne, goddess of Memory and Mother of the Muses, will have the deciding vote as to which ones, now or in the future, will survive the ravages of time.
Part Six. Art

The outlines in the twelve sections of Part Six are concerned with mankind's creation, experience, and evaluation of works made primarily for aesthetic enjoyment and contemplation. The arts of making things primarily for practical use are treated in Part Seven, on technology.

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Division I. Art in General

The outlines in the three sections of Division I treat the theory and classification of the arts; the experience and criticism of works of art; and the nonaesthetic contexts of art.

Section 611. Theory and Classification of the Arts 221
612. Experience and Criticism of Works of Art; the Nonaesthetic Contexts of Art 222
613. Characteristics of the Arts in Particular Cultures 224

Section 611. Theory and Classification of the Arts

A. The philosophy of art
   1. Diverse conceptions of the scope of art
   2. Diverse theories concerning the nature, functions, and effects of art: mimetic theories, expressive theories, formalist theories, pragmatic theories
   3. The making of works of art: the creative process

B. Classification of the arts
   1. Major distinctions among the kinds of art
      a. By reference to the intention of the maker or the recipient of the work of art: useful art, fine art, arts that are both useful and fine
      b. By reference to the manipulation of physical matter: the production of artistic works that are physical objects
      c. By reference to performers as interpreters or creators of works of art
      d. By reference to the use of notational devices; e.g., literature, music, dance
   2. Other distinctions among the kinds of art; e.g., space and time arts, primary and auxiliary arts
   3. The characterization of works of art by reference to the cultural or social circumstances of their production or the extent and character of their audience: the primitive, folk, and popular arts
   4. Style in the arts
      a. The nature of style
      b. The varieties of style; e.g., personal, school, ethnic, regional, and period styles
      c. The dynamics of style: the historical development, diffusion, change, and duration of style in the arts
Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major article dealing with the theory and classification of the arts
Philosophies of the Branches of Knowledge

MICROPAEDIA: Selected entries of reference information
  art mimesis
  fine art popular art
  folk art

INDEX: See entries under all of the terms above

Section 612. Experience and Criticism of Works of Art; the Nonaesthetic Context of Art

A. The aesthetic experience: the apprehension, interpretation, and appreciation of works of art
1. Influences affecting the apprehension of works of art: individual temperament, social and cultural conditioning, acquired attitudes and values
2. The interpretation of works of art
   a. Meaning in art
   b. Symbol and myth in the arts
      [see Division II, below]
3. The appreciation of works of art
4. Special problems of appreciation and apprehension
   a. In the sphere of literature
      [see 621]
   b. In the sphere of the theatrical arts
      [see 622, 623, and 625]
   c. In the sphere of music
      [see 624]
   d. In the sphere of the visual arts
      [see 626, 627, 628, and 629]

B. The criticism of works of art
1. Diverse criteria of evaluation: aesthetic criteria; criteria related to the union of form and content; criteria related to meaning; criteria related to social, moral, or religious significance; criteria related to technique; criteria related to the intention of the artist
2. The practice of criticism
   a. The functions of the critic in relation to the artist, to his work, and to its public reception
   b. Critical methods: analytical, interpretative, and descriptive types of criticism
   c. Critical styles: journalistic criticism, scholarly criticism, annotative and referential criticism
   d. Critical approaches to the arts
   e. Factors affecting the excellence of criticism

C. Scholarship in the arts
1. Resources and methods of scholarship in the field of the arts
2. The relation of scholarship in the arts to other humanistic disciplines; e.g., to linguistic studies, to history, to archaeology

D. The interaction of the arts with social, economic, and cultural institutions
1. Social uses of art
   [see 521.D.5]
2. Social control of art: censorship and related forms of regulation

3. The arts and religion
   [see 811.G.1.]

4. Technology, science, and the arts
   [see 711.B.4.]

5. The arts in education: aesthetic education

E. The economics of art
   1. Factors affecting the economic value of a work of art
   2. Systems of financing artistic activities
   3. The art market
   4. Remuneration of artists and protection of their rights
   5. Fraudulence in the arts: forgery, piracy, plagiarism

F. The training and work of the artist
   1. The preparation of the artist: methods of training
   2. Art as a vocation: conditions of work in the arts
   3. Professionalism and amateurism in the arts

G. The preservation and dissemination of works of art
   1. The role of institutions: libraries and archives; museums and galleries; producing associations—
      the preservation of works of art by performance
   2. The role of writing and notation
   3. The role of industry and commerce
   4. The role of mechanical and electronic media
   5. The role of oral tradition
   6. The role of imitative tradition
   7. The role of fairs, festivals, exhibitions, expositions, and related phenomena

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the experience and criticism of works of art; the
nonaesthetic contexts of art
   Arts, Practice and Profession of the
   Libraries
   Museums

MICROPAEDIA: Selected entries of reference information

General subjects

| Actors Studio, The antique | forgery | Stanislavsky method |
| Armory Show | library | Treasury Relief Art Project |
| art collection | little magazine | Treasury Section of Painting and Sculpture |
| art conservation | maniera | Universal |
| art criticism | Mbari Mbayo Club | Copyright |
| art history | museum | Convention |
| Beaux-Arts, École des Arts | PEN, International | World Intellectual Property |
| Berne Convention | pinacotheca | Organization |
| censorship | Royal Academy of Dramatic Art | |
| copyright | Salon | |
| Degenerate Art | Salon des Indépendants | |
## Biographies

| Baumgarten, Alexander Gottlieb Cotton, Sir Robert Bruce, 1st Baronet | Fenollosa, Ernest F. Fry, Roger Read, Sir Herbert Rosetti, William | Ruskin, John Santayana, George Thou, Jacques-Auguste de | Vasari, Giorgio Winckelmann, Johann |

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### Section 613. Characteristics of the Arts in Particular Cultures

A. Arts of the Stone Age peoples

B. Arts of the Western tradition

1. In antiquity: the arts of ancient Egypt and the ancient Middle East, ancient Greek and Hellenistic arts, ancient Roman and Early Christian arts
2. Arts of the Middle Ages
3. Arts from the Renaissance to the present in Europe and America

C. Arts of Asian peoples

1. In East Asia: China, Japan, Korea
2. In Central Asia: Turkey, Afghanistan, Turkistan, Mongolia, and Siberia; Tibet and other Himalayan countries; the arts of the nomadic peoples
3. In South Asia: India, Sri Lanka, Kashmir, Pakistan, Bangladesh
4. In Southeast Asia: Burma, Cambodia, Indonesia, Malaysia, Thailand, Vietnam, the Philippines

D. Arts of the Middle East and of the Islamic peoples

1. Arts of the Jewish peoples
2. Arts of North Africa and of the Arab world

E. Arts of the African peoples

1. Arts of Sudanic cultures
2. Arts of Central African cultures
3. Arts of East African cultures
4. Arts of Southern African cultures
5. Arts of West African cultures

F. Arts of the Oceanian peoples

1. Arts of Melanesia
2. Arts of Micronesia
3. Arts of Polynesia
4. Arts of the Australian Aboriginal peoples

G. Arts of the American Indian peoples

1. Arts of the Eskimo and North American Indian peoples
2. Arts of Meso-American peoples
3. Arts of South American peoples

H. Primitive, folk, and popular arts

[see also 611.B.3.]
Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the characteristics of the arts in particular cultures; historical development of the arts

| African Arts | Egyptian Arts and Architecture, Ancient | Middle Eastern Arts and Architecture, Ancient | Prehistoric Peoples and Cultures |
| American Peoples, Arts of Native | | | |
| Central Asian Arts | Islamıc Arts | Oceanic Arts | South Asian Arts |
| East Asian Arts | | Asian Arts | Southeast Asian Arts |

MICROPAEDIA: Selected entries of reference information

| arts in particular cultures: | Anglo-Saxon art | Expressionism | Novembergruppe |
| African arts | Art Deco | formalism | Op art |
| Central Asian arts | Baroque period | Georgian style | Ottonian art |
| Chinese art | Biedermeier style | Gothic art | Pop art |
| East Asian arts | Bohemian school | Henry IV style | Queen Anne style |
| Egyptian art | Byzantine art | Impressionism | realism |
| Islımıc arts | Carolingian art | Jacobean age | Régence style |
| Korean art | Classicism and Neoclassicism | Louis XIII style | Régency style |
| Oceanic arts | Constructivism | Louis XIV style | Renaissance |
| Paleolithic Period | Coptic art | Louis XV style | Rococo style |
| South Asian arts | Cubism | Louis XVI style | Romanesque art |
| Southeast Asian arts | Dada | Mannerism | Romanticism |
| historical periods, styles, schools, and movements: | Early Christian art | minimalism | Stiil, De |
| Aesthetics | Early | modern art | Stuart style |
| | | Mannerist | Surrealism |
| | | minimalism | Symbolist |
| | | modern art | movement |
| | | naive art | Visigothic art |

INDEX: See entries under all of the terms above

Division II. The Particular Arts

[For Part Six headnote see page 221.]

Division I deals generally with the theory and classification of the arts, the experience and criticism of works of art, and the interaction of the arts with social, cultural, and economic institutions. The outlines in the nine sections of Division II treat the particular arts: literature; theatre; motion pictures; music; dance; architecture, garden and landscape design, and urban design; sculpture; drawing, painting, printmaking, and photography; and the arts of decoration and functional design.

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624. Music 238
625. Dance 244
626. Architecture, Garden and Landscape Design, and Urban Design 246
627. Sculpture 249
628. Drawing, Painting, Printmaking, and Photography 250
629. Arts of Decoration and Functional Design 254

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A. The art of literature
1. The nature and scope of literature: the distinction between literature and other forms of writing
2. Literary composition
3. The contents of literature: its subject matter
4. Literature and its audience
5. The integration of literature with other arts
6. Literary genres: diverse systems of classifying literary works
7. Writings on literature: theoretical treatises, scholarly research and writing, critical writing

B. Techniques of literature
1. Rhetoric: the art of discourse
   a. Elements of rhetoric: figures of speech; e.g., metaphor, simile, personification, hyperbole, allegory, parallelism
   b. The relation of rhetoric to grammar and syntax, to literary diction and style, and to prosody
2. Prosody: the manipulation of the elements of language that contribute to acoustic and rhythmic effects in literature
   a. Elements of prosody
      i. Rhythmic elements; e.g., accent, beat, cadence, the foot, the stanza, metre
      ii. Acoustic elements; e.g., rhyme, assonance, alliteration
   b. Prosodic style: the uses of prosody in verse, prose, drama, and oratory

C. Kinds of literary composition
1. Poetry: distinctions between verse and prose
2. Narrative imaginative literature
   a. Epic; e.g., the “literary” epic, the beast epic, the mock epic, the romantic epic
   b. Saga: the king’s sagas, legendary sagas, the sagas of Icelanders, and related forms
   c. Romance: the romance of love, chivalry, and adventure; e.g., Arthurian romance, the pastoral romance, the Gothic romance, the historical romance
   d. The novel and the tale
   e. The short story and its antecedents
   f. Fable, parable, allegory, and related forms
   g. Ballad, lay, idyll
3. Dramatic or theatrical literature
   a. Tragedy
   b. Comedy
   c. Tragicomedy
   d. Farce and related forms
   e. Melodrama
   f. Religious drama and ritual
   g. Radio, motion-picture, and television scripts
4. Lyric literature
   a. Music-based lyrics; e.g., ballad, hymn, madrigal
   b. Language-based lyrics; e.g., sonnet, ode, elegy, pastoral
5. Satiric literature: satire, parody, lampoon
6. Nonfictional prose literature
   a. The essay
   b. History as literature
   c. Criticism as literature
   d. Doctrinal and religious literature
   e. Philosophical literature
   f. Political literature
   g. Polemical literature
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h. Scientific literature
i. Reportage: journalism
j. Aphorism, epigram, adage, maxim, and related short forms
k. The dialogue: philosophical and literary dialogues
l. Travel literature
m. Epistolary literature: the letter as literature
n. The oration, the speech, and related forms
o. Biographical and autobiographical literature; e.g., character sketch, critical biography, popular biography, interpretive biography, letter, diary, journal, memoir

7. Children’s literature
8. Primitive, folk, and popular literature
[see also 613]

D. The history of literature
1. Literature of Western peoples
2. Literatures of non-Western peoples
[see also 613]

Suggested reading in the *Encyclopedia Britannica*:

**MACROPAEDIA**: Major articles and biographies dealing with literature

**General subjects**
- African Arts
- American Literature
- American Peoples, Arts of Native Australia and New Zealand, Literatures of Belgium
- Canadian Literature
- Celtic Literature
- Central Asian Arts
- Chinese Literature
- Dutch Literature
- English Literature
- French Literature
- German Literature
- Greek Literature
- Hebrew Literature
- Homeric Epics, The
- Hungarian Literature
- Icelandic Literature
- Italian Literature
- Japanese Literature
- Korean Literature
- Latin-American Literature
- Latin Literature
- Literature, The Art of Literature, The History of Western
- Oceanic Arts
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- Rhetoric
- Russian Literature
- Scandinavian Literature
- South Asian Arts
- Southeast Asian Arts
- Spanish Literature
- Yiddish Literature

**Biographies**
- Cervantes
- Goethe
- Dostoyevsky
- Greek Dramatists, The Classical
- Johnson, Samuel
- Shakespeare
- Milton
- Molière
- Montaigne
- Voltaire

**MICROPAEDIA**: Selected entries of reference information

**General subjects**

*dramatic literature:*

- Absurd, Theatre of the
- anagnorisis
- catharsis
- chronicle play
- cloak and sword drama
- comédie
- larmoyante
- comedy
- dialogue
- domestic tragedy
- dramatic literature
- fabula Atellana
- fabula palliata
- farce
- hamartia
- Hocktide play
- hubris
- humours,
- comedy of intrigue,
- comedy of manners,
- comedy of melodrama
- New Comedy
- Old Comedy
- prologue and epilogue
- revenge tragedy
- Senecan tragedy
- sentimental comedy
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|                                                                                  | manners, novel of maqāmah                                                      |
| African arts                                                                       | memoir                                                                         |
| Albanian literature                                                               | nonfiction novel                                                               |
| American literature                                                               | novel                                                                          |
| Anglo-Norman literature                                                          | novella                                                                        |
| Arabic literature                                                                 | picarresque novel                                                             |
| Armenian literature                                                               | psychological novel                                                           |
| Australian literature                                                             | roman à clef                                                                   |
| Belgian literature                                                                | roman-fleuve                                                                   |
| Breton literature                                                                 | sentimental novel                                                             |
| Bulgarian literature                                                              | short story                                                                    |
| Burmese literature                                                                | romances:                                                                      |
| Canadian literature                                                               | Alexander                                                                      |
| Caribbean literature                                                              | romance                                                                        |
| Celtic literature                                                                 | Arthurian legend                                                              |
| Central Asian arts                                                                | romance                                                                        |
| Chinese literature                                                                | romance                                                                        |
| Coptic literature                                                                 | romance                                                                        |
| Croatian literature                                                               | romance                                                                        |
| Czech literature                                                                  | romantic fiction                                                               |
| Danish literature                                                                 | sentimental fiction                                                           |
| Dutch literature                                                                  | short story                                                                    |
| English literature                                                                | romances:                                                                      |
| Estonian literature                                                               | Alexander                                                                      |
| Ethiopian literature                                                              | romance                                                                        |
| Finnish literature                                                                | romance                                                                        |
| French literature                                                                 | romance                                                                        |
| Frisian literature                                                                | romance                                                                        |
| Georgian literature                                                               | romance                                                                        |
| German literature                                                                 | romance                                                                        |
| Greek literature                                                                  | romance                                                                        |
| Hebrew literature                                                                 | romance                                                                        |
| Hungarian literature                                                               | romance                                                                        |
| Icelandic literature                                                              | romance                                                                        |
| Indian literature                                                                 | romance                                                                        |
| Indonesian literature                                                             | romance                                                                        |
| literature                                                                        | romance                                                                        |
| New Zealand literature                                                            | romance                                                                        |
| Norwegian literature                                                              | romance                                                                        |
| Oceanic arts                                                                       | romance                                                                        |
| Polish literature                                                                 | romance                                                                        |
| Portuguese literature                                                              | romance                                                                        |
| Provençal literature                                                              | romance                                                                        |
| Russian literature                                                                | sentimental fiction                                                           |
| Sanskrit literature                                                                | sentimental fiction                                                           |
| Scandinavian literature                                                            | sentimental fiction                                                           |
| Scottish literature                                                               | sentimental fiction                                                           |
| Serbian literature                                                                | sentimental fiction                                                           |
| Slovak literature                                                                 | sentimental fiction                                                           |
| Slovene literature                                                                 | sentimental fiction                                                           |
| South African literature                                                           | sentimental fiction                                                           |
| South East Asian arts                                                             | sentimental fiction                                                           |
| literature                                                                        | sentimental fiction                                                           |
| Southeast Asian literature                                                        | sentimental fiction                                                           |
| Spanish literature                                                                | sentimental fiction                                                           |
| Swahili literature                                                                 | sentimental fiction                                                           |
| Swedish literature                                                                | sentimental fiction                                                           |
| Swiss literature                                                                  | sentimental fiction                                                           |
| Syrian literature                                                                 | sentimental fiction                                                           |
| Thai literature                                                                   | sentimental fiction                                                           |
| Tibetan literature                                                                | sentimental fiction                                                           |
| Turkish literature                                                                | sentimental fiction                                                           |
| Ukrainian literature                                                              | sentimental fiction                                                           |
| poplar literature:                                                                 | sentimental fiction                                                           |
| best-seller                                                                       | sentimental fiction                                                           |
| detective story                                                                   | sentimental fiction                                                           |
| heralded fiction                                                                  | sentimental fiction                                                           |
| mystery story                                                                      | sentimental fiction                                                           |
| science fiction                                                                   | sentimental fiction                                                           |
| prose forms:                                                                      | sentimental fiction                                                           |
| antinovel                                                                          | sentimental fiction                                                           |
| apology                                                                           | sentimental fiction                                                           |
| Bildungsroman                                                                      | sentimental fiction                                                           |
| biography                                                                         | sentimental fiction                                                           |
| confession                                                                        | sentimental fiction                                                           |
| diary                                                                              | sentimental fiction                                                           |
| epistolary novel                                                                  | sentimental fiction                                                           |
| essay                                                                              | sentimental fiction                                                           |
| frame story                                                                        | sentimental fiction                                                           |
| Gothic novel                                                                       | sentimental fiction                                                           |
| historical novel                                                                  | sentimental fiction                                                           |
| I novel                                                                            | sentimental fiction                                                           |
| Indianista novel                                                                  | sentimental fiction                                                           |
| Künstlerroman                                                                      | sentimental fiction                                                           |
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| Lohengrin                                                                          | Bluestocking                                                                   |
| Mephistopheles                                                                     | cancionero                                                                     |
| Merlin                                                                             | cankam literature                                                             |
| Morgan le Fay                                                                      | chapbook                                                                       |
| noble savage                                                                       | character writer                                                              |
| Perceval                                                                           | children's literature                                                         |
| poète maudit                                                                       | literature                                                                    |
| Round Table                                                                       | classical literature                                                           |
| superfluous man                                                                    | conceptismo                                                                    |
| Tristan and Isolde                                                                 | costumbrismo                                                                   |
| type name                                                                          | culteranism                                                                    |
| other:                                                                            | dolce stil nuovo                                                              |
| bard                                                                               | emblem book                                                                    |
| black humour                                                                       | fellow traveller                                                               |
| Bluestocking                                                                       | fili                                                                            |
| cancionero                                                                         | frontier humour                                                                |
| cankam literature                                                                  | goliard                                                                        |
| classical literature                                                               | Hindiliterature                                                               |
| conceptismo                                                                       | journalism                                                                     |
| costumbrismo                                                                       | literature                                                                     |
| culteranism                                                                        | local colour                                                                   |
| dolce stil nuovo                                                                  | Marinism                                                                       |
| emblem book                                                                        | pastoral literature                                                           |
| fellow traveller                                                                   | poet laureate                                                                  |
| fili                                                                               | preciosity                                                                      |
| frontier humour                                                                   | rawi                                                                            |
| goliard                                                                           | saudade                                                                        |
| Hindiliterature                                                                   | Spielmann                                                                      |
| journalism                                                                        | troubadour                                                                     |
| local colour                                                                       | trouvère                                                                       |
| Marinism                                                                          | Weltschmerz                                                                    |
| pastoral literature                                                                | yellow journalism                                                              |
| poet laureate                                                                      | Zhdanovshchina                                                                 |
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| rawi                                                                               |                                 |
| saudade                                                                           |                                 |
| Spielmann                                                                          |                                 |
| troubadour                                                                         |                                 |
| trouvère                                                                          |                                 |
| Weltschmerz                                                                       |                                 |
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**African writers:**
Achebe, Chinua
Beti, Mongo
Bosman, Herman
Charles
Boudjedra, Rachid
Clark, John
Cordeiro da Matta, Joaquim Dias
Dib, Mohammed
Ekwensi, Cyprian
Ferreira, Manuel
Kateb Yacine
Kezilahabi,
Khatibi,
Abdelkebir
Laye, Camara
Mutswairo,
Solomon M.
Ngugi wa Thiong’o
Okara, Gabriel
Ousmane
Sembene
Oyono, Ferdinand
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Soromenho,
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**Australian writers:**
Boldrewood, Rolf
Clarke, Marcus
FitzGerald, R.D.
Lawson, Henry
McAuley, James
Phillip
Paterson, A.B.
Richardson, Henry
Handel
Stewart, Douglas
White, Patrick

**British and Irish writers:**
Addison, Joseph
Akenside, Mark
Arden, John
Auden, W.H.
Austen, Jane
Beaumont, Francis
Behan, Brendan
Belloc, Hilaire
Bennett, Arnold
Blake, William
Boswell, James
Bronțe, Charlotte
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Browne, Sir
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Browning, Robert
Bunyan, John
Burns, Robert
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Byron, George
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Carlyle, Thomas
Carroll, Lewis
Cary, Joyce
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Chaucer, Geoffrey
Chesterton, G.K.
Coleridge, Samuel
Taylor
Collins, William
Congreve, William
Conrad, Joseph
Cowper, William
Crabbe, George
Crichton, James
De Quincey, Thomas
Defoe, Daniel
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**American writers:**
Adams, Henry
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Cooper, James
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Donnelly, Ignatius
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Maier, Norman
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Pound, Ezra
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Sandburg, Carl
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Shepard, Sam
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Simms, William
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Stein, Gertrude
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**American writers:**
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Orwell, George
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Terentius
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Bashô
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Chikamatsu
Monzaemon
Chou Tso-jen
Ding Ling
Fujisawa Sadaie
Futabatei Shimei
Ihara Saikaku
Kakinomoto
Hitomaro
Kawabata
Yasunari
Kuo Mo-jo
Lao She
Li Po
Lu Hsün
Mao Dun
Mishima Yukio
Mori Ōgai
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Natsume Sōseki
Ô Kenzaburō
Ou-yang Hsiu
Shiga Naoya
Tu Fu
Wang An-shih
Zeami
French writers:
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Anouilh, Jean
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Charles
Beauvoir,
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Camus, Albert
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Corneille, Pierre
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Dumas, Alexandre
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Flaubert, Gustave
France, Anatole
Gautier, Théophile
Genet, Jean
Gide, André
Giraudoux, Jean
Hugo, Victor
Huysmans,
Joris-Karl
Ionesco, Eugène
Jarry, Alfred
La Fontaine, Jean
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Laforgue, Jules
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Alphonse de
Machaut,
Guillaume de
Mallarmé,
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Marivaux, Pierre
Marot, Clément
Maupassant,
Guy de
Mauriac, François
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Mistral, Frédéric
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Nerval, Gérard de
Proust, Marcel
Rabelais, François
Racine, Jean
Rimbaud, Arthur
Sade, Marquis de
Sand, George
Sartre, Jean-Paul
Scarron, Paul
Staël,
Germaine de
Stendhal
Valéry, Paul
Verlaine, Paul
Vigny,
Alfred-Victor,
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Villon, François
Voltaire
Zola, Émile

*German writers:*
Alexis, Willibald
Arndt, Ernst
Moritz
Arnim, Bettina von
Böll, Heinrich
Brecht, Bertolt
Broch, Hermann
Büchner, Georg
Chamisso, Adelbert von
Dürrenmatt, Friedrich
Fontane, Theodor
Freiligrath, Ferdinand
Freytag, Gustav
Frisch, Max
Goethe, Johann
Wolfgang von
Görres, Joseph von
Gottfried von
Strassburg
Grass, Günter
Grillparzer, Franz
Grimm, Jacob
Ludwig Carl and Wilhelm Carl
Grimmelshausen, Hans Jacob
Christoph von Haller, Albrecht von
Hartmann von Aue
Hauptmann, Gerhart
Hebbel, Friedrich
Heine, Heinrich
Herder, Johann
Gottfried von Hesse, Hermann
Hoffmann, E.T.A.
Hoffmannsthal, Hugo von
Hölderlin, Friedrich
Immermann, Karl Leberecht
Jean Paul
Johnson, Uwe
Kafka, Franz
Kaiser, Georg
Kaschnitz, Marie Luise
Keller, Gottfried
Kleist, Heinrich von
Mann, Thomas
Meyer, Conrad
Ferdinand
Morgenstern, Christian
Mörike, Eduard
Friedrich
Novalis
Opitz, Martin
Rilke, Rainer
Maria
Schiller, Friedrich von
Schnitzler, Arthur
Sternheim, Carl
Stifter, Adalbert
Storm, Theodor
Woldsen
Sudermann, Hermann
Tieck, Ludwig
Trakl, George
Walafrid Strabo
Walthier von der Vogelweide
Wedekind, Frank
Werfel, Franz
Wieland, Christoph Martin
Wolfram von Eschenbach
Zuckmayer, Carl
Zweig, Stefan

*Hebrew writers:*
Agnon, S.Y.
Berdichevsky, Micah Joseph
Bialik, Hayyim
Nahman
Hisdai ibn Shaprut
ibn Ezra, Moses
Ibn Gabirol
Judah ha-Levi
Zunz, Leopold

*Hungarian writers:*
Ady, Endre
Arany, János
Éötvös, József
Báro
Kazinczy, Ferenc
Petöfi, Sándor

*Indian writers:*
Chatterjee, Bankim
Chandra
Harischandra
Iqbal, Sir
Muhammad
Kālidāsa
Tagore, Rabindranath
Tulsidās

*Italian writers:*
Alfieri, Vittorio
Conte
Amicis
Edmondo De Angiòlieri, Cecco
Aretino, Pietro
Ariosto, Ludovico
Bacchelli, Riccardo
Bandello, Matteo
Basile, Giambattista
Belli, Giuseppe
Gioacchino
Betti, Ugo
Boccaccio, Giovanni
Boiardo, Matteo
Maria
Buzzati, Dino
Calvino, Italo
Campanella, Tommaso
Carducci, Giosuè
Casa, Giovanni
Della
Castiglione, Baldassare
Cavalcanti, Guido
Chiabrera, Grazia
D’Annunzio, Gabriele
Dante
Eco, Umberto
Folengo, Teofilo
Foscolo, Ugo
Gadda, Carlo
Emilio
Giraldi, Giambattista
Goldoni, Carlo
Gozzi, Carlo
Conte
Leopardi, Giacomo
Levi, Carlo
Machiavelli, Francesco
Scipione
Malaparte, Curzio
Mantegna, Alessandro
Marinetti, Filippo
Tommaso
Marino, Giambattista

*Latin-American writers:*
Agustini, Delmira
Alegria, Ciro
Alencar, José de Amado, Jorge
Asturias, Miguel
Angel Azuela, Mariano
Bandeira, Manuel
Bello, Andrés
Benedetti, Mario
Biy Casares, Adolfo
Blest Gana, Alberto
Borges, Jorge Luis
Cardenal, Ernesto
Carpentier, Alejo
Cruz, Sor Juana
Inés de la Cunha, Euclides de Darío, Rubén
Durão, José de Santa Rita
Echeverría, Esteban
Ercilla y Zúñiga, Alonso de Fernández de Lizardi, José
Joaquín
Freyre, Gilberto de Mello
Fuentes, Carlos
Gallegos, Rómulo
Metastasio, Pietro
Montale, Eugenio
Moravia, Alberto
Parini, Giuseppe
Pascoli, Giovanni
Pavesi, Cesare
Petrelli
Pirandello, Luigi
Politian
Pratolini, Vasco
Pulci, Luigi
Quasimodo, Salvatore
Sannazzaro, Jacopo
Silone, Ignazio
Svevo, Italo
Tasso, Torquato
Tassoni, Alessandro
Ungaretti, Giuseppe
Verga, Giovanni
Vittorini, Elio
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Middle Eastern writers:
- Cevdet Paşa,
- Ahmed
- Edib Advar,
- Halide
- Ferdowsi
- Gökalp, Ziya
- Hafez
- Hakim, Tawfiq al-
- Ibn Batûtah
- Ibn Hazm
- Jâhiz, al-
- Jamalzadeh,
- Mohammad Ali
- Kemal, Namık
- Ma'ârrî, al-
- Mutanabbi, al-
- Omar Khayyam
- Sâdi
- Taha Husseîn

New Zealand writers:  
- Baxter, James K.
- Mansfield,
- Katherine
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- Sinclair, Sir Keith

Portuguese writers:  
- Camões, Luís de
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- Francisco de
- Vicente, Gil
- Vieira, António

Scandinavian writers:  
- Almqvist, Carl
- Jonas Love
- Andersen, Hans
- Christian
- Asbjörnsen, Peter
- Christen; and
- Moe, Jørgen
- Engebretsen
- Bergman, Hjalmar
- Fredrik Elgérus
- Björnson,
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- Arnold

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- Andrij, Ivo
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- Afanasievich
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- Ehrenburg, Ilya
- Grigorievich
- Fredro, Aleksander
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- Gorky, Maksim
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- Ilf, Ilya; and
- Petrov, Yevgeny
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- Kundera, Milan
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- Seifert, Jaroslav
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- Henryk
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- Szymborska,
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- Zamiatin,
- Yevgeny
- Ivanovich

Spanish writers:  
- Alarcón y Ariza,
- Pedro Antonio de
- Aleixandre,
- Vicente
- Azorín
- Baroja, Pío
- Béqueur, Gustavo
- Adolfo
Section 622. Theatre

A. The art of theatre
   1. The nature and origins of theatre as an art
   2. Functions of theatre and theatrical production; e.g., theatre as social, moral, or religious expression; theatre as entertainment
   3. Problems of theatre and theatrical production
   4. Interrelation of theatrical performance and audience
   5. The arts of design in the theatre: staging and the design of stages, sets, lights, costumes, and makeup
      [see C.2., below]
   6. Directing
   7. Acting
   8. The roles of other arts in the theatre: literature, music, dance, painting, and architecture
      [see C., below]

B. Kinds and methods of theatrical production
   1. Diverse kinds of theatrical production
      a. Kinds defined by the nature of the production itself
         i. The traditional dramatic forms or genres; e.g., tragedy, comedy
         [for these forms as literature, see 621.C.3.]
ii. Dramatic improvisation: commedia dell’arte and related forms

iii. Mime and pantomime

iv. Puppet, marionette, and shadow plays and related forms

v. Nondramatic theatrical production
   [see B.1.f., below]

b. Kinds defined by their special purpose or audience; e.g., religious theatre, civic theatre, educational theatre, court theatre

c. Kinds defined by their system of production; e.g., single-performance productions, repertory systems, stock companies, touring companies

d. Kinds defined by the controlling artist; e.g., actor-dominated productions, dramatist-controlled productions, productions controlled by a nonperforming director

e. Kinds defined by their style: general aesthetic style; styles of particular countries, historical periods, and playwrights

f. Kinds defined by the lack of a unified dramatic structure
   i. Circuses and carnivals
   ii. Pageants, parades, and related forms
   iii. Popular entertainments: music hall, variety, and burlesque productions; nightclub shows; cabaret; musical comedy and revue

g. Kinds defined by the cultural character of their audience: primitive, folk, and popular theatre

h. Kinds defined by their production media: radio and television

2. Methods of theatrical production

C. Elements of theatrical production

1. The production area: theatre buildings, stages, auditoriums
   a. Theatre as place: kinds and uses of theatre buildings, stages, and auditoriums
   b. The historical development of theatres in Western and non-Western cultures

2. Staging and stage design: the arrangement of words, dance, music, costumes, makeup, lighting, sound, and properties for theatrical effect

D. The history of theatre

1. Western theatre
2. Non-Western theatre

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**Suggested reading in the Encyclopædia Britannica:**

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2. The component arts of motion pictures

a. The role of the writer of the script or screenplay

[see 621.C.3.g.]
b. Motion-picture acting: characteristics that distinguish it from acting in the theatre

c. The role of the director

d. The role of the film editor

e. The use of technology in the creative process: the camera, sound, animation, and other special effects

3. Motion-picture production: scenic design, costumes and makeup, lighting, shooting, editing, film processing

B. The interrelation of other arts in motion pictures: literature, music, dance, painting and drawing, architecture

C. The nonaesthetic contexts of motion pictures
   1. The motion-picture industry
   2. Functions of motion pictures: their use as media of education and propaganda
   3. The study and appreciation of motion pictures

D. The history of motion pictures

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major article dealing with motion pictures

*Motion Pictures*

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   1. Diverse conceptions of music as an art
   2. Problems of musical meaning
   3. Musical performance and interpretation
   4. The relation of music to other human activities
      [see also E.3., below]
   5. Writings about music

B. The sources of musical sound
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      [see C., below and 128.E.6.]
   2. The human voice: techniques, styles, and historical developments of the art of singing in
      Western and non-Western cultures
   3. Musical instruments: the history, technology, and technique of classes and specific types of
      instruments
      a. Idiophonic and membranophonic instruments: instruments that produce sound by means of
         percussion
      b. Aerophonic instruments: instruments that produce sound by the vibration of a column
         of air
      c. Chordophonic instruments: instruments that produce sound by the vibration of struck,
         plucked, or bowed strings
      d. Electrophonic instruments: instruments that produce sound by electrical, electromechanical,
         or electronic means; e.g., electronic organs, tape recorders, synthesizers, computers

C. The elements of music: their patterning and modes of organization in composition
   1. Pitch
      a. Interval: the difference in pitch between two tones
      b. Scale: a pattern of pitch relationships expressed as a series of intervals dividing an octave
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      c. Tempo
   3. Timbre
   4. Harmony
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   6. Texture: monophonic, homophonic, heterophonic, polyphonic
   7. Orchestration and instrumentation
   8. Form in music: the design and structures whereby musical ideas are presented

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E. Musical forms and genres: the types of musical composition
1. Forms and genres characterized by the medium of performance
   a. Instrumental music
      [see 2., below]
   b. Vocal music
      i. Vocal music for solo performance; e.g., liturgical chant, secular song, lied, aria
      ii. Choral music; e.g., mass, motet, cantata, oratorio
      iii. Vocal music for several voices, the parts for either solo or choral performance;
           e.g., madrigal, glee
   c. Electrophonic music: e.g., tape music, computer music

2. Forms and genres characterized by the technique of composition
   a. Musical compositions with fully notated structures
      i. Sonata
      ii. Symphony
      iii. Concerto
      iv. Variation forms; e.g., chaconne, passacaglia, variation set
      v. Fugue
   b. Jazz: music combining notated material with extemporaneous performance
      i. General considerations about jazz: its differentiation from and relation to folk
         music, popular music, and “art” music; its emphasis on the performer as creator; the
         importance of improvisation; its reflection of social and cultural forces
      ii. Development of jazz styles

3. Forms and genres characterized by function or by social setting
   a. Liturgical music
   b. Chamber music
   c. Music for the theatre
      i. Opera
      ii. Music for theatrical dance; e.g., ballet, modern dance
         [see also 625]
      iii. Music theatre; e.g., musical, operetta, zarzuela, nô theatre
         [see also 622]
      iv. Incidental and background music; e.g., for the theatre, for motion pictures and
          television

4. Genres determined by the cultural milieu: primitive, folk, and popular music

F. Recording and reproduction of music
   1. Types of music reproduction; e.g., mechanical, magnetic, optical
      [see 735.F.]
   2. Techniques of music recording: the role of the producer
   3. Effects of music recording: on composition, on teaching, on criticism, on performance, on
      musicology
   4. Development of music recording

G. The history of music
   1. Western music
   2. The music of non-Western peoples
Suggested reading in the *Encyclopædia Britannica*:

**Macropaedia:** Major articles and biographies dealing with music
- African Arts
- American Arts of Native Peoples
- Bach
- Beethoven
- Central Asian Arts
- East Asian Arts

**Microopaedia:** Selected entries of reference information

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2. Choreography and dance notation
3. Diverse classifications of kinds of dance
4. Theoretical, critical, and descriptive writing about dance
5. The integration of dance with other arts: dance in the theatre, in motion pictures
   [see 622.C.2. and 623.B.]

B. Ballet
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2. The integration of ballet with other arts; e.g., with opera, drama, motion pictures, television
3. Major kinds of ballet: traditional, classical, modern, abstract, expressive
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C. Modern dance
1. Principles underlying modern dance: expression and communication of feeling
2. The relation of modern dance to other arts; e.g., to musical theatre, drama, motion pictures, television
3. Development of modern dance: kinds, theories, techniques, and methods of modern dance

D. Primitive, folk, and popular dance

E. The history of dance
1. The dance of Western peoples
2. The dance of non-Western peoples
Suggested reading in the *Encyclopaedia Britannica*:

**Macropaedia:** Major articles dealing with dance

- African Arts
- American Peoples, Arts of Native
- Central Asian Arts
- Dance, The Art of
- Dance, The History of Western
- East Asian Arts
- Folk Arts
- Oceanic Arts
- South Asian Arts
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- Balanchine, George
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- Dolin, Sir Anton Duncan, Isadora
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- Massine, Léonide Nijinsky, Vaslav
- Nikolais, Alwin
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- Petit, Roland Rambert, Dame Marie
- Saint Denis, Ruth Tamiris, Helen
- Taylor, Paul Weidman, Charles
Section 626. Architecture, Garden and Landscape Design, and Urban Design

A. The art of architecture

1. Elements of design and principles of composition

2. Aesthetic aspects of building materials and constructional systems used in architecture
   [for technological aspects, see 733]
   a. Building materials; e.g., stone, brick, wood, iron and steel, concrete
   b. Constructional systems; e.g., load-bearing wall and nonload-bearing wall, post and lintel, arch, vault, dome, truss, framed structures

3. Diverse structural elements and details of buildings; e.g., floors, walls, ceilings, roofs, windows, doors, stairways

4. Architectural ornamentation: mimetic ornament, applied ornament, organic ornament

5. Diverse kinds of architecture and building types determined by their functions
   a. Domestic, or residential, architecture; e.g., houses, apartments, castles, hotels
   b. Religious and commemorative architecture; e.g., temples, churches, synagogues, mosques, tombs, shrines, memorials, monuments
   c. Governmental architecture; e.g., town halls, capitols, courthouses, post offices
   d. Recreational architecture; e.g., theatres, auditoriums, athletic facilities, museums, libraries
   e. Educational and public welfare architecture; e.g., schools and universities, hospitals, prisons, aqueducts
   f. Commercial and industrial architecture; e.g., office buildings, banks, stores, factories, refineries
   g. Agricultural architecture; e.g., barns, stables, silos
   h. Military architecture; e.g., forts, castles, armouries
      [see also 736]

6. Primitive and folk architecture
   [see also 613]

7. The history of architecture
   a. Western architecture
   b. The architecture of non-Western peoples
      [see also 613]

B. Garden and landscape design

C. Urban design: the artistic aspects of city planning
   [for the sociological, political, economic, and psychological aspects of urban design, see 524.B.; for the technological aspects, see 737.C.2.]

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with architecture, garden and landscape design, and urban design

- African Arts
- American Peoples, Arts of Native
- Architecture, The Art of
- Architecture, The History of Western
- Central Asian Arts
- East Asian Arts
- Egyptian Arts and Architecture, Ancient
- Folk Arts
- Garden and Landscape Design
- Middle Eastern Arts and Architectures
- Oceanic Arts
- South Asian Arts
- Southeast Asian Arts

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- architecture—
- building materials and techniques:
  - See Section 733 of Part Seven
- architecture—
- military:
- ornamentation:
- fortification
- kremlin
- alcázar
- castle
- acanthus
- acroterion
- anthemion
- brattishing
- bucranium
candelabrum  minaret  buttress
coffer  mosque  canopy
diaper  narthex  cantilever
finial  nave  capital
fluting and reeding  obelisk  carrel
dome  pagoda  thermal window
drept  presbytery  ceiling
drive  pulpit  chigai-dana
fret  rood screen  chimney piece
corbel
frieze  squinch
c hannock  transept
corbel table
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Carolingian arts
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Section 627.  Sculpture

A. The art of sculpture
   1. Elements of design and principles of composition
   2. The iconography of sculpture
   3. Materials of sculpture;  
      e.g., stone, wood, metal, clay, ivory, plaster, concrete, glass fibre, wax, paper
   4. Tools, methods, and techniques of sculpture;  
      e.g., carving, modeling, casting and molding, surface finishing

B. The diverse kinds of sculpture
   1. Kinds of sculpture distinguished by their spatial context;  
      e.g., sculpture in the round, relief sculpture, kinetic sculpture, environmental sculpture
   2. Kinds of sculpture distinguished by subject matter
      a. Representational sculpture;  
         e.g., human figures, devotional images and objects, portraits, still lives, animal figures
      b. Nonrepresentational sculpture
      c. Decorative sculpture
   3. Kinds of sculpture distinguished by their special uses or functions
      a. Ceremonial and ritualistic objects
      b. Coins and medals
      c. Commemorative sculpture;  
         e.g., monuments, tombs, tombstones, stelae
         [see also 626.A.5.b.]
      d. Masks
   4. Primitive and folk sculpture

C. The history of sculpture
   1. Western sculpture
   2. The sculpture of non-Western peoples

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with sculpture

- African Arts
- American Peoples, Arts of Native
- Central Asian Arts
- East Asian Arts
- Egyptian Arts and Architecture, Ancient
- Folk Arts
- Islâmic Arts
- Masks
- Middle Eastern Arts and Architecture, Ancient
- Oceanic Arts
- Sculpture, The Art of
- Sculpture, The History of Western
- South Asian Arts
- Southeast Asian Arts

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- **styles:**
  - Amarâvâti sculpture
  - Baroque period
  - Beak style
  - Bîharbîj sculpture
  - Classicism and Neoclassicism
  - Cubism
  - Eastern Indian bronze
  - Fujiwara style
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  - Sânchi sculpture
  - South Indian bronze
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  - Tami style
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  - Western Indian bronze

- **types:**
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    Adolf von    Pisano, Giovanni

INDEX: See entries under all of the terms above

Section 628. Drawing, Painting, Printmaking, and Photography

A. Drawing

1. Elements of design and principles of composition
2. Drawing media; e.g., chalk, charcoal, crayon, ink, pastel, pencil, scratchboard, silverpoint, wash
3. Diverse kinds of drawing
   a. Kinds of drawing determined by subject matter; e.g., portraits, landscapes, figure compositions, still lifes
   b. Kinds of drawing determined by special uses
      [for aspects of drawing related to writing, see 629.C.4.a.]
      i. Animation
      ii. Caricature, cartoon, comic strip
      iii. Cartography and mapping
      iv. Drafting
4. The history of drawing

B. The art of painting

1. Elements of design and principles of composition
2. The iconography of painting
3. Painting media; e.g., acrylic, casein, encaustic, fresco, gouache, ink, oil, tempera, watercolour
4. Related media and techniques
   a. Calligraphy
      [see 629.C.4.a.]
   b. Drawing
      [see A., above]
   c. Mosaic
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d. Photography
[see D., below]
e. Printmaking
[see C., below]
f. Stained glass
g. Tapestry

5. The kinds of painting
a. Kinds of painting determined by the type or form of the physical object on which the picture is painted
i. Fixed objects; e.g., cave painting, mural painting
ii. Movable objects: easel painting, fan painting, manuscript illumination, miniature painting, screen painting, scroll painting

b. Kinds of painting determined by subject matter
i. Representational painting; e.g., devotional painting, genre painting, landscape painting, narrative painting, portrait painting, still-life painting
ii. Nonrepresentational painting

C. Printmaking

1. Printmaking as an art: its characteristics and problems; e.g., the problem of originality versus reproduction

2. Printmaking media
a. Relief or cameo media; e.g., woodcuts and linoleum cuts, wood engraving
b. Intaglio media; e.g., aquatint, drypoint, etching, lift-ground prints, line engraving, mezzotint, soft-ground prints, stipple engraving
c. Surface media: lithography, monoprint, serigraphy

3. Printmaking tools and techniques
[see 735.E.4.]

4. The history of printmaking

D. Photography as an art

1. The nature and problems of photography as an art

2. Photographic equipment and techniques: lenses; cameras; exposure, processing, and printing
[see 735.G.]

3. The kinds of photography
a. Major kinds of photography determined by subject matter; e.g., portraits, landscapes
b. Kinds of functional photography; e.g., photojournalism and photo reportage, astronomical photography, aerial photography, radiography

4. The history of photography

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and biographies dealing with drawing, painting, printmaking, and photography

General subjects

Caricature, Cartoon, and Comic Strip
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Mapping and Surveying
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Section 629. Arts of Decoration and Functional Design

A. The nature and scope of the arts of decoration and functional design

B. The kinds of decorative arts and types of decorative objects classified by the materials and methods used to produce or decorate them, or both
1. Clay; e.g., earthenware, stoneware, porcelain
2. Fabrics
3. Gems
4. Glass
5. Metals
6. Paper; e.g., papier-mâché, wallpaper
7. Stone
8. Wood

9. Other kinds of inorganic materials
   with special attention to
   a. Plaster, cement, and concrete
   b. Plastics and other synthetic materials

10. Other kinds of organic materials
    with special attention to
    a. Flowers, foliage, and related botanical materials; e.g., bouquets, garlands, wreaths
       [for garden and landscape design, see 626.B.]
    b. Plant fibres, reeds, branches, and related materials; e.g., baskets, mats
    c. Skins, furs, and related materials
    d. Shell, horn, bone, ivory, and related materials
    e. Wax

11. Special decorative finishing materials, processes, and techniques
    a. Enamelwork; e.g., cloisonné, champlévé, painted enamels
    b. Lacquerwork; e.g., carved lacquer, inlaid lacquer, laque burgauté
    c. Inlay work; e.g., veneering, intarsia, marquetry

C. The arts of functional design: kinds and types of artistic object classified by their function

1. Dress design and body decoration
   a. Dress and dress accessories
      [for the technological aspects of garment making, see 732.B.3.]
   b. Jewelry
   c. Body decoration: cosmetics; hairdressing and hair adornment; physical modification; perfumes, scents, and fragrances

2. Industrial design
   a. Industrial design as an art
   b. Diverse kinds of industrial design classified by function; e.g., design of commercial equipment, design of communications equipment, design of household appliances, design of transportation equipment

3. Interior design
   a. Interior design as an art
   b. The integration of interior design and decoration with architecture: the design and decoration of interior architectural elements
      i. Ceilings
      ii. Floors
      iii. Floor coverings; e.g., rugs, carpets, mats
      iv. Walls; e.g., molding, paneling, wallpaper
      v. Windows and doors
      vi. Other interior architectural elements; e.g., heating units, stairs and staircases
   c. Objects used for interior decoration: furniture and accessory furnishings
      [for technological aspects, see 732.B.4.]

4. The design of materials and objects for communication and identification
   a. Handwriting systems and styles: calligraphy, lettering, illuminating
      [for forms of writing, see 514.E.]
   b. Printing arts: typography and printing design, illustration, bookbinding
      [for printmaking, see 628.C.]
   c. Advertising art and design
   d. The design of signs and symbols used primarily for identification; e.g., heraldic design
   e. The design of exhibitions and displays; e.g., museum and gallery display
5. The design and decoration of diverse kinds of specialized functional objects
   a. The design of coins and currency and of medals
   b. The design and decoration of play materials
   c. Automata: the design of decorative mechanical objects
   d. The design and decoration of arms
   [for the technological aspects of arms, see 736]

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with the arts of decoration and functional design

- African Arts
- Central Asian Arts
- Decorative Arts and Furnishings
- Dress and Adornment
- East Asian Arts
- Folk Arts
- Heraldry
- Marketing and Merchandising
- Oceanic Arts
- Printing,
- Typography, and Photoengraving
- South Asian Arts
- Southeast Asian Arts

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**General subjects**

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Benjamin Franklin defined man as "the tool-making animal." If he had added the phrase "with foresight," he would have adequately described Homo faber, man the technologist.

Inventiveness was the indispensable condition for the survival of the human species. Without fur or feather, carapace or scale, ancestral man stood naked to the elements; and without fang or claw or tusk to fight his predators, without speed to elude them, without camouflage to deceive them or the ability to take to the trees like his cousin, the ape, he was physically at a hopeless disadvantage. What he developed to deal with his deficiencies was the capacity to invent. He possessed not only sensory perceptions (though these were less acute than those of many of his fellow creatures), he also possessed imagination and finger-skills. He did not just improvise to meet an emergency as an ape might in using a broken branch as a weapon; he also saw the need for keeping a club handy—he planned ahead. Other creatures had their inherited instincts, their built-in experience. Some, like the beaver or the weaverbird, with their biological tools, could contrive quite elaborate structures; others, like the bees or the ants, could evolve efficient organizations; others, like the squirrel, were provident in experience. He clothed himself in pelts and moved to inhospitable climes, he mastered fire and dared to bring it into his dwelling for heating and cooking, he learned to cultivate and plant the soil, he domesticated animals, and he devised specialized tools like the hoe and the ax to improve the efficiency of his labour.

From earliest time and beginning with the simplest contrivances, every discovery and invention has depended on the fact that the human being is not only a perceptual but also a conceptual creature capable of observing, memorizing, and juxtaposing images. He can make a mental design, a techno-poetic fantasy, even when the means of actually producing it are not available. Seven hundred years ago Roger Bacon could imagine a power-driven ship, a horseless carriage, an airplane, the miniaturized servo-motor, "but one finger in length and one in width," and the bathtub. The vision cannot materialize, however, unless man has the method. This is the process by which he makes an observation (perceptual); forms a hypothesis (conceptual); experiments to test this "hunch"; formulates a theory to justify his insights; and by further proofs produces "laws" according to which anyone can go on repeating the results. The predicted yield is have to rediscover Newton's laws or the laws of thermodynamics every few years. This systematic treatment of the arts and crafts is the simplest expression of the meaning of "technology," from the Greek roots technē, arts, and logos, words. The ancient Greeks had no such combined term because their philosophers divorced manual skills from intellectual pursuits. Plato berated Eudoxus and Archytas when by experiments and recourse to instruments they solved problems that the theorists considered insoluble. He accused them of "making use of matter which requires manual labour and is the object of servile trades."

This intellectual condescension still persists, although individual technologists have won recognition from scientific societies and learned academies. The prejudice is suggested by the acceptance of the term "science and technology." Yet both science and technology use the scientific method. Was Leonardo da Vinci, apart from being an artist, a scientist or a technologist? In terms of discovering and testing new knowledge he was a man of science, but his designs for practical innovations outnumbered those of Thomas Alva Edison. Edison, 400 years later, patented over 1,000 inventions. They included major ones, for which he is remembered, but also hundreds of bits of useful hardware, important in their way. He made only one scientific discovery, the Edison effect, which he patented but did not pursue. The rest were derived from scientific knowledge and developments. He saw the profitable relevancies that lesser men missed; he fitted the mental nut to the mental bolt and created things.

Customarily, science, or the scientific hierarchy, is divided into four categories:

**Pure, or academic, research** is the pursuit of knowledge for its own sake. It is mainly the work of an individual, or the group he leads. The pure scientist has to justify himself only before a jury of his peers. He is judged not by the usefulness but by the integrity of his work. He is the Maker Possible.

**Oriented fundamental research** is still basic science; that is to say, the scientist is still questioning nature, seeking to extend knowledge and understanding, but he is not a free agent indulging his curiosity. He is restrained within a frame of reference. For instance, in studying chemical reactions at high pressures he is not assuming that he is going to discover polyethylene, or if he is studying gases at high temperatures he is not necessarily thinking of jet engines or rockets; but he is compiling data that will be important in a general field and likely to have some foreseen applications. In the big corporations, this is called "speculative research." Such a scientist is likely to have adequate research facilities, endowments, or contracts. He is the Maker Probable.

**Applied research** is programmed research. The target is specified, and results are expected. The predicted yield is

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Knowing How and Knowing Why
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the measure of the support. The scientist is held accountable in the annual report. He is the Maker to Happen.

Development is really technology, but coupling it with research (R and D) keeps it in the scientific hierarchy and away from the “rude mechanicals.” It is the transfer of laboratory results, through the pilot plant, to the production line. R and D is far and away the most expensive scientific bracket because large-scale trial and error (“back to the drawing board”) involves multimillions of dollars. The R and D scientist is the Maker to Work.

Through the craft guilds and their “mysteries” and their conversion to factory methods, technology had an evolutionary history in many cultures and many lands. Alfred North Whitehead claimed that “the greatest invention of the nineteenth century was the invention of the method of invention.” Nowhere was this better demonstrated than at Edison’s “invention factory” at Menlo Park, New Jersey, where, starting in 1876, Edison organized the first industrial research laboratory. In folklore, he is regarded as a “loner,” who invented by intuition. In fact, he systematized the process of invention, coordinating and applying relevant knowledge through a hard-worked team that included mathematicians, physicists, chemists, and skilled mechanics. Invention was no longer the private indulgence of the gifted amateur or the rare professional; a techno-methodology had been created to guarantee commercial success. In Edison’s case the result was often a “package deal”—not just the incandescent lamp, but the generating plant and the transmission system. In the case of Henry Ford, it was not just the Model T, but the assembly line, which he enlarged to a factory that was one-fifth of a mile long, with a conveyor-belt system that synchronized each stage of construction with the delivery of each part to the operator. He embodied scientific management, with its time-and-motion studies and production engineering.

The feedback system between the know-why (academic science) and the know-how (technology) is recalibrating the time-function of change. A new scientific discovery (explanation of a phenomenon) is seized by the technologists and put to work. In turn the technologists provide the instruments that, with greater refinements and speed, enable the scientists to make further discoveries. An outstanding example is cybernetics. The pencil-and-paper mathematicians had long known the principles of the computer, but they had to wait for the post-World War II electronic engineers to produce the “hardware.” Now with instant responses, or nearly so, and vast computer capacities and prodigious “memories,” with means not only for numerical calculation but for logical simulation, with feedback (like a burned finger signaling to the brain and the brain withdrawing the finger from the hot plate), scientists are not only able to do calculations so complex that they would not previously have attempted them, but they are also learning, from the engineers, about the nature of systems, including the systems of nature itself. Cybernetics deals with the information-processing aspects, as distinguished from the energy-transforming aspects, of all systems regardless of their physical nature. This has facilitated the development of automatic control, telecommunications, and computing; it is applicable also to systems engineering, economies, and neurophysiology.

Though we acknowledge the truth of Whitehead’s apophorism, his essentially engineering approach to technology is too restrictive. Every advance in the practical arts from hunting to food-gathering to cultivation, to animal husbandry, to irrigation, to mining, and on through construction, transportation, food-processing, heating, power generation, lighting, communications, military engineering, and clinical medicine has produced social and cultural changes. The Neolithic Revolution was as climacteric as the Industrial Revolution. Moreover, the preoccupation with Western technology ignores the cultural origins of many major innovations and forgets that, historically, the European Dark Ages (not so dark as is often supposed) coincided with Golden Ages of material advances in China, India, and pre-Columbian America. Only in recent years have historians (Singer, Crombie, Lynn White, Hall, Needham, Forbes, and others) given serious attention to these facts. The anthropologists, looking at cultural influences, have been similarly remiss. Economists have been preoccupied with the “production function” and sociologists with the social effects of innovation (from television to freeways) and with work-force redundancy. The present distortions, produced by rapid technological change, obscure the fact that civilization itself derived from excess production and redundancy. When agriculture surpassed subsistence, fewer tillers were required to support the cities, with their artisans (specializing in other forms of production), their priesthoods, their scholars, their soldiers and warrior-kings, their tithe-gatherers, their merchants, and their money-changers. Technological displacement today, whether it is called unemployment, underemployment, leisure, or nonwork, similarly calls for social readjustments to find nonmanufacturing expressions of human capacities.

No explanation of the intrinsic or historic attributes of technology can convey the love-hate overtones that the term has acquired. In the ogre sense of the word, it has become a threat to lives and livelihoods and to the total environment. In the efficiency sense, it is hailed as the methodological solution of all our problems from government administration to the production of miracle grains to abolish hunger. Some, like Jacques Ellul and B.F. Skinner, claim that we are already the hostages of our man-made environment: the first maintaining that technology has taken over all of man’s activities and not just his productive activities; the second, that autonomous man, with free will and freedom and dignity, is now an anachronism and has to be intentionally controlled by the “technology of behaviour.”

Obviously this usage is stretching the meaning of “technology” beyond the foregoing derivations and descriptions—the etymology; the cultural origins; the scientific precedents; the nuts-and-bolts and something popularly promoted to capital letters as “The Machine.” This usage expands even Harold Lasswell’s accommodating version: “The ensemble of practices by which one uses available resources to achieve values.” It is more consistent with the French la technique, which refers to any complex of standardized means for attaining predetermined ends. Thus it would apply to organization, government institutions, systems of politics or religions, or anything which reduces spontaneous or impulsive behaviour to a rationale. As was said of la technique of wartime operational research, “it ran the war by numerical thinking instead of gusts of emotion.”
In adventurously exploring the three divisions and fifteen sections of the encyclopaedia's treatment of technology of which this introduction is, hopefully, the appetizer, the reader will find other interpretations and probably produce his own. In common usage, however, the preoccupation is with "The Machine" and the effects of its products on our lives.

Resentment against the replacement of men by machines goes back beyond Ned Ludd and the machine-wreckers of the Industrial Revolution, but present-day attitudes are of a different order of magnitude. They derive from the speed and scale of change. Hahn and Strassmann's laboratory discovery of uranium fission in 1938 was transformed into a nuclear bomb in 1945. If there is no nuclear war, history will consider the Manhattan Project, which produced the bomb, as important as the bomb it produced. It is the archetype of the crash program in which men, materials, and methods are mobilized to attain an objective in a given time. Man on the Moon by 1970 was another example, with the time-target beaten by six months. The time-lapse between a fundamental scientific discovery and its practical application has been reduced from centuries to decades to years to months. Since World War II, we have had the Atomic Age, the Cybernetic Age, the Space Age, and now the Bioengineering Age, in which not only by organ transplants but also by the deliberate manipulation of genes it may be possible to engineer the nature of man himself. Thus in the growing up of the postwar generation there have been four major epochs nearly as significant as the Stone Age, the Iron Age, the Renaissance, and the Industrial Revolution. At the same time there has come the shocked awareness of the effects on the environment of the wastes of technology. Again this is a matter of scale and lack of prescience. (The ore miners and metal workers of Cyprus and Asia Minor were polluting the Mediterranean with heavy metals 5,000 years ago, but the effects were insignificant compared with volcanic debris.) When people complain, however, of "interference with the environment" they should be mindful that such interference has been the sine qua non of the survival of Homo sapiens. Moreover, when we try to get rid of our guilt-sense about the effects of misused technology and reject the gadgeting we ashamedly enjoy, we should not go too far and "throw out the baby with the bathwater." We cannot go back to the apes nor even to Arcadia.

The great problem is how to force ebullient technology and its transnational expansion to produce human well-being, not just in the quantity of artifacts but in improving the quality of life, including redressing of the mischief in the environment. This requires an enlightened and informed society that knows what it wants and is not cult-ridden or crash-programmed into accepting what it does not want or need. This cannot be achieved through programmed learning nor the technology of behaviour nor systems engineering. We are back with the know-why as the initiator and the monitor of the know-how.
Several points should be noted about the relations of this part to other parts. Technology involves applications of the knowledge of nature dealt with in Parts One, Two, and Three and in turn has an influence on the development of that knowledge. It has a major role in relation to human communication and an influence on the cultural, social, economic, political, legal, and educational life of humankind, dealt with in Part Five; and a conditioning effect on the development of the fine arts, dealt with in Part Six. To a degree, technological developments affect developments in the religious life of humans, dealt with in Part Eight. Technology is a major dimension in the history of humankind, the subject of Part Nine.

The branches of technology and of engineering have themselves become the subject of historical and analytical studies. Those studies are presented in Section 10/37 of Part Ten.

Division I. The Nature and Development of Technology 265
II. Elements of Technology 268
III. Major Fields of Technology 280

Division I. The Nature and Development of Technology

The outlines in the two sections of Division I treat the scope and history of technology, and the organization of human work.

Section 711. Technology: Its Scope and History 265
712. The Organization of Human Work 266

Section 711. Technology: Its Scope and History

A. General conceptions or definitions of technology

B. Relations between technology and other spheres of contemporary life
   1. Technology and wealth
   2. Technology and war
   [see 736]
   3. Technology and education
   4. Technology and art
   [see also 612.D.4.]
   5. Technology and social institutions
   [see also 512.B.3.]
   6. Technology and the underdeveloped regions: the export of Western technology
   [see also 512.B.3.]
   7. Effects of technology on the environment
   [see also 355.B.1.]

C. History of technology: sociocultural consequences of technological changes
   [see also 512.B.]
   1. Technology in the ancient world
      a. The beginnings of technology (to c. 3000 BC): emergence of the earliest communities, use of
         stone tools and weapons, beginnings of mining and agriculture
      b. The urban revolution (c. 3000–500 BC): early civilization in the valleys of the Nile and Tigris-Euphrates river systems, waterworks for irrigation, urban manufacturing
      c. Technological achievements of Greece and Rome (500 BC–AD 500): mastery of iron, invention of mechanical contrivances, architectural and constructional works
2. Technology from the Middle Ages to 1750
   a. Medieval advances (AD 500–1500): harnessing of wind power and waterpower; construction of canals and bridges; construction of full-rigged ships; invention of printing
   b. The emergence of Western technology (1500–1750): invention of early scientific instruments and tools, birth of steam power, development of agricultural and constructional techniques
3. The Industrial Revolution (1750–1900)
   a. Advances in power technology: development of steam power, internal-combustion engine, and electric power; exploitation of mineral and fossil fuels
   b. Development of industries: iron and steel, textiles, chemicals, transportation, communications
4. Technology in the 20th century
   a. Early developments: exploitation of hydroelectric power; synthesizing of fibres, plastics, rubber, dyes, and drugs; rationalization of production
   b. Space Age technology: nuclear power, automation and the electronic digital computer, rocketry and space exploration, advances in agricultural technology, advances in transportation and communication
   c. Effects of technology on the environment

Suggested reading in the Encyclopædia Britannica:
MACROPAEDIA: Major articles and a biography dealing with technology: its scope and history
   Edison
   Technology, The History of
MICROPAEDIA: Selected entries of reference information
General subjects
   industrial engineering
   Industrial Revolution
   industrialization manufacturing
   research and development
   safety safety engineering
   security and protection system
   service industry technology

Biographies
   See Section 10/37 of Part Ten

INDEX: See entries under all of the terms above

Section 712. The Organization of Human Work

A. The organization of work
1. The organization of work in the prehistoric world
   [see also 512.B.1.]
   a. Origin of division of labour based on age and sex differences, initial absence of class divisions
   b. Communal organization: specialization required by the development of pottery, textiles, agriculture, and metallurgy
2. The organization of work in the ancient world
   a. Theories of civilization's development: explanations of the origin of hierarchical organization
   b. Effect of social classes on the organization of labour
   c. Organization of agricultural labour
   d. Organization of industrial labour by craft
   e. Organization of labour for large-scale construction
3. The organization of work in the medieval world: the manor system, the craft guilds, organization of free labour for large-scale construction
4. Changes in production techniques from the 16th to the 18th century: foundations of modern industrial production
5. Mass production: the organization of labour by product rather than by process
6. The use of machines as replacements for labour

B. The application of scientific methods to managerial functions
1. Operations research: the application of scientific method to the management of organized systems
2. Systems engineering: the utilization of scientific and technological knowledge in planning and designing complex systems
3. Systems-design techniques, tools, and procedures
   a. Techniques: use of flow charts and other symbolic models, precise formulation of suitable objectives
   b. Tools: optimization theory, communication theory, queuing theory, game theory
      [see also 10/23.E. and F.]
   c. Procedures: exploratory planning, development planning

C. The relation between man and machine in industrial production
1. The effects on mankind of the rationalization of work: psychological and social aspects of mass production and automation
2. The human-factors approach: the design of machines, tools, and work environments with consideration for the capabilities and limitations of humans

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the organization of human work
- Automation
- Industrial Engineering and Production Management
- Modernization and Industrialization
- Work and Employment

**MICROPAEDIA:** Selected entries of reference information

**General subjects**
- assembly line
- automation
- critical path
- analysis
- domestic service
- domestic system
- game theory
- Hawthorne
- research
- human-factors
- engineering
- mass production
- mathematical
- programming
- operations research
- queuing theory
- robot
- standardization
- systems engineering
- time-and-motion
- study
- trade organization
- work

**Biographies**
See Section 10/37 of Part Ten

**INDEX:** See entries under all of the terms above
### Division II.

#### Elements of Technology
[For Part Seven headnote see page 265.]

Division I is concerned with the nature and effects of technology as a whole. The outlines in the five sections of Division II deal with technical processes not specific to any of the major fields of technology. The technologies of the major fields are dealt with in Division III.

Section 721. Technology of Energy Conversion and Utilization 268
722. Technology of Tools and Machines 270
723. Technology of Measurement, Observation, and Control 271
724. Extraction and Conversion of Industrial Raw Materials 274
725. Technology of Industrial Production Processes 277

### Section 721. Technology of Energy Conversion and Utilization

#### A. Major types of energy useful to humankind

1. Primary energy sources: thermonuclear reaction, nuclear fission, radioactivity
2. Recurring energy sources: solar energy, natural thermal energy, wind and water energy, biomass
3. Nonrenewable energy sources: coal, natural gas, oil

#### B. Devices and techniques for the utilization of energy

1. Devices for utilizing muscle energy: pulley, lever, block and tackle, treadmill
   [see also 722.B.1.]
2. Devices for utilizing wind and water energy: sails and sailboats, windmills, waterwheels, wind and water turbines
3. Devices for utilizing gravitational energy: pendulums, counterweight mechanisms
4. Devices for utilizing strain and compression energy
   a. Steam engines and steam power plants
   b. Steam turbines
      [see B.2., above]
   c. Compressed-air and compressed-gas tools and machines
   d. Hydraulic devices
5. Devices for utilizing magnetic and electrical energy
   a. Magnets, electromagnets
   b. Electric motors: induction motors, synchronous motors, commutator motors utilizing alternating current and direct current
6. Devices for utilizing rotational energy: centrifuges, gyroscopes
7. Devices for utilizing heat energy: heat exchangers, refrigeration equipment
8. Devices for utilizing chemical energy
   a. Internal-combustion engines: gasoline and gas turbine engines; diesel engines; jet, turbojet, fan-jet, and turboprop engines; rocket engines
   b. Chemical explosives: black powder, nitroglycerin, dynamites, nitrocellulosic explosives, military explosives, other modern high explosives
9. Devices and materials for utilizing nuclear energy: nuclear fission reactors, radioactive isotopes, nuclear fusion reactors
   [see also 112.B., C., F., and G.]
10. Devices for utilizing solar energy

#### C. Devices for energy conversion

1. Thermoelectric devices
2. Thermionic devices
3. Magnetohydrodynamic power generators
4. Batteries and fuel cells
5. Lamps and other lighting devices
6. X-ray tubes
   [see also 111.D.1.]
7. Devices for electric power generation: turbine-driven generators, engine-driven generators, nuclear-powered generators, hydraulic-turbine-driven generators, thermoelectric generators, dynamos, photovoltaic devices

D. Devices for energy concentration and control
1. Electron tubes
2. Solid-state devices; e.g., transistors, semiconductor diodes, integrated circuits
3. Optoelectronic devices; e.g., liquid-crystal displays, optical fibres, semiconductor lasers

E. Devices for unlimited production of free energy: attempts to design perpetual motion machines

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**Suggested reading in the *Encyclopædia Britannica:***

**MACROPAEDIA:** Major articles dealing with the technology of energy conversion and utilization

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**MICROPAEDIA:** Selected entries of reference information

**General subjects**

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**major types of energy:**

| electric power      | energy               | fire                  |
|                     |                     | fossil fuel           |
|                     |                     | geothermal energy     |
|                     |                     | hydraulic power       |
|                     |                     | hydroelectric power   |
|                     |                     | solar energy          |
|                     |                     | tidal power           |
|                     |                     | waterpower            |

**other:**

blowpipe
magnetohydrodynamic power
generator
perpetual motion
thermionic power
converter
thermoelectric device
transducer
Biographies

Braun, Wernher von Goddard, Robert Sperry, Elmer
Carnot, Sadi Hutchings Ambrose
De Forest, Lee Nobel, Alfred Stevens, John
Diesel, Rudolf Bernhard Tesla, Nikola
Evans, Oliver

See also Section 10/37 of Part Ten

INDEX: See entries under all of the terms above

Section 722. Technology of Tools and Machines

A. Hand tools
   1. Early history of hand tools: Paleolithic and Neolithic stone tools, development of metal tools
   2. Basic types of hand tools
      a. Percussive tools: hammers, axes
      b. Cutting, drilling, and abrading tools: knives, saws, files
      c. Screw-based tools: screwdrivers, wrenches
      d. Measuring and defining tools: levels, dividers, rules
      e. Tool auxiliaries: workbench, vise
   3. Power-driven hand tools: electric drills and circular saws, pneumatic hammers and riveters

B. Machines and machine components
   1. Simple machines: lever, wedge, wheel and axle, pulley, and screw
   2. Machine mechanisms: devices that transmit motion by means of flexible connectors, rigid
      connecting links, or direct contact
   3. Machine components
      a. Gears
      b. Cams
      c. Linkages
      d. Flywheels
      e. Belt and chain drives
      f. Couplings
      g. Clutches
      h. Brakes
      i. Bearings
      j. Shafts and shaft accessories
      k. Screws
      l. Springs
   4. Friction accommodation and reduction
      a. Bearings
         [see B.3.i., above]
      b. Lubricants and their functions, types, and properties

C. Machine tools: stationary power-driven machines for shaping and forming parts made of metal or
   other materials
   1. History and characteristics of machine tools
   2. Operation of metal-cutting tools
   3. Basic machine tools: turning machines, shapers and planers, drilling machines, milling
      machines, grinding machines, power saws, and presses
4. Modifications of basic machines; e.g., turret lathes, production millers
5. Special-purpose machines; e.g., gear-cutting machines, broaching machines

D. Computer-aided machining
1. Computer numerical control
2. Computer-aided design and computer-aided manufacturing (CADCAM)
3. Robots
4. Computer-integrated manufacturing

E. Nonconventional methods of machining
1. Electrical methods: electron-beam machining, electrical-discharge machining, electrochemical machining, ion beam machining, laser machining, plasma arc machining
2. Other methods: ultrasonic machining, chemical machining, photochemical machining, water-jet machining

**Suggested reading in the Encyclopædia Britannica:**

**MACROPAEDIA:** Major article dealing with the technology of tools and machines

Tools

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

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<th>Basic machine tools:</th>
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<td>Wrench</td>
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See Section 10/37 of Part Ten

**INDEX:** See entries under all of the terms above
C. Principles and processes by which instruments of measurement operate

D. Common types of measuring instruments

1. Instruments for measuring basic dimensions
   a. Devices for measuring length: rules, calipers, micrometers
   b. Devices for measuring mass and weight: scales, balances
   c. Devices for measuring time: mechanical, electric, and atomic clocks
   d. Devices for measuring temperature: gas, liquid, and electrical resistance thermometers
   e. Devices for measuring electric current and other electrical properties: galvanometers, ammeters, voltmeters
   f. Devices for measuring light intensity: photometers, light meters, exposure meters

2. Instruments for measuring physical properties and relationships derived from basic dimensions
   a. Instruments for measuring pressure: barometers, manometers
   b. Instruments for measuring rate of flow: flowmeters, water meters, gas meters
   c. Instruments for measuring position by angulation and direction finding
      i. Compasses: magnetic compasses, gyrocompasses
      ii. Surveying instruments: levels, transits, sextants
   d. Instruments for measuring gravity: gravimeters
   e. Instruments for making optical measurements: polarimeters, refractometers
   f. Instruments for measuring ionizing radiation: Geiger counters, scintillation counters
   g. Instruments for measuring volumetric and mechanical properties of materials, including density, viscosity, and mechanical strength

E. Instruments used for observing and recording

1. Instruments for observing phenomena
   a. Microscopes: optical, electron, acoustic, and scanning tunneling microscopes
   b. Telescopes: optical, radio, and other types (e.g., infrared, ultraviolet, X-ray, and gamma-ray systems)
   c. Spectroscopes and spectrographs
   d. Interferometers

2. Instruments for recording phenomena: cameras
   [see also 735 G.]

F. Special instruments and apparatus used in scientific research

1. General laboratory equipment: filters, mixers, centrifuges
2. Research reactors
3. Particle accelerators; e.g., Cockcroft-Walton generators, Van de Graaff generators; linear resonance accelerators, betatrons, cyclotrons, synchrotrons, colliding-beam storage rings
4. Mass spectrometers
5. Chromatographs
6. Seismographs
   [see also 213.B.6.]
7. Particle detectors: bubble chambers, scintillation counters

G. Major systems of measurement and observation

1. Surveying
   [see also D.2.c.ii., above, and 733.A.2.]
2. Mapping and cartography
3. Hydrographic charting
4. Oceanographic measurement
   [see also 222.B., E., F., G., and H. and 738.B.]
5. Meteorological measurement
   [see also 221 and 223]
6. Astronomical observations
7. Navigational techniques and devices
8. Radiological techniques and devices

H. Instrumentation and control systems
   1. Instrumentation systems: systems that operate or actuate control devices or record measurements automatically
   2. Control systems
   3. Telemetry systems: remote monitoring and control

Suggested reading in the *Encyclopaedia Britannica:*

**MACROPAEDIA:** Major articles dealing with technology of measurement, observation, and control

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**astronomical devices:**

- Caliper
- Depth finder
- Gauge
- Range finder
- Strain gauge
- Vernier caliper
- Instruments for measuring electrical and magnetic quantities:
  - Ammeter
  - Bridge
  - Cathode-ray oscilloscope
  - Electrometer
  - Galvanometer
  - Magnetometer
  - Ohmmeter
  - Oscilloscope
  - Signal generator
  - Voltmeter
- Watt-hour meter
- Instruments for measuring force:
  - Balance
  - Gravimeter
  - Roberval balance
  - Spring balance
  - Torsion balance
- Instruments for measuring motion and fluid flow:
  - Accelerometer
  - Airspeed indicator
  - Anemometer
  - Gas meter
  - Speedometer
  - Tachometer
  - Venturi tube

**Instruments in Meteorology:**

- Actinometer
- Barometer
- Hygrometer
- Isentropic chart
- Isobar
- Isotherm
- Radiosonde
- Temperature-humidity index
- Weather bureau
- Wind rose
- World Weather Watch
- Celestial navigation
- Compass
- Dead reckoning
- Direction finder
- Great circle route
- Inertial guidance system
- Loran
- Loxodrome
- Navigation
- Navigation chart
- Portolan chart
radio direction
radio range
sextant
shoran
solar compass
radio range

**particle accelerators:**
- betatron
- colliding-beam storage ring
cyclotron
linear accelerator
particle accelerator
synchrotron

**pressure measurement:**
- barometer
- pressure gauge

**radiological dating techniques:**
- carbon-14 dating
- fission-track dating
helium dating
ionium-thorium dating
lead-210 dating
potassium-argon dating
protactinium-231–thorium-230 dating
radiation-damage dating
rubidium-strontium dating
uranium-thorium–lead dating

**timekeeping:**
- astrolabe
- atomic clock
clock
- Coordinated Universal Time

**units and standards of measurement:**
- ampere
- apothecaries’ weight
- astronomical unit
- barrel
- British Imperial System

**Biographies**
- Gilbert, Sir
- Hakluyt, Richard
- Humphrey
- Henry the Navigator
- Lawrence, Ernest
- Lovell, Sir Bernard
- Orlando
- Mercator, Gerardus

INDEX: See entries under all of the terms above
C. Primary conversion of raw materials

1. Petroleum refining
   [see also B.2., above, 214.B.5.b., and 732.D.2.]

2. Coal utilization: production of coke, coal tar, light oil, gas, and chemicals
   [see also B.1.b., above, and 214.B.5.a.]

3. Production and processing of metal ores and metals
   [see also B.1.b., above, and 214.A.4.c.]
   a. Aluminum
   b. Calcium
   c. Chromium
   d. Cobalt
   e. Copper
   f. Gold
   g. Iron
   h. Lead
   i. Magnesium
   j. Mercury
   k. Nickel
   l. Platinum
   m. Silver
   n. Sodium and potassium
   o. Steel and steel alloys
   p. Tin
   q. Titanium
   r. Tungsten
   s. Uranium
   t. Zinc
   u. Rare-earth metals
   v. Metal alloys

4. Production of synthetic gemstones and industrial crystals

5. Processing of stone, sand, clay, and gravel
   a. Manufacture of conventional and special types of glass and glass products
   b. Manufacture of cement, gypsum plasters, and plastic cements
   c. Manufacture of industrial ceramics
   d. Manufacture of bricks and tiles

6. Processing of water to obtain salt, magnesium, oxygen, hydrogen, and other elements

7. Processing of air to obtain oxygen, nitrogen, noble gases, and other gases

8. Processing of plant and animal products
   a. To obtain paper and pulp
      [see also 732.D.3.]
   b. To obtain roundwood, sawn wood, veneer, plywood and laminated constructions, particleboard, and fibreboard
      [see also 732.C.8.]
   c. To obtain tobacco and other nonfood products
   d. To obtain leather and hides
      [see also 732.C.3.]
   e. To obtain furs
      [see also 732.C.4.]
   f. To obtain natural fibres
      [see also 732.C.1. and 732.D.9.]
g. To obtain pharmaceuticals
   [see also 732.D.4.]

h. To obtain oils, fats, and waxes

i. To obtain resins and other products

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the extraction and conversion of industrial raw materials
- Conservation of Natural Resources
- Forestry and Wood Production
- Industrial Ceramics
- Industrial Glass
- Industries, Extraction and Processing

MICROPAEDIA: Selected entries of reference information

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</table>
Section 725. Technology of Industrial Production Processes

A. Materials processing: the operations that are used to transform industrial materials from a raw-material state into finished parts or products

1. Preliminary processing of raw materials
   a. Mechanical processing; e.g., crushing, mixing, blending, separating, grading
   b. Chemical processing; e.g., leaching, smelting, coagulation, polymerization

2. Forming: processes in which parts are produced by casting or molding liquid materials or by applying pressure to solid materials
   a. Processing liquid materials
      i. Casting metals; e.g., sand casting, die casting
      ii. Casting and molding nonmetals; e.g., slip casting, injection molding
   b. Processing solid materials; e.g., rolling, forging, stamping, pressing

3. Material removal: processes for shaping parts by removing portions of a solid piece of material

Biographies
See Section 732

INDEX: See entries under all of the terms above
4. Joining: processes for bonding materials to each other
   a. Thermal joining: welding, brazing, and soldering
      [see B.4., below]
   b. Adhesive bonding: natural and synthetic adhesives and their uses

5. Property modification: alteration or improvement of the properties of materials
   a. Thermal processing
      i. Basic heat-treating operations: annealing, stress relieving, and hardening
      ii. Radio-frequency heating: induction and dielectric heating
      iii. Zone melting: zone refining and other techniques
      iv. Exposure to cryogenic temperatures
   b. Processing of materials by exposure to physical conditions other than heat or cold
      i. Processing of materials in a vacuum
      ii. Use of ultrasonic and infrasonic waves
      iii. Other processes; e.g., exposure to radiation
   c. Mechanical and chemical processing

6. Finishing processes: modification of the surfaces of materials
   a. Mechanical and chemical processes; e.g., cleaning, polishing, embossing, coating
   b. Electrochemical processes: electroplating

B. Metallurgy

1. Mineral processing: crushing and grinding of ores, concentration of metallic minerals

2. Extractive metallurgy: separation of metallic elements from mineral form
   a. Pyrometallurgy: processes that involve the use of heat
      i. Roasting: oxidizing, reducing reactions
      ii. Smelting: processes for removing molten metal from molten slag
      iii. Converting: techniques for making steel, blister copper
      iv. Refining: techniques for purifying copper, lead, gold, and other extracted metals
   b. Electrometallurgy: processes that involve electrochemical reactions
      i. Electrolytic smelting; e.g., the Hall-Héroult process
      ii. Electrowinning: techniques for recovering metals from solution
      iii. Electrorefining: techniques for purifying copper, silver, and other metals
   c. Hydrometallurgy
      i. Leaching: techniques for dissolving metallic minerals
      ii. Recovery techniques; e.g., solvent extraction, chemical precipitation

3. Physical metallurgy
   a. Cold and hot working; e.g., forging, rolling, drawing
   b. Foundry processes; e.g., sand casting, die casting
   c. Surface treatments; e.g., galvanizing, carburizing
   d. Powder metallurgy: powder manufacture, processes, and products
   e. Nuclear engineering metallurgy: production, fabrication, and application of uranium and other metals of importance in nuclear engineering
   f. Heat treatment; e.g., annealing, quenching, tempering
   g. Metallography
      [see also 125.D.1.]
   h. Inspection and testing: mechanical and nondestructive testing
4. Welding, brazing, and soldering
   a. Basic principles: the metallurgy of metal joining
   b. Welding processes; e.g., forge welding, arc welding, resistance welding, brazing, soldering
   c. Types of joints; e.g., fillet welds, brazed joints
   d. Weldability of metals
   e. Testing and inspection of welds: nondestructive and destructive methods
   f. Applications; e.g., construction of bridges, storage tanks, and ships
   g. Recent developments; e.g., plasma welding, laser welding, ultrasonic welding

C. Materials handling in the production process
   1. Types of materials-handling systems by process
   2. Materials-handling equipment; e.g., wheeled carts, power trucks, trailer trains, racks, bins, conveyors
   3. Transportation of materials
      [see also 734]
   4. Technology of storage and warehousing

D. Technology of packaging

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major article dealing with the technology of the industrial production processes
   Industries, Extraction and Processing

MICROPAEDIA: Selected entries of reference information

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<table>
<thead>
<tr>
<th>adhesives, fasteners, and joining processes: adhesive</th>
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<th>sintering</th>
<th>packaging: aerosol container, bottle, drum, packaging</th>
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<tr>
<td>bolt brazing cement joint</td>
<td>hose industrial truck materials handling pipeline stoker storage</td>
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Biographies
See Section 732

INDEX: See entries under all of the terms above
Division III. Major Fields of Technology
[For Part Seven headnote see page 265.]

Division I of Part Seven is concerned with the nature and effects of technology as a whole. Division II deals with technical processes not specific to any of the major fields of technology. The outlines in the eight sections of Division III deal with the major fields of technology, differentiated by the various needs, purposes, products, and services that have elicited technological development.

Section 731. Agriculture and Food Production 280
732. Technology of the Major Industries 283
733. Construction Technology 286
734. Transportation Technology 288
735. Technology of Information Processing and of Communications Systems 290
736. Military Technology 293
737. Technology of the Urban Community 296
738. Technology of Earth and Space Exploration 297

Section 731. Agriculture and Food Production

A. The history of agriculture

B. Farm management
   1. Basic management problems and practices
   2. Farm labour, draft animals, and farm machinery
   3. Farm buildings
   4. Farming in relation to other disciplines; e.g., weather, pollution control

C. Crop farming
   1. Soil preparation and care
   2. Plant propagation, seeding and cultivation
   3. Harvesting and crop processing
   4. Specialized crop farming techniques: dryland farming, tropical farming, hydroponic farming, greenhouse farming
   5. Control of pests and disease organisms
      [see also 321.E.2.]
   6. Major crops
      a. Horticultural crops: vegetables and legumes, fruits and nuts, flowers
      b. Cereals
      c. Forest crops: trees, rubber
      d. Production of other major field crops; e.g., coffee, tea, cocoa, sugar, tobacco

D. Livestock farming
   1. Animal breeding
   2. Major flock and stock animals
      a. Cattle
      b. Swine
      c. Sheep and goats
      d. Horses
      e. Poultry
      f. Bees
      g. Other livestock; e.g., buffalo, asses and mules, camels
   3. Disease and pest control

E. Technology of hunting and fishing, whaling
F. Food processing
   1. Fruit and vegetable processing
   2. Cereals, cereal products, and other starch products
   3. Bakery products: basic ingredients, types of products and production methods, market
      preparation, quality maintenance and testing
   4. Confectionery and candy production
   5. Meat and meat products
   6. Fish and marine products
   7. Dairying and dairy products
      a. Milk production and handling techniques
      b. Dairy products: fluid and concentrated milk, dried milk, ice cream, butter, and cheese
   8. Beverage production
      a. Technology of brewing
      b. Technology of wine making
      c. Technology of producing distilled liquor
      d. Technology of producing nonalcoholic beverages: soft drinks, coffee, tea
   9. Spices, herbs, and flavourings
   10. Cane sugar, beet sugar, and other sweeteners
   11. Oils, fats, and waxes
   12. Eggs and egg products
   13. Cocoa and chocolate products

G. Food preservation
   1. Methods of preservation
      a. Low-temperature preservation: refrigeration and freezing
      b. Preservation by drying and by smoking
      c. High-temperature preservation: canning and pasteurization
      d. Fermentation and pickling
      e. Chemical preservation
      f. Preservation by heat radiation and by ionizing radiation
   2. Food storage and packaging

H. Techniques for controlling the quality of food
   1. Evaluation of food quality: sensory evaluation; objective evaluation by chemical, instrumental,
      and microbiological methods
   2. Control of food quality
   3. Regulation of food quality by legislation, grading, and inspection

I. Food sources and new product development
   1. History and development of new foods and new food products
   2. Utilization of new food sources; e.g., oilseeds, leaves, grasses, single-cell protein
   3. Development of new market forms
   4. Development of special foods; e.g., for space exploration
Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with agriculture and food production

- Agricultural Sciences
- Agriculture, The History of
- Beverage Production
- Farming and Agricultural Technology
- Fishing, Commercial
- Food Processing
- Forestry and Wood Production
- Gardening and Horticulture
- Gastronomy
- Industries, Extraction and Processing
- Public Works

**MICROPAEDIA**: Selected entries of reference information

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- beekeeping: paella
- beekeeping: pasta
- beeswax: polenta
- honey: tamale
- nectar: cooking
- cooking: baking
- beverages: boiling
- absinthe: braising
- alcoholic beverage: broiling
- aquavit: cookbook
- beer: frying
- brandy: leavening agent
- champagne: pressure cooker
- cider: sauce
- coffee: shortening
- cognac: tandoori cookery
- distilled liquor: wok
- gin: egg and dairy
- liqueur: products: butter
- maté: butterfat
- proof: buttermilk
- pulque: candling
- rum: cheese
- sake: churn
- soft drink: cream
- tea: dairying
- tequila: egg
- vodka: ice cream
- whiskey: milk
- wine: yogurt
- cereal crops: farm equipment and buildings: barbed wire
- barley: barn
- buckwheat: celliar
- corn: combine
- millet: corn harvester
- oats: cotton gin
- popcorn: cotton harvester
- rice: cream separator
- rye: crib
- sorghum: crop duster
- wheat: cultivator
- cereal grain products: farm machinery
- bran: fence
- breakfast cereal: grain drill
- couscous: grain elevator
- dumpling: harrow
- hominy: hog house
- noodle: millstone
- proof: plow
- rice: reaper
- pasta: scarecrow
- polenta: silo
- tamale: thresher
- tequila: tractor
- wok: windrower
- nectar: farming techniques:
- cooking: chinampa
- baking: contour farming
- boiling: crop rotation
- braising: drainage
- broiling: dry farming
- cookbook: fertilizer
- frying: hacienda
- leavening agent: hydroponics
- pressure cooker: irrigation
- sauce: Norfolk
- shortening: four-course
- tandoori cookery: system
- wok: open-field system
- egg and dairy: organic farming
- products: paddy
- butter: ranch
- butterfat: shifting agriculture
- buttermilk: spraying and
- candling: dusting
- cheese: tenenat farming
- churn: terrace cultivation
- cream: three-field system
- dairying: till-less agriculture
- egg: fishing and sea
- ice cream: products:
- milk: agar
- yogurt: ambergris
- cream separator: aquaculture
- crib: baleen whale
- crop duster: bêche-de-mer
- cultivator: caviar
- farm machinery: commercial fishing
- fence: factory ship
- grain drill: fishery
- grain elevator: lobster pot
- harrow: net
- hog house: roe
- millstone: seafood
- plow: shellfish
- reaper: sponge
- scarecrow: tuna
- silo: whaling
- thresher: food preservation:
- tractor: canning
- windrower: dehydration
- fertilizer: fermentation
- hacienda: food preservation
- hydroponics: freezing
- irrigation: pasteurization
- Norfolk: preservation
- four-course: refrigeration
- system: smoking
- organic farming: horticulture:
- paddy: graft
- ranch: horticulture
- shifting agriculture: pruning
- spraying and: transplant
- dusting: livestock and feeds:
- tenenat farming: cattle
- terrace cultivation: feed
- three-field system: goat
- till-less agriculture: hay
- fishing and sea: livestock
- products: pig
- agar: sheep
- ambergris: silage
- aquaculture: meat
- baleen whale: pork
- bêche-de-mer: sausage
- caviar: veal
- commercial fishing: venison
- factory ship: oils, fats, and
- fishery: waxes—edible:
- lobster pot: babassu palm
- net: beeswax
- roe: butter
Section 732. Technology of the Major Industries

A. Principles of organization of work and production
   [see 712]

B. Major manufacturing industries
   1. The aerospace industry
   2. The automotive industry
   3. The clothing and footwear industry
   4. The furniture industry

C. The major fabrication industries
   1. The textile industry
   2. The steel industry
      [see also 725.B.]
   3. The leather and hide industry
   4. The fur industry
   5. The floor-covering industry
   6. The electronics industry
   7. The tool and die industry
   8. The lumber industry
   9. The cutlery industry
  10. The abrasives industry

D. The major processing industries
   1. The chemical industry
   2. The petroleum industry
      [see also 724.B.2.]
   3. The paper industry
   4. The pharmaceuticals industry
      [see also 10/35.C.4.]
   5. The plastics industry

INDEX: See entries under all of the terms above
6. The rubber industry
7. The surface-coating industry
8. The dye and pigment industry
   [see also 122.G.1.1.]
9. The man-made fibre industry
10. Production of industrial and residential gases
    [see also 724.C.7.]
11. The cosmetics and personal care industry

E. The construction industries
   [see 733]

F. The service industries
   1. Hotels and motels
   2. Restaurants
   3. Food service systems
   4. The transportation industry
      [see 734]
   5. Security and protection systems

G. The utilities industries

H. The merchandising and marketing of consumer goods
   [see 533.H.5.]

I. Industrial research and development

J. Technology of industrial safety

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles and a biography dealing with the technology of the major industries

- Dress and Adornment
- Ford, Henry
- Forestry and Wood Production
- Industrial Ceramics
- Industrial Glass
- Industries, Chemical Process
- Industries, Extraction and Processing
- Industries, Manufacturing
- Industries, Textile

**MICROPAEDIA:** Selected entries of reference information

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polystyrene
polysulfone
polytetrafluoroethylene
polyurethane
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accelerator
foam rubber
hose
tire
vulcanization
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protection:
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process
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flannel
fustian
Section 733. Construction Technology

A. General building construction

1. Preconstruction planning: design programming, drafting

2. Surveying procedures: techniques for laying out building foundations
   [see also 723.D.2.c.ii.]

3. Building materials
   a. Earth, clay, and sod
   b. Vegetable matter: thatch, reeds, and other materials
   c. Lumber
   d. Bricks and tiles: other fired clay and ceramics
      [see 724.C.5.d.]
   e. Stone
   f. Mortar, cement, portland cement, and plaster
      [see 724.C.5.b.]
   g. Metals; e.g., iron, steel, aluminum, copper
      [see 724.C.3.]
   h. Glass
      [see 724.C.5.a.]
   i. Concrete, reinforced concrete, and prestressed concrete
   j. Composition materials, plastics
   k. Structural fabrics

4. Testing of building materials

5. Construction machinery
   a. Transport machinery
   b. Lifting machinery; e.g., cranes, cables, ropes

6. Construction techniques
   a. Wood and timber construction
   b. Masonry construction
   c. Concrete construction
   d. Steel construction

7. Building components
   a. Foundations and footings
   b. Structural systems
   c. Floor systems
d. Roof systems
e. Space-enclosure systems
f. Interior finishes: *e.g.*, carpeting, hardware, ceiling systems
g. Auxiliary systems
   i. Plumbing systems
   ii. Heating, ventilating, and air-conditioning systems
   iii. Electrical wiring
   iv. Systems for illumination: interior and exterior lighting
   v. Vertical transport systems; *e.g.*, elevators, moving stairways
   vi. Life-safety systems
8. Acoustics and sound-control techniques

B. Construction of civil engineering works
1. Dams
2. Aqueducts
3. Bridges
4. Underground construction
5. Harbour and hydraulic works
6. Lighthouses and lightships

C. Prefabrication and shop fabrication

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with construction technology
- Analysis and Measurement, Physical and Chemical
- Building Construction
- Drafting
- Public Works

**MICROPAEDIA**: Selected entries of reference information

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**Building construction:**

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searchlight  roof types:  tunnel  other:
spotlight  dome  tunneling shield  escalator
masonry construction:  geodesic dome  gate
arch  hip roof  hippodrome
cyclopean masonry  roof  jetty
masonry  vault  levee
mortar  tunneling:  construction
pointing  air lock  plumbing
reticulated work  caisson  porch
rubble masonry  elevator

Biographies
Brunel, Sir Marc Isambard
Eads, James Buchanan
Fuller, R. Buckminster

See also Section 10/37 of Part Ten

INDEX: See entries under all of the terms above

Section 734. Transportation Technology
A. History of transportation
1. Primitive transportation; e.g., travois, slide car, sledge, pack animal, dugout
2. The wheel and the road: development of the vehicle wheel, roads of the ancient world, beginnings of the modern road
3. Sails and oars: beginnings of shipping and shipbuilding, growth of inland waterways
4. Steam transportation
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   b. Steam navigation: the first steamships, introduction of iron ships, decline of sailing fleets
5. Development of modern transportation
   a. Construction of road vehicles, roads, bridges, and tunnels
   b. Development of mass urban transport and traffic networks
   c. Development of the air transport industry
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C. Vehicles and devices for transportation across country and on roads and highways
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2. Animal-drawn wheeled vehicles: wagons, coaches, and carriages
3. Bicycles
4. Automobiles
5. Trucks and buses
D. Rail transportation
E. Stationary conveyance systems; e.g., pipelines, conveyor belts
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F. Water transportation
1. Types of ships and other waterborne vessels
2. Ship design and construction
   a. Ship design: hydrodynamic and hydrostatic factors that influence ship stability and maneuverability, structural strength and safety considerations
   b. Shipbuilding, shipyard layout and construction; planning, fabrication, and assembly; launching, outfitting, and trials
Division III. Section 734

3. Canals and inland waterways

4. Harbour works: docks and quays, bulk terminals
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G. Air transportation

1. Aircraft: configurations, flight characteristics, missions, and special uses
   a. Lighter-than-air craft: balloons, airships
   b. Heavier-than-air craft: fixed-wing aircraft, rotary-wing aircraft, experimental and research aircraft
   c. Air-cushion machines

2. Airports

3. Air transport industry

4. Space travel
   [see 738.C.]

5. Aeronautical and space research

H. Traffic control: history, problems associated with traffic, government regulations, conventional and computerized techniques of control

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major article dealing with transportation technology

Transportation

MICROPAEDIA: Selected entries of reference information

General subjects

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Biographies

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INDEX: See entries under all of the terms above

Section 735. Technology of Information Processing and of Communications Systems

A. Communication and information theory  
[see 10/23.F.]

B. Calculating devices: the abacus, tally sticks, mechanical and electromechanical calculators  
[see C.2., below]

C. Office machines  
1. Writing and reproducing machines: typewriters, dictating and transcribing machines, word processors, duplicating machines and processes, copying machines and processes  
2. Calculating and accounting machines  
3. Miscellaneous office machines

D. Computers  
[see also 10/23.A.6. and 7.]

1. Types of computers: analogue and digital computers, hybrid computer systems  
2. Programming systems: the encoding and entering of instructions into computer memory, the concept of software, the systems approach to writing computer programs  
3. Computer languages  
4. Applications of microcomputers, minicomputers, and supercomputers  
5. Developments in artificial intelligence: devising expert systems; natural-language processing; computer vision; robotics

E. General information-recording devices  
1. Simple recording implements and devices; e.g., writing implements, slates, chalkboards  
2. Typewriters and word processors  
3. Printing machines and processes  
4. Production of printing plates: engraving and other techniques  
a. Mechanical techniques: woodcut, mechanical engraving, etching, lithography  
b. Photomechanical techniques: photoengraving

F. Sound and video recording and reproducing devices  
[see also 128.E.]

1. Mechanical systems: phonographs  
2. Magnetic systems: audio tape recorders, video tape recorders and players  
3. Optical systems: audio and video disk players  
4. Auxiliary equipment  
5. High-fidelity concepts and systems

G. The technology of photography  
1. Still photography  
[see also 628.D.]
2. Motion-picture and television photography  
[see also 623.A.]

3. Holography: laser photography  
[see also 128.B.4.c.]

H. Information processing and systems

1. Elements of information processing
   a. Analog and digital forms of information
   b. Recording and storage: image scanning and optical character recognition; mass storage via 
electromagnetic and electro-optical media (e.g., magnetic and digital-audio tape and disk, 
and optical disk, respectively)
   c. Organization and retrieval: indexes and indexing; bibliographic and numeric databases; 
computerized catalogs in libraries and library networks
   d. Display and dissemination: television monitors and interactive computer terminals; 
electronic mail, bulletins, and teleconferencing; electronic printing and photocomposition; 
speech synthesis

2. Types of information systems
   a. Organizational systems
      i. Management-oriented systems (executive, command and control, and decision 
support)
      ii. Administration-oriented systems (financial, personnel, and project management)
      iii. Service-oriented systems (manufacturing, transaction processing, and expert)
   b. Public information utilities (on-line database search systems)
   c. Educational and reference systems
      i. Dictionaries and lexicons
      ii. Encyclopaedias
      iii. Atlases and map collections

I. Major systems of communication

1. Book, newspaper, and magazine publishing
2. Postal systems and equipment
3. Telegraph systems and equipment
4. Telephone and telecommunications systems and equipment
5. Radio communications systems and equipment
6. Television communications systems and equipment
7. Communications satellite systems and equipment
8. Electronic networks
9. Encryption and decryption techniques and devices: signal security and message authentication, 
history of cryptology

J. Major systems of detection and remote sensing

1. Radar systems and equipment
2. Sonar systems and equipment

K. Electronic components and techniques used in communications

1. Components
   a. Active components: vacuum and gas-filled tubes, semiconductor devices
   b. Passive components: resistors, capacitors, and inductors; other solid-state devices; antennas 
and waveguides
   c. Integrated circuits: miniature arrays of interconnected active or passive circuit elements 
(e.g., microprocessors)

2. Sensing devices and transducers; e.g., piezoelectric devices, photomultiplier tubes
3. Circuitry
### Suggested reading in the *Encyclopædia Britannica:*

**MACROPAEDIA:** Major articles dealing with the technology of information processing and of communications systems

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Section 736. Military Technology

A. Offensive weaponry

1. Early hand-powered weapons
   a. Construction materials: wood, stone, precious metals, copper, bronze, iron
   b. Shock weapons: e.g., mace, axe, sword, halberd
   c. Missile weapons: e.g., spear, javelin, sling, arrow
   d. Mechanical weapons: e.g., ballista, catapult, ram, crossbow

2. Gunpowder weapons
   a. Construction materials: cast bronze, cast or wrought iron, forged or stamped steel
   b. Loading: muzzle-, breech-, automatic
   c. Artillery: e.g., cannon, howitzer, mortar
   d. Small arms: e.g., musket, rifle, pistol, machine gun
   e. Ammunition
      i. Propellant: black powder, smokeless powder
      ii. Projectiles: e.g., cannonball, shrapnel, shell, bullet

3. Explosives: e.g., grenades, mines, depth charges, bombs, missile warheads

4. Self-propelled missiles
   a. Basing
      i. Land: e.g., barrage rocket, ballistic missile, surface-to-air missile
      ii. Sea: e.g., torpedo, submarine-launched ballistic missile, antiship missile
      iii. Air: e.g., air-to-air missile, cruise missile
   b. Propulsion: rocket, jet, propeller
   c. Guidance: free-flight, energy-sensing, command, inertial

INDEX: See entries under all of the terms above
d. Payloads: e.g., single-warhead, cluster bomblet, multiple reentry vehicle
e. Warheads: e.g., high-explosive, antipersonnel, nuclear

5. Nuclear weapons
a. Energy sources: fission, fusion
b. Effects: blast, heat, radioactive fallout

6. Chemical and biological weapons

B. Defensive weaponry

1. Personal protection
a. Armour against early hand-powered weapons
   i. Materials: e.g., leather, bronze, iron
   ii. Construction: e.g., mail, scale, brigandine, plate
   iii. Protection: e.g., shield, helmet, cuirass, greave
b. Armour against gunpowder and explosive weapons
   i. Materials: steel, plastic, Kevlar
   ii. Protection: e.g., helmet, flak jacket, bullet-proof vest
c. Protection against nuclear and chemical weapons: e.g., gas mask, overgarments

2. Fortification
a. Field fortification: e.g., log breastwork, wooden pallisade, trench, foxhole
b. Permanent fortification before gunpowder: masonry citadel, motte-and-bailey castle
c. Permanent fortification in the early gunpowder era: sunken profile, bastioned trace
d. Permanent fortification in the modern gunpowder era: e.g., concrete bunkers, pillboxes, reinforced aircraft hangars
e. Antinuclear fortification: e.g., hardened missile silos, bomb shelters

3. Missile defense: surface-to-air missiles, rapid-fire guns

C. Weapon platforms

1. Land vehicles
a. Animal mounts: e.g., horses, elephants, camels
b. Man- and animal-powered vehicles: e.g., chariots, siege towers
c. Steam power: e.g., railroad cars, early tanks
d. Internal combustion: e.g., tanks, armoured personnel carriers

2. Surface ships and craft
a. Oar-powered: e.g., galleys, longboats
b. Sail-powered: e.g., galleons, ships of the line, frigates
c. Steam-powered: e.g., battleships, cruisers, aircraft carriers
d. Internal combustion: e.g., gunboats, landing craft
e. Nuclear-powered: e.g., aircraft carriers, cruisers

3. Submarines
a. Propulsion: steam turbine, diesel-electric, nuclear
b. Vessels: attack, strategic missile launching

4. Aircraft
a. Fixed-wing airplanes
   i. Propulsion: internal combustion/propeller, jet
   ii. Configuration: e.g., biplane, monowing, variable-geometry wing
   iii. Types: e.g., fighter, bomber, early warning
b. Helicopters
   i. Propulsion: internal combustion, gas turbine
   ii. Types: e.g., attack, naval antisubmarine, transport
D. Engineering

1. Tactical support: e.g., fortification
2. Strategic support: e.g., roads, bridges, ports, airfields
3. Ancillary support: e.g., maps, bomb disposal

E. Logistics: supply, transport, lodging, services

F. Electronics

1. Electromagnetic sensors and transmitters: the use of radio, radar, infrared, ultraviolet, optical, and laser technology in communication, navigation, warning and detection, and weapon guidance
2. Electronic countermeasures: radar jammers, infrared flares, chaff

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with military technology

**MICROPAEDIA:** Selected entries of reference information

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**Launch vehicles and rockets:**

| Atlas rocket | B-24 |
| P-38 | monitor |
| P-47 | ship of the line |
| P-51 | submarine |
| Spitfire | U-boat |
| Stuka | AK-47 |
| Harrier | anti-aircraft gun |
| Ilyushin Il-2 | anti-tank weapon |
| Ilyushin Il-76 | Armalite rifle |
| Me 109 | artillery |
| MiG | assault rifle |
| Mirage | automatic pistol |
| Mosquito | automatic rifle |
| P-38 | battering ram |
| P-47 | bayonet |
| P-51 | bazooka |

**Personal protective equipment:**

| armour | bow and arrow |
| arm | Bren machine gun |
| chain mail | Browning |
| gas mask | automatic rifle |
| helmet | cannon |
| Zero | carbine |
| | catapult |
| | coastal artillery |
| | crossbow |
| | dagger |
| | flame thrower |
| | Gatling gun |
| | Greek fire |
| | gun |
| | lance |
| | Lee-Enfield rifle |
| | Luger pistol |
| | machine gun |
| | MAG |
| | machine gun |
| | Mauser rifle |
| | MG42 |

**Aircraft:**

| aircraft carrier | battle ship |
| cruiser | destroyer |
| galleon | frigate |
| galley | galleon |
| ironclad | galleon |
| minesweeper | galleon |

**Armoured vehicle:**

| armoured vehicle | battleship |
| panzer division | cruiser |
| tank | destroyer |
| infantry | frigate |
| | galleon |
| | galley |
| | ironclad |

**Military aircraft:**

| AWACS | B-1 |
| B-17 | B-17 |

**Mechanized ground warfare:**

| armoured vehicle | battleship |
| destroyers | frigate |
| galleys | galleys |
| minesweepers | minesweepers |
| submachine guns | submachine guns |
| Uzis | Uzis |

**Other:**

| ram | repeating rifle |
| revolver | rifle |
| speech carmine | Springfield rifle |
| Sten gun | sword |
| Thompson submachine gun | Uzi submachine gun |
| weapon | weapon |

**Rockets:**

| Atlas rocket | P-38 |
| Atlas rocket | P-47 |
| cruise missile | P-51 |
| Nike missile | Spitfire |
| Peacekeeper missile | Stuka |
| Polaris missile | torpedo plane |
| Poseidon missile rocket | trainer |
| Thor rocket | personal protective equipment: |
| Trident missile | Lee-Enfield rifle |
| V-1 missile | Luger pistol |
| V-2 missile | machine gun |
| | MAG |
| | machine gun |
| | Mauser rifle |
| | MG42 |
| | musket |
| | pistol |

**Other:**

| Agent Orange | alcazar |
| ammunition | biological warfare |
| camouflage | chemical warfare |
| ficklack | fortification |
| matchlock | military bridge |
| military | military engineering |
| sapper | shrapnel |
| snorkel | stealth |
| Strategic Defense Initiative | strategic weapons system |
| system | tactical weapons system |
Section 737. Technology of the Urban Community

A. Basic engineering services of the city

1. Water-supply systems

2. Sanitation systems
   a. Development and operation of sewage disposal systems
   b. Construction and operation of street clearance and refuse disposal systems

3. Urban transportation systems

4. Interurban transportation systems
   [see 734]

5. Technology of electric power
   [see 721.C.7.]

6. Fire prevention and control

B. Technology of the basic social services of the city

1. Police technology
   a. Traffic control technology
      [see 734.H.]
   b. Crime control technology

2. Design, construction, and maintenance of recreational facilities; e.g., parks, stadiums, racetracks, planetariums, aquariums

C. Technological responses to new urban problems

1. Control of air, water, land, and other pollution

2. The planning of cities and urban environments: the systems approach to urban design and construction, the development of new towns

Suggested reading in the *Encyclopædia Britannica*:

MACROPAEDIA: Major articles dealing with technology of the urban community

Conservation of Natural Resources  Public Works
Police  Transportation
## Section 738. Technology of Earth and Space Exploration

### A. Techniques and equipment of surface and underground exploration

1. Types and purposes of exploration
   a. Scientific exploration: the determination of the properties of the Earth’s interior
   b. Resource exploration: the discovery of sources of ores, building materials, fuels, water, and geothermal energy
   c. Exploration for construction: the planning of tunnels, foundations, and other works

2. Methods of exploration
   a. Indirect methods: geophysical and geochemical methods
   b. Direct methods: on-site testing by means of excavation, boring, and sampling of soil and rock

### B. Techniques and equipment of undersea exploration

1. Platforms for exploratory work
   a. Surface vessels; e.g., deep-sea drilling ships and twin-hull vessels
   b. Submersibles
   c. Aircraft and satellites: application of remote sensing and satellite telemetry
   d. Buoys and other unmanned units; e.g., the Self-Propelled Underwater Research Vehicle (SPURV)

2. Navigational methods and systems for establishing the precise location of discoveries

3. Developments in oceanographic sampling and measurement techniques; e.g., acoustic methods and solid-state microelectronic ocean-current measuring devices

### C. Techniques and equipment of space exploration

1. History of space flight prior to Sputnik I: early speculations and fictional accounts, development of space flight theory and technology during the 20th century

2. Space programs since 1957
   a. Space launch vehicles: rockets designed to provide orbital or escape velocity for manned or unmanned spacecraft
   b. Unmanned space probes
      i. The use of sounding rockets to explore the upper atmosphere of Earth
ii. The use of orbiting satellites for scientific purposes; e.g., to study the natural phenomena of space, to test instrumentation and communication techniques

iii. The use of unmanned spacecraft to probe the Moon and the planets and their satellites


d. The use of Earth-oriented satellites: communications, Earth survey, and navigation satellites

3. Elements of space flight

a. The environment of space: the definition of space, characteristics affecting space flight

b. Technology of spacecraft subsystems

c. Launch principles and techniques: staging of propulsion systems, acceleration rates

d. Mechanics and techniques of space flight

i. Types of trajectories: suborbital, Earth orbital, Earth escape, and interplanetary

ii. Navigation in space

iii. Rendezvous and docking

iv. Reentry and recovery

4. Contributions of space exploration to advances in the physical sciences

D. Techniques of life-support systems for exploration

1. Systems used in undersea exploration

2. Systems used in space exploration

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with the technology of Earth and space exploration

**MICROPAEDIA:** Selected entries of reference information

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Biographies

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See also Section 721

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Religion as Symbolism

Introduction to Part Eight:

by Wilfred Cantwell Smith

There is more to human life than meets the eye. More to oneself; more to one's neighbour; more to the world that surrounds us. There is more to the past out of which we come; and especially, it would seem, more to the present moment, maybe even infinitely more. There is more to the interrelationships that bind us together as persons. And the further we probe, we have always found, the deeper the mystery, or the reward, or the involvement. It is this "more," perhaps, that provides at least one of the bases for human religion. We have seldom been content to be "superficial," to remain on the surface, to imagine that reality does not transcend our finite grasp; and throughout most of our history on this planet we have ordered our lives, both personal and cultural, in terms of that transcendence.

Yet how is one to point to what one does not visually see? How to resort to a milieu beyond all space? How to talk or to think about what transcends not only words but the reach of the mind? How even to feel about what one does not touch? Man's inherent and characteristic capacity to do these things finds expression through his special relation to symbols. These have proven over the centuries sometimes more, sometimes less, adequate to such a task, but in any case indispensable, and ubiquitous. Such symbols, it turns out, have the power not merely to express man's otherwise inchoate awareness of the richness of what lies under the surface, but also to nurture and to communicate and to elicit it. They have an activating as well as a representational quality, and an ability to organize the emotions and the unconscious as well as the conscious mind, so that into them we may pour the deepest range of our humanity and from them derive an enhancement of our humanity and from them derive an enhancement of the personality. Without the use of symbols, including religious symbols, man would be radically less than human.

Quite diverse types of things have served the purpose: a heaven, the sky, a ceremonial procedure, silence; erotic love, or austere asceticism; the Qur'an; a historical figure; reason. The variety has been immense, different groups having chosen different things to serve them as symbols, not all equally successful. Virtually universal, however, is that peoples have found it possible to designate some item from within the visible world and to sacralize it in such a way that it becomes then for them the symbol or locus of the invisible, the transcendent. In Japan, a simple open gateway (torii) marks off the shrine precincts: one passes through it, leaving behind psychologically, symbolically, the humdrum ordinary world to enter the sacred space of the temple; and after worship, one again moves through the gate in the other direction, to reenter now the realm of everyday life, but as a renewed person. Virtually all peoples have set aside some portion of what outsiders would regard as ordinary terrain to serve for them as sacred space, erecting in it temple, church, or shrine whereby is then represented for them, often with great force, quite another dimension of reality.

Similarly with time: the Jew, for instance, sets apart one day in seven, whereby the other six days symbolize the mundane world with its bitter imperfections, perhaps its devastating pain, and at best its transient successes, while the Sabbath creatively represents the inviolate splendour of transcendence—with which therefore the other six days, however bleak, cannot keep him out of touch. Every people has its festivals, weekly or seasonal or occasional, its sacred times when life in its empirical and work-a-day aspects is transcended and life in its timeless dimension is reaffirmed: moments when truth, significance, worth are recognized and cultivated—and carried back then into the ordinary world.

We are somehow aware, if only through imaginative vision or sensibility or our special capacity for hope, not only of what is but also of what ought to be. We have sensed that the status quo (nowadays, the fluxus quo) is not the final truth about man or the world. We have felt, to take one example, that social justice and concord, personal righteousness, health, joy stand over against the current observable condition of strife, loneliness, wickedness, poverty, and sorrow not as fancy against truth, wishful and irrational dreaming against reality, but in some fashion vice versa—as a norm by which the present imperfect world is judged, in some sense a truth in relation to which empirical actuality is in some sense an error. This too has been affirmed symbolically. One rather common way of doing so has been by representing a more perfect world elsewhere. Some have located their utopias chronologically in the past ("Once upon a time"; or Golden Age theories, as in Greece and India); or in the future (millennialisms, a coming just ruler, secular ideas of progress, a life after death); or geographically, somewhere else (the medieval Irish "Isle of the Blessed" in the then inaccessible Western Sea); or high above the sky (heaven, the heaven of heavens); or in a domain beyond time (Paradise); or in another realm than this universe (a metaphysical order, idealist realities).

However it be symbolized and articulated, a moral dimension to human life has been perceived and affirmed. Man has been aware not only of the profitable and the disadvantageous but also of the better and the worse, and has been inspired by some power to pursue the better; he has known that some actions are right, some wrong, and that it matters. At most times and most places, morality has been an integral part of the religious complex (although situations have on occasion arisen when the two have become historically dislocated—when a given form of religion has seemed not good; or to put it another way, when man's sense of what is worthwhile, and the inherited symbols by which worth used to be formulated, have no longer converged).
If the panorama of man’s religious life is, in its outward form, selected mundane data symbolizing the more than mundane, then the task of the student of religion is to know those data but to consider them not in themselves but in their role in our lives. Our concern is not primarily the doctrines and scriptures and prayers and rites and institutions; but rather, what these do to us. Not the tribal dance, so much as what happens to the African dancing; not the caste system, so much as what kind of person the Hindu becomes within it, or without it; not the events at Sinai, so much as what role the recounting of these events has played in both Jewish and Christian life over the centuries since; not the Qur'an, so much as what the Qur'an means to a Muslim.

In illustration, let us consider as an example a statue of the Buddha, and take note specifically of one small part of it, the pose of the right hand. Among several such stylized poses used throughout the Buddhist world, we may choose just one, the abhaya mudra ("fearlessness pose"), in which the right arm is somewhat raised, that hand held straight up, palm facing out. Over and above the more universal significance of such a gesture (power, authority, benediction), in the Buddhist case this represents also an incident from the life of the Buddha, in which reputedly a wild elephant charging him and his group was stopped in its tracks when the Teacher raised his hand so, and became tame. The gesture gives artistic expression, then, to the Buddha’s fearlessness in the face of the threat, and also to his conferring of fearlessness, and of grounds for fearlessness, on his disciples: his serene triumph over danger.

To say that this particular feature of sculpture symbolizes for Buddhists the overcoming of fear is to indicate not merely that it depicts an event in someone else’s life, but also that it effects a change in one’s own—since, to repeat, symbols not only represent but activate. The animal in its fury in the remembered anecdote may itself be taken as symbolic, representative of the pressures and assaults of life, which faith in the Buddha gives one the inner resources to withstand: the passions, for instance, to which such faith bestows on one the power quietly to say “no.”

To understand this particular item in the religious life of Buddhists, accordingly, is to know the history of how a Japanese emperor or a Thai merchant or a Chinese peasant through contemplating it in some nearby temple has touched on below.)

Although correlative conceptualizations are virtually worldwide and history-long, this particular concept was developed in its most powerful and characteristic form in the Near East and has permeated, at times dominated, the civilizations that have emerged from there to cover almost half the planet, especially the Islamic and the Judeo-Christian. And even these great complexes, each of which has an elaborate and ever-changing history, constitute systems to be understood not in themselves, as structures to be looked at, but rather in terms of the ambience that they make available for men and women to live within. "In order to understand Buddhists, one must look not at something called Buddhism, but at the universe, so far as possible through Buddhist eyes.” It is not the symbols themselves
that one must grasp, so much as the orientation that they induce: how the whole complex of symbols enables those who live in terms of it to see a sunset, a broken marriage, prosperity, the onset of cancer, one's election to public office.

The religious history of the Hindu community is a history, in part, of traditional ceremonial and ideological and sociological patterns. Yet in more significant part it is a history, however difficult this may be to discern, of fortitude and of quiet humaneness, of a conviction that life is worth living and death worth dying, that goals are worth striving for, that the immediate is caught up in the eternal. The Buddhist metaphors have served to kindle in the mind and heart of the Buddhist the perhaps unconscious awareness that one's own fortune is not a reason for gloating, or one's neighbour's fortune, for envy; that knowledge is more important than wealth, and wisdom than knowledge; that the world is to be appreciated and not merely exploited; that one's fellow is to be treated as an end, not merely as a means; that sorrow is not a reason for despair. Islamic law, theology, architecture, and the rest have been symbols that at their best have crystallized and nurtured, for Muslims, the courage and serenity, the sense of order and the aspiration to justice, the forbearance, the humility, the participation in community, that the Islamic system traditionally inspired. Christian symbols have given both form and actuality, among Christians, to many things, including for instance the ability of human suffering to become redemptive.

Of course, religious symbols and sets of symbols have been used also for mean and destructive purposes. Man's wickedness, and not only his capacity for virtue, has been expressed and even encouraged by his symbol systems, at times. Through them he has found his freedom, his transcendence of the immediately given, his ability to move beyond being merely an organism reacting to its environment; but sometimes he has used these destructively, or has become a victim of their inherent ambiguities. Nothing has turned a society into a community so effectively as religious faith: to share common symbols is about the most powerful of social cohesions. And yet few gulfs have been greater than those that separate differing religious communities, few hostilities so fierce as those between groups whose symbols differ.

Religious symbols do not raise man above the human level; only to it. A final word about history. The history of religion has at times been mistaken for the history of its symbols; but this is superficial. The same symbols have discernibly changed their meanings over time, and indeed from person to person, and even within one person's life: also, persisting or widespread orientations and perceptions have been expressed in strikingly different symbolizations. The true history of religion is more deeply personalist—not in the sense of individualist: the personal is also the social, and especially so in the religious realm. The true history of religion, not yet written, is the history of the depth or shallowness, richness or poverty, genuineness or insincerity, splendid wisdom or inane folly, with which men and women and their societies have responded to such symbols as were around them. It is also, however, the tale, and to some degree this can be told, of when and in what fashion they have forged new symbols, or neglected or found themselves unable to respond to old. And nowadays it is also the story of how they deal or fail to deal with a plurality of symbolisms.

One's faith is in some sense the meaning that religious symbols have for one; but more profoundly, it is the meaning that life has, and that the universe has, in the light of those symbols. For religious symbols do not "have" meanings of their own; they crystallize in various ways the meaning of the world, of human life. There is a history of their varying ability to do this, at various times and places (or of people's varying ability to have them do it). How new symbols or patterns of symbols emerge is too complex or controversial a question to be summarized here; but how they develop once launched, how they are reinterpreted (sometimes radically) over the centuries, how their success in pointing beyond themselves often gives way to a rigidity and narrowness in which they or their institutions are prized or defended simply in themselves: how iconoclastic movements arise, to shatter the symbols (literally, smashing idols; or figuratively, attacking concepts and mores), whether in the name of something higher or out of misunderstanding, and often both: saddest of all, how a time may arrive when the symbols no longer serve a community, no longer communicate a transcendent vision, and then a profound malaise settles on the society and life comes to seem without meaning, and people become alienated from each other and even from themselves and from the world in which they live—all this the historian can trace.

In recent Western history an aberrational tendency has arisen to imagine that human life is fundamentally or naturally "secular," and that religion has been an added extra, tacked on here and there to the standardly human. This view now appears to be false. Rather, the various religious systems have expressed varying ways of being human. The unbiased historian cannot but report that it has been characteristic of man to find that life has meaning and to formulate that meaning in symbolic ways, whether grotesque or sublime.
Part Eight. Religion

The outlines in the eleven sections of Part Eight set forth studies of religion in general and studies of the particular religions. The ways in which religion is related to studies of human society, the fine arts, the history of civilizations, and science and philosophy are dealt with in Parts Five, Six, Nine, and Ten.

Division I. Religion in General 303
II. The Particular Religions 306

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Division I. Religion in General

The outlines in the two sections of Division I deal with diverse views of the nature, purpose, validity, and value of religion, and with the problems, methods, and results of the empirical, comparative, and phenomenological study of religions and of religious experience.

Section 811. Knowledge and Understanding of Religion 303
812. The Religious Life: Institutions and Practices 305

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Section 811. Knowledge and Understanding of Religion

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   1. Basic questions and problems
      a. The existence of the divine or sacred (God)
      b. The attributes of the divine or sacred
      c. The extent to which mankind can have knowledge of the divine or sacred
      d. The special problems of free will, evil and suffering, and immortality
   2. Questions about the nature and character of the divine or sacred
      a. Whether the divine or sacred is personal or impersonal
      b. Whether the divine or sacred is one or more unique beings or powers

B. Religious experience: its nature, elements, and varieties

C. Religious phenomenology: the basic patterns of religious thought, action, and association

D. Theology as an attempt to understand and state the rationale of religious belief
   1. Theology in relation to divine revelation
      a. The role of Sacred Scriptures
      b. Doctrine and dogma
      c. Articles of faith: religious creeds
   2. Mystical theology: immediate experience of the divine or sacred
   3. Doctrines concerning God or the gods
      a. Polytheism
      b. Religious dualism
      c. Monotheism
         i. Theism
ii. Deism
iii. Pantheism and panentheism
d. Atheism and agnosticism
4. Doctrines of creation
5. Angelology
6. Doctrines of divine government and providence
7. Eschatological theories
8. Doctrines of grace and salvation
9. Sacramental doctrines
10. The doctrine of the Covenant
11. Miracles

E. The study and classification of religions

F. Other systems of belief
1. Myth and mythology
2. Magic
3. Witchcraft
4. Shamanism
5. Astrology and alchemy
6. Ancestor worship
7. Hero worship
8. Nature worship

G. Religion in relation to other aspects of human experience
1. Religion and art
   [see also Part Six]
2. Religion and science
3. Religion and society
   [see also 521.D.6.]
4. Religion and morality
   [see also 10/2.B.6.]
5. Religion and philosophy
   [see also Part Ten, Division V]

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the knowledge and understanding of religion

Doctrines and Dogmas, Religious
Myth and Mythology
Occultism
Philosophies of the Branches of Knowledge

RELIGIONS, THE STUDY AND CLASSIFICATION OF
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Section 812. The Religious Life: Institutions and Practices

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   a. Prayer
   b. Confession
   c. Pilgrimage
   d. Sacrifice

2. Passage and purification rites: birth, puberty, marriage, death

3. Religious regulation of personal and social behaviour
   a. Religious law
      [see 551.B.3.d. and 827.F.6.a.]
   b. Dietary customs
   c. Monasticism
   d. Celibacy
   e. Asceticism
   f. Prophecy and divination

4. Religious feasts and festivals

B. Religious leaders and institutions

1. The religious state: theocracies, sacred kingships

2. Forms of religious organization: church, temple, congregation, sect, council; the priesthood

3. Sainthood

4. Institutions of religious education

C. Material manifestations of religious beliefs

1. Sacred writings

2. Art and architecture, religious symbolism and iconography

3. Ceremonial and religious objects, the sacraments

4. Religious dress and vestments

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the religious life: institutions and practices

Doctrines and Dogmas, Religious
Religious Experience
Religious Symbolism and Iconography
Rites and Ceremonies, Sacred
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**Division II. The Particular Religions**

[For Part Eight headnote see page 303.]

The outlines in the nine sections of Division II treat the particular religions of mankind, in different historical eras and world areas.

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**Section 821. Prehistoric Religion and Primitive Religion**

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   c. Totemism: the socioreligious system in which men are intimately related to plants, animals, or other natural phenomena
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   d. Asia: aboriginal religions of Asian peoples
   e. The Arctic: religions of the Eskimo, Aleuts, Sami (Lapps), Chukchi, Yakuts, Nganasan, Nenets, and other Arctic peoples

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with prehistoric religion and primitive religion
   Doctrines and Dogmas, Religious
   Prehistoric Peoples and Cultures
   Sacred Offices and Orders

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I. Religions of pre-Columbian American civilizations
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   2. Mayan religion
   3. Aztec religion

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Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with religions of ancient peoples

- Doctrines and Dogmas, Religious
- European Religions, Ancient
- Middle Eastern Religions, Ancient
- Mystery Religions
- Pre-Columbian Civilizations
- Zoroastrianism and Parsiism

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| Opet | Lyr |
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| Egyptian worship, practices, and institutions: |
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- Religious Literature: Pantheon:
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- Basilides
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5. The early Hindu period (2nd century BC–4th century AD): the rise of the major sects and other developments
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7. The rise of devotional Hinduism (8th–11th century): the Tamil hymnists, the Bhāgavata-Purāṇa after Hinduism
8. The age of bhakti (11th–19th century)
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1. Hindu sacred literature
   a. Primary scriptures regarded as eternal revelations: the Veda
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2. Hindu mythology: varieties of myths, modes of representation and themes
3. Hindu philosophy: the integral relation of philosophy and religion in Hinduism
4. Hindu mysticism: its general characteristics, varieties, goals, and methods

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4. Cultural expressions of Hindu values and ideas
   a. The traditional religious functions of Indian art: symbols and images
      i. Types of symbols: yantras, mandalas, liṅgas, yonis
      ii. Icons: their role in expressing theological elements of Hinduism
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      i. Early background: traditional accounts of Mahāvira's predecessors
      ii. The life, work, and teachings of Vardhamāna Mahāvira
      iii. Later developments (6th century BC–20th century AD)
   b. Myths about Jaina "great souls": Tirthaṅkaras, ascetic and monastic figures, and lesser deities
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      i. Islamic and Hindu background (11th–15th century) [see also A., above, and 828.A.]
      ii. The origin of Sikhism in the life and work of Nānak, first of the ten Gurūs (15th–16th century)
      iii. The establishment and growth of Sikhism under the nine succeeding Gurūs, the establishment of Sikh militarism (16th–18th century)
      iv. The condition of Sikhism during the Sikh empire (18th–19th century)
      v. The condition of Sikhism under British rule (19th–20th century)
      vi. Sikhism in independent India and Pakistan
   b. Sikh religious literature
   c. Beliefs, practices, and institutions of Sikhism
3. Parsiism: Zoroastrianism in India
   [see 822.B.4.]
   a. History of Parsiism
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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with Hinduism and other religions of India
   Hinduism
   Indian Philosophy
   Jainism
   Sikhism
Hinduism—
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Buddhism

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1. The cultural context: its background in Hinduism; its geographical, ethnic, and cultural base
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2. The founding of Buddhism: the life, work, and teachings of Siddhartha Gautama (6th–5th century BC)
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5. The relationship of Buddhism to nationalist movements: its contemporary situation, its prospects

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major article dealing with Buddhism
Buddhism, The Buddha and

MICROPAEDIA: Selected entries of reference information

General subjects

deities and mythology:
- Amitābha
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   e. Introduction of Confucianism into Korea and Japan (1st and 4th centuries AD) [see D. and E., below]
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d. The Meiji era and after (1868 to the present): new religious movements

2. Shintō: the Way of the Gods

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b. Characteristics of primitive Shintō: the role of guardian shrines and shamans
c. Shintō literature and mythology: the form and content of the Kojiki, Nihon shoki, and other writings
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with indigenous religions of East Asia: religions of China, Korea, and Japan

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with Judaism
Doctrines and Dogmas, Religious Judaism Moses

MICROPAEDIA: Selected entries of reference information

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and biographies dealing with Christianity

Biblical Literature and Its Critical Interpretation
Calvinism, Calvin and Christianity
Doctrines and Dogmas, Religious Eastern Orthodoxy
Jesus: The Christ and Christology
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5. Modern reform movements

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with Islam

Islam, Muhammad
Islamic World, The

MICROPAEDIA: Selected entries of reference information

General subjects

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with other religions and religious movements in the modern world
   Doctrines and Dogmas, Religious Occultism

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   General subjects

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Everything that we call the arts and the humanities comes out of some natural desire and acquires value by satisfying it. Painting and music and literature are important not because there are museums and concert halls and libraries to be kept supplied but because human beings want to draw and sing and tell stories as well as enjoy seeing others fulfill these native and universal impulses.

Among the humanities, history holds a special place in that its origin within each of us is not even dependent on impulse. A person may lack altogether the wish to sing or the knack of telling a story, but everybody without exception finds occasion to say: "I was there; I saw it; I remember it very well." In saying (or even thinking) these words, every man is a historian. History is inescapably a part of consciousness. The Greeks expressed this truth by describing Clio, the muse of history, as the daughter of part of consciousness. The Greeks expressed this truth by describing Clio, the muse of history, as the daughter of part of consciousness. The Greeks expressed this truth by describing Clio, the muse of history, as the daughter of part of consciousness. Hence the greater impulse. A person with any interest in history we mean the past is a historian. His interest begins with himself and his environment, but it is soon stretched out, haphazardly, into such domains of history as chance or special interests have developed. And special interests need not mean explicitly intellectual ones; baseball and chess, model trains and furniture, pottery and boat-building have their heroes and revolutions too, and whoever cares about these activities or artifacts for themselves inevitably becomes engrossed in their histories.

It is of course true that when we ordinarily speak of someone having an interest in history we mean the political, social, or cultural history of great civilizations; and for a long time history was arbitrarily taken to mean the sequence that leads from the ancient civilizations of the eastern Mediterranean to the modern ones of the West. It is a tremendous spectacle, even though concentrated on a relatively small territory. But now that certain dynamic elements of Western civilization have aroused the rest of the world to both imitation and resistance, it has become imperative to widen the panorama and see behind the vast and confused modern scene the several histories of the great civilizations of the West as well as the traditions and vicissitudes of the African societies.

Two questions readily occur at the mere thought of so much to know. Can a reader who is not a professional historian find his way in this huge maze of names, dates, and facts? And if he can, why should he? The answer to the first question is the old reply of the mathematician to the nervous student: "What one fool can do, another can." A real compliment is concealed in this gruff retort, for what it implies is that given an interest, a motive, any man can inform himself about any part of world history through secondary accounts such as are digested in an encyclopedia. There is no obligation to master every detail, to dispute or criticize sources—in a word, to ape the professional, who, for the best of reasons, limits himself to a small segment of the whole. A reader of history is one who follows with his mind the steps another took on his voyage of discovery; and this is easier in history than in mathematics, for history is told in plain words and deals with ordinary human relationships.

So the main difficulty lies in the second question: Why embark on the journey? The answers are numerous and varied, for temperaments differ, as do "special interests" in the sense referred to above. But there is one answer that covers the rest: it is the answer suggested by what was said earlier about every man's unconscious absorption of haphazard fragments of history. The best motive for reading history deliberately is curiosity about the portions missing reports—which is contemporary history and which usually brings with it fragments of a remote past—we begin to see that every man who lives in a modern, communicative society is forced to become in some sense a conscious historian. His interest begins with himself and his environment, but it is soon stretched out, haphazardly, into such domains of history as chance or special interests have developed. And special interests need not mean explicitly intellectual ones; baseball and chess, model trains and furniture, pottery and boat-building have their heroes and revolutions too, and whoever cares about these activities or artifacts for themselves inevitably becomes engrossed in their histories.

It is of course true that when we ordinarily speak of someone having an interest in history we mean the political, social, or cultural history of great civilizations; and for a long time history was arbitrarily taken to mean the sequence that leads from the ancient civilizations of the eastern Mediterranean to the modern ones of the West. It is a tremendous spectacle, even though concentrated on a relatively small territory. But now that certain dynamic elements of Western civilization have aroused the rest of the world to both imitation and resistance, it has become imperative to widen the panorama and see behind the vast and confused modern scene the several histories of the great Eastern civilizations as well as the traditions and vicissitudes of the African societies.

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from one’s own picture of the past. Curiosity: How did things come to be as they are? How was it when they were different? Is it true that once upon a time men did thus and so? History deals with particulars, and most recorded particulars contain puzzles, contradictions, enormities, all of them spurs to curiosity: the Hudson River in the state of New York was named after the navigator often called Hendrik Hudson, who first sailed up the stream. But why Hendrik and not Henry? Well. Henry was his baptismal name; how did he acquire the other and why? The full answer leads really to a comprehensive view of exploration and colonization by the national states at the dawn of the modern age—the aims, drives, desires, errors, follies, cruelties, and incalculable consequences of a great movement that occupies two and a half centuries and that has continued in different forms down to the landings on the Moon.

The most striking feature of history is its fusion of purposeful direction and unexpected drift. For example, read about Plato, Aristotle, and the ancient mathematicians, and you will discover how their speculations and discoveries have been transformed and amplified into the methods and systems that we still work with. But you will also be told how at various times these same streams of thought or belief generated entirely new and remote, strange and absurd consequences. Again, ancient astrology led to the science of astronomy, and science (as we think) replaces superstition. Yet astrology fills columns in 20th-century newspapers and the minds of their millions of readers. What is the explanation? We lack the pythones of Delphi, in whom Socrates believed or affected to believe, and we have no official college of augurs to scan the entrails of birds as a guide to future political action, but fortune-tellers are never out of business and we do have Gallup polls. Truly, the wonders of cultural history are infinite.

To conjure up these beliefs and institutions in this comparative fashion is not to equate them with one another or across the centuries; it is rather to stress the identity in diversity that is the principle of human affairs and that makes human history accessible to any willing reader. In different times and places, men are the same and also different. The differences are due to the varying emphases given by one people at one time to some element of life and feeling or to some form of its expression. This is most easily seen in the plastic arts. Think of the representations of the human body in Egypt, Greece, medieval Europe, the west coast of Africa, pre-Columbian America, and the art galleries of world capitals in the second half of the 20th century: is it the same human body or different? The question is really idle, for it is both and neither. In paint or marble there is strictly no human body, only a view of it, a feeling about it. Similarly, what we see in history is not so much Man distorted in one way or another as men who existed only as we see them; that is, in their society and culture, under their skies and gods, never staying put for more than a short time, never to be reduplicated elsewhere or at a later time, even when the effort to imitate is strong and shrewd—as in the Italian Renaissance, which tried to restore the ancient culture of Greece and Rome.

Despite this irreducible plasticity, diversity, and restlessness, we draw historical parallels, we make comparisons. That we can do so is what persuades us of the unity and continuity of history. When we find the Celtic druids and the Aztecs making human sacrifices to their gods we say we recognize a human tendency, though we profess to abhor it. Yet some future reader of history might be tempted to compare with those ancient peoples our contemporary revolutionists, who sacrifice 400,000 kulaks (or some other hapless group) for the good of the tribe and its eternal prosperity. But we also notice a strange difference: we know that fanatical faith presides over each type of human sacrifice, ancient and modern, but even as we condemn we think we understand the modern more readily: we know its background, have heard its advocates. It is one of the illuminations of history, not merely to know abstractly, but, by learning the local shape of things, to feel how the reality of each time and place differs; how the faiths diverge in contents and origins and thus in persuasiveness. We may now lump together the Celts and the Aztecs, but they were far apart in thought and character: in short, nothing is truly comparable; in history everything is sui generis.

The wise reader of history keeps his equilibrium between these two extremes of likeness and difference. He tries to see the unfamiliar in the familiar, and vice versa. He stands away from his own prejudices and satisfies his curiosity by trying to sympathize with what is farthest away or most alien. This is very hard to do when what is before us is a bloody sacrifice, a massacre, a piece of treachery or cynical greed that violates our sensibilities as well as our moral principles. But to sympathize is not to condone or approve, it is only to acknowledge in oneself the ever-present possibility of the same feeling or action. Certainly the enlightened 20th century has no warrant for looking down on times and places where treachery and massacre were commonplace. And it is a sobering observation to find in both past and present the evidence that inhumanities have been and are being committed by the brutish and civilized alike, the ignorant and the educated, the cynical and the devout, the selfish and the heroic.

A principal good derived from history is thus an increase in self-knowledge, through a fellow-feeling with men singly and in groups as history tells about them. That self-knowledge in turn makes the reader of history less ready to find “monsters of error” in his own time and place. Let it be said again, he need not condone or accept with indifference, but he is spared one of the very errors that perpetuates man’s inhumanity to man—fanatical self-righteousness.

On the constructive side, what history tells is the long series of efforts to overcome the constraints of nature and the difficulties of living in society. Those efforts we call civilizations. They start small. In the West they first take the form of city-states. They clash, with one another or with the barbarians “outside.” Trade and war, war and trade expand the scope of power, government, and law. Great men introduce broader conceptions of citizenship, morals, and religions. Others invent practical devices of administration, manufacture, and—again—war. Still others discover the workings of nature, create mathematics or art or systems of philosophy. A concentration of such activities over a given territory is what is meant by a high civilization—Egypt, Greece, the Hellenistic Age, Rome, the Saracens, the High Middle Ages, the Renaissance. And also China, Japan, the Khmers, India, the Mayas, the Incas, and so on.

Along this hazardous and always violent course, innumerable characters rise and play their parts. Their fates
provide stories within the story. Visibly, biographies are the bricks of which history is made, for the story of mankind can only be the stories of men. But by a paradox of man's social existence, the life of communities is not a simple sum of individual lives. The reader of history must therefore imagine from the printed page characteristic acts, moods, errors, disasters, achievements that are nobody's doing and everybody's doing. This imagining is another important good bestowed by historical reading, for it dispels the illusion that H.G. Wells called the "governor's illusion" of history: They (the bad people) are doing this terrible thing to Us (the good people). The fallacy in it is to suppose that any large group acts as with one mind, clear in purpose and aware of consequences. Such a projection of the single ego upon whole masses is a form of provincialism that is encountered in most political discussions and certainly in all social prejudices: "If the President would only act..." A reader of history is cured of this simple-mindedness by developing a new sense—the historical sense—of how mankind in the mass behaves, neither free nor fatally pushed, and in its clearest actions mysterious even to itself.

It is this peculiarity that, while marking the difference between history and biography (where acts can be deemed individual and responsible), has led many minds to postulate a meaning in history, a meaning discoverable but obscured by the multiplicity and confusion of facts. A famous passage in Cardinal Newman's Apologia records in admirable prose the feelings that lead to the elaboration of philosophies of history: for Newman it is of course the traditional Christian interpretation that unifies the multiplicity and resolves the confusion:

"For consider the world in its length and breadth, its various history, the many races of man, their starts, their fortunes, their mutual alienation, their conflicts, and then their ways, habits, governments, forms of worship, their enterprises, their aimless courses, their random achievements and acquirements, the impotent confusion of long-standing facts, the tokens so faint and broken, of a superintending design, the blind evolution of what turn out to be great powers or truths, the progress of things, as if from unreasoning elements, not towards final causes, the greatness and littleness of man, his far-reaching aims, his short duration, the curtain hung over his futurity, the disappointments of life, the defeat of good, the success of evil, physical pain, mental anguish, the prevalence and intensity of sin, the pervading idolatries, the corruptions, the dreary hopeless irreligion, that condition of the whole race, so fearfully yet exactly described in the Apostle's words, "having no hope and without God in the world."—all this is a vision to dizzy and appal, and inflicts upon the mind the sense of a profound mystery, which is absolutely beyond human solution.

To the practical writer or reader of history these philosophies appeal mainly by their suggestiveness; they are valued for their scattered insights and analogies. As systems they negate the very spirit of history, which seeks the concrete and particular, the opposite of system and abstraction. True, there have been historians who took a middle course and attempted to find empirical regularities in history—again with occasionally suggestive results—but very soon their methods begin to do violence to the facts in order to group them and count them and treat them like identities in physical science. When the physical world itself has not yet been fully systematized, to assume or "find" a system in history without the means and the liberties that science uses is to think like neither a scientist nor a historian. It is in fact an attempt to remove the difficulty of history at the cost of destroying its unique merit and interest.

By the "liberties" that science takes is meant the experimenter's elimination of all but a very few components in a given trial, so as to ascertain precisely the nature and amount of a given effect. When this is done, the result is usually stated in causal terms—so much of this, under such and such conditions, will produce so much of that. Hardly anyone needs to be told that history defies a similar treatment. Its elements cannot be exactly measured, and although each historical situation presents to the discerning eye a variety of clear conditions or factors, the isolating of a cause for what happens is beyond reach.

That is but another way of saying that history is and must remain a story. And a story, if properly told, is a whole, to be understood as a whole—synthetically, not analytically. History in this regard resembles the arts. We say we "analyze" a work of art, but that is to speak metaphorically. We can enjoy and understand the products of art only as wholes. In history, the artful story is offered as a true story, and great pains are taken to see that it is true. But except in the broadest sense, the historical wholes are not given as such in the record; they are devised by the historian, to make the welter of facts intelligible and hence able to be remembered. Clio was not only the muse of history but also of eloquence, by which the Greeks meant good, intelligible prose, to be spoken before an audience unused to books. The same requirements still hold: written history must be readable with pleasure, or Clio is defeated.

But, it will be said, from many diverse writers will come divergent stories, rival interpretations. That is true, for only a divine mind could know "how it actually happened." But this limitation of history is also a merit, for it can thereby be written and read over and over again in as many versions as are plausible or accessible. There is and will be no final statement: the perspective forever changes, and with it the interest of history renews itself into infinity. As the philosopher William James once remarked, "What has been concluded that we should conclude about it?"
Part Nine. The History of Mankind

The outlines in the thirty-nine sections, in seven divisions, of Part Nine deal with the history of the peoples and civilizations of the world.

Certain points should be noted about Part Nine.

History, like philosophy, has developed methods applicable to the subject matter of other disciplines. The results of these applications are set forth in other parts. Each of the nine sections of Division II of Part Six includes a historical treatment of each of the arts. Similarly, each of the nine sections of Division II of Part Eight includes a historical treatment of each of the particular religions dealt with. Certain sections of the five divisions of Part Ten set forth the history of logic and mathematics; the history of science generally; the history of each of the natural and social sciences; the history of medicine; the history of technology; the history of philosophy; the history of humanistic scholarship; and the history of historiography and of the study of history itself.

It should also be noted that here and in the other portions of the Outline of Knowledge that treat historical matters, the level of detail is greater than that elsewhere. This reflects the editors' belief that an outline of history imposed upon a geographical or chronological base requires a high degree of particularization.

The topical breakdown of the history of mankind into seven divisions and thirty-nine sections reflects more or less traditional judgments—judgments regarding the regional divisions of world history; the identification of peoples and civilizations; the temporal periodization in historical accounts of particular civilizations; and the periods of relative isolation and of relative confluence of different civilizations.

The titles of the seven divisions in this part indicate the regional and temporal divisions used. Introductory headnotes for each of the seven divisions indicate the temporal periodizations used in the accounts of particular civilizations.

Division I. Peoples and Civilizations of Ancient Southwest Asia, North Africa, and Europe 343
Division II. Peoples and Civilizations of Medieval Europe, North Africa, and Southwest Asia 356
Division III. Peoples and Traditional Civilizations of East, Central, South, and Southeast Asia 373
Division IV. Peoples and Civilizations of Sub-Saharan Africa to 1885 388
Division V. Peoples and Civilizations of Pre-Columbian America 394
Division VI. The Modern World to 1920 396
Division VII. The World Since 1920 443

Division I. Peoples and Civilizations of Ancient Southwest Asia, North Africa, and Europe

The outline in Section 911 first treats of the geography of the regions covered in the section, the sources for the history of the peoples in these regions, and the character and achievements of ancient Near Eastern, Aegean, and North African civilizations. It then deals separately with the history of each of the peoples in these regions in ancient times.

The outline in Section 912 begins with the history of the peoples of non-Classical ancient Europe. It then deals with the whole course of the Classical Greco-Roman civilization, extending from the emergence of Classical Greece from Archaic Greece, through the Hellenistic Age and the history of republican Rome, to the history of the Roman Empire up to AD 395.

Section 911. Early Peoples and Civilizations of Southwest Asia and Egypt, the Aegean, and North Africa 344
912. Peoples of Ancient Europe and the Classical Civilizations of the Ancient Mediterranean World to AD 395 350
Section 911. Early Peoples and Civilizations of Southwest Asia and Egypt, the Aegean, and North Africa

A. The character and achievements of ancient Near Eastern, Aegean, and North African civilizations; the geography of these regions; archaeological and documentary historical sources; historiographic problems

B. Mesopotamia and Iran to c. 1600 BC

1. Development of river valley civilization in Mesopotamia
   a. The Late Neolithic, Chalcolithic, and protohistoric (pre-urban) periods
   b. The Sumerians from their origins to the end of the Early Dynastic Period (c. 2350 BC)
      i. Their conjectured origins: literary and other historical sources (king lists and invention of cuneiform writing), early kings and legendary figures (Gilgamesh)
      ii. Foundation of city-states (e.g., Kish, Ur, Uruk, Lagash, Mari, Umma): rivalry among the cities, the temple city and theocracy, social and economic organization, contacts with Egyptian and Indus Valley civilizations, Sumerian culture
   c. Sumer and Akkad from c. 2350 to 2000 BC
      i. The ascendancy of the Semitic Akkadians under Sargon I of Akkad and his successors, invasions and the fall of the dynasty
      ii. The unification of Sumer, Akkad, and Elam under the 3rd dynasty of Ur (c. 2112-2004 BC): administration and composition of the empire, Ur in decline
   d. The Old Babylonian Period and the early history of Assyria
      i. Isin and Larsa: rivalry and political fragmentation, literary texts, decentralization
      ii. Early Assyria: Ashur, Nineveh, and Urbilum: Akkadian inscriptions and language; the economy; the reign of Shamshi-Adad I (c. 1813-1781 BC)
      iii. Establishment of the Old Babylonian Empire under the dynasty of Hammurabi (c. 1792-1750 BC): law, society, and literature
   e. Hurrian expansion to c. 1600 BC and the decline of the Old Babylonian Empire after c. 1750 BC

2. Early Elam (Iran); cultural ties and political and military interaction with Mesopotamia

C. Emergence of river valley civilization in Egypt (to c. 1600 BC)

1. The Predynastic Period (to c. 2925 BC) and the Early Dynastic Period (1st through 3rd dynasties, c. 2925-c. 2575 BC): unification of Upper and Lower Egypt under King Menes (Narmer), capital at Memphis

2. The Old Kingdom (c. 2575–2130 BC) and the First Intermediate Period (c. 2130–1939 BC)
   a. The Old Kingdom (4th–8th dynasties, c. 2575–c. 2130 BC): divine kingship; the building of the great pyramids near Memphis; centralized government; class structure; foreign trade; increased provincialization; instability of the throne
   b. The First Intermediate Period (9th–11th dynasties, c. 2130–1939 BC): governmental decentralization; collapse of the Old Kingdom and ensuing disunity and foreign raids; reunification by Mentuhotep I under the 11th dynasty, ruling from Thebes

3. The Middle Kingdom (1938–c. 1600 BC) and the Second Intermediate Period (c. 1630–1540 BC)
   a. The Middle Kingdom (12th–14th dynasties, 1938–c. 1600 BC): the cult of Amon; developments in the monarchical institutions; the conquest of Lower Nubia; trade; immigration

D. Early civilizations in Syria and Palestine, Anatolia, and the Aegean to c. 1600 BC

1. Emergence of civilization in Syria and Palestine
   a. The Stone Age cultures and their transition from the Neolithic to the Early Bronze Age until c. 2300 BC, agricultural and technological developments, Proto-Urban settlements, Jericho
      i. Paleolithic and Mesolithic periods: development of horticulture and the domestication of animals
ii. Pre-Pottery Neolithic areas, grouped houses and town walls, arrival of new peoples and their rectangular architecture; Pottery Neolithic areas, molded plaster vessels, dark-faced burnished ware and the spread of its associated culture

iii. The Chalcolithic Period and the Early Bronze Age: migrations and spread of Halafian culture, development of trade, beginnings of urbanization. Early Bronze Age cities

b. The Intermediate Period (c. 2300–c. 1900 BC) and the Middle Bronze Age (c. 1900–c. 1525 BC): revival of trade and connecting link between the greater states; e.g., Aleppo, Byblos, Alalakh in Syria

i. The Amorite invasion: breakup of settled areas by nomadic peoples, bronze weapons and votive objects

ii. Reappearance of urban civilization in the Middle Bronze Age: hieroglyphics, clay tablets, development of new pottery in Canaan

2. Emergence of civilizations in Anatolia, Cyprus, and the Aegean

a. Anatolia: the Neolithic, Chalcolithic, and Bronze ages; settlement by the Hittites

i. Neolithic farming communities: house styles, tools and weapons, pottery, foodstuffs

ii. Appearance of painted pottery in the Chalcolithic Period, uses of metal

iii. Bronze Age culture; e.g., Troy, Alaca Hüyük: jewelry, pottery, burial customs, metalworking, weaponry, migrations

iv. The Hittite occupation of Anatolia and establishment of the Old Hittite Kingdom (c. 1700–c. 1500 BC): expansion into northern Mesopotamia and Syria under Hattusilis and Mursilis, the Hurrian invasions, the Middle Kingdom

b. The Late Neolithic, Chalcolithic, and Bronze ages in Cyprus

c. The early Aegean civilizations (to c. 1450 BC)

i. The Paleolithic, Neolithic, and Chalcolithic ages in Greece, Crete, and the Aegean islands; the pre-Greek (Early Bronze or Helladic) population of Greece from c. 3000 BC; the Early Bronze or Cycladic Age in the Aegean islands; the shaft grave period on the mainland

ii. The Minoan civilization on Crete: the period of the Early Palaces (c. 2200–1700 BC), cultural efflorescence, Kamares ware, commerce, Knossos, Middle Cycladic culture, period of the Later Palaces (c. 1700–c. 1450 BC) on Crete, the arts, Linear A tablets

E. The era of the Egyptian and Hittite empires (c. 1600–1050 BC): the expansion of the Indo-Europeans

1. The New Kingdom of Egypt (18th–20th dynasties, 1539–1075 BC)

a. The 18th dynasty (1539–1292 BC): the emergence of strong centralized administration, territorial expansion, religious and cultural developments

i. Expulsion of the Hyksos from Egypt under Ahmose (1539–1514 BC); cult of Amon-Re, expansion into Syria and Palestine, contacts with the Aegean and its arts

ii. Egyptian culture and prosperity in the reigns of Amenhotep III (1390–1353 BC) and Akhenaton (Amenhotep IV; 1353–1336 BC): domination over Nubia, erection of new temples at Thebes, cult of the god Aton, subsequent eclipse of the dynasty

b. The 19th and 20th dynasties (1292–1075 BC): political shift to the north, new construction, foreign policies

i. Reassertion of Egyptian power: campaigns against the Hittites and Libyans, succession disputes

ii. The reign of Ramses III (1187–1156 BC) and subsequent decline of the 20th dynasty, campaigns against the Sea Peoples, growth of influence of the priests of Amon-Re

c. Society and culture in the New Kingdom: the king as the embodiment of the state; the civil service; the military; the priesthood; the artisans, common people, and slaves; trade and commerce

2. The Hittite Empire and its conflict with Egypt: Syria and Palestine under Egyptian and Hittite domination: the period of the migrations of new peoples

a. The Hittite Empire (c. 1525–1190 BC)

i. Expansion of the Hittite Empire under Suppiluliumas I into Syria (c. 1365 BC): reduction of the Mitannian state, ensuing conflicts and treaties with Egypt, relations with neighbouring states
ii. The capital of the Hittite Empire at Hattusa (Boğazköy): geographical position, architecture, invasions from the West, fall of the empire and destruction of the capital (c. 1190 BC), emergence of the Indo-European Phrygians as the chief Anatolian power

b. Syria and Palestine under Egyptian, Mitannian, and Hittite domination, and the period of the migrations of new peoples (c. 1550–1200 BC)

i. The development of Levantine seafaring trade: the Levantine city-states (e.g., Ugarit), political organization, economy, culture, development of the linear alphabet by the Canaanites and the spread of its use

ii. The origins of the Hebrews in the patriarchal age and their sojourn in and Exodus from Egypt in the 13th century BC, their conquest of Palestine, the Sea Peoples and the Philistine conquest of the Palestinian littoral

iii. The Syro-Hittite states and the migration of the Semitic Aramaeans into Syria and Palestine c. 1100 BC and their foundation of states in Syria: spread of the Aramaic language, trends in religion and the arts

3. Mesopotamia from c. 1600 to c. 900 BC

a. The Kassites in Babylonia (c. 1595–c. 1155 BC): their conjectured origins, their adoption of Mesopotamian culture, Elamite and Assyrian invasions after c. 1250, the fall of the Kassites

b. The kingdom of the Hurrians and the Mitanni (c. 1500–1360 BC) in northern Mesopotamia, its displacement by Assyria

c. The rise of Assyria (c. 1360–1076 BC): expansion under Ashur-uballit I (c. 1365–c. 1330 BC), conquest of Babylon, continued expansion to Tiglath-pileser I (c. 1115–c. 1077 BC), temporary eclipse of Assyria (to c. 900 BC)

4. The Elamite kingdom and its struggle with Babylonia in the 13th and 12th centuries BC

5. Mycenaean (Achaean, Late Helladic) civilization in Greece (c. 1450–1100 BC); the eruption of Thera (c. 1500 BC), the conquest of Minoan Crete (c. 1450 BC), and the arrival of the Greeks

a. The overthrow of the existing social order, introduction of new artistic styles, conquest of the Cyclades, the evidence of the Linear B tablets, destruction of the palace at Knossos and period of the Mycenaean Empire

b. The end of the Bronze Age in the Aegean: destruction of Mycenaean centres, invasion from the north and the coming of the Greeks

c. The people of the Bronze Age Aegean: physical types, dress, society, economy, warfare, religion, and arts

F. The era of the new states of Southwest Asia: the beginning of the Iron Age (c. 1050–700 BC)

1. Egypt and Babylonia in decline, further Assyrian expansion

a. Egypt under the 21st–25th dynasties (c. 1075–656 BC): loss of influence in Syria, disunity and the diminution of royal power, Libyan domination, civil war and Kushite (Ethiopian) rule, the Assyrian conquest (671–664 BC)

b. Babylonia (c. 1050–750 BC): the brief resurgence of Babylonian power under Nebuchadnezzar I (1124–1103 BC); the cult of Marduk; Aramaean, Assyrian, and Chaldean invasions from the 11th to the 9th century BC

c. Emergence of Assyria as the dominant Mesopotamian state after c. 900 BC: internal disension and the challenge of Urartu in the 8th century BC

2. Palestine, Syria, Anatolia, and Iran

a. Development of Canaanite–Phoenician commercial city-states from c. 1100 to c. 700 BC (e.g., Tyre, Sidon): trade and colonization, Phoenician civilization

b. The Hebrew kingdom (c. 1020–c. 700 BC): subjection of the Philistines, territorial expansion in Syria and Palestine

i. The reigns of David and Solomon in the 10th century, growth of separate kingdoms of Judah (south) and Israel (north, conquered by Assyria in 722 BC)

ii. The cult of Yahweh and biblical literature, social and political structure, arts

c. The neo-Hittite states of southeastern Anatolia: Carchemish, Milid (Malatya), Tabal, and Que (c. 1180–700 BC); conquest by the Aramaeans and Assyrians

d. Foundation of Urartu in about the 13th century BC, rise of the Urartian kingdom (c. 840–c. 744 BC), Assyrian influences, the Cimmerian invasion (c. 714 BC) and destruction of the kingdom (c. 609 BC), influence of the Urartian state, the Armenian Empire under the Artaxiads
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e. Phrygia in central and western Anatolia (c. 1180–c. 700 bc): capital at Gordium, relations with Assyrians and Luwians, the Cimmerian invasions in the beginning of the 7th century, the cult of Cybele

f. The Aramaean kingdoms (e.g., Damascus) and their cultural and commercial role: conquest by Assyria

g. The Neo-Elamite period: the occupation of Iran by the Indo-European Medes and Persians by the 9th century BC

G. The era of the Assyrian and Neo-Babylonian empires and the Achaemenid Persian Empire (746–250 bc)

1. The first imperial unification of the ancient Near East under the Assyrian Empire (746–609 bc)
   a. Assyrian culture in the context of the Mesopotamian tradition: the great cities; e.g., Nineveh
   b. Expansion of the empire under Tiglath-pileser III (744–727 bc), Sargon II (721–705 bc), and Sennacherib (704–681 bc); decline from the reign of Ashurbanipal (668–627 bc); conquest by the Medes (625–609 bc)

2. The interval between Assyrian and Achaemenid hegemony (610–539 bc)
   a. The Neo-Babylonian Empire (636–539 bc): conquests, treatment of Jews, decline of the empire
      i. The reign of Nebuchadrezzar II (604–562 bc): subjection of Syria and Palestine, the Babylonian Exile of the Jews and the post-Exile period, building activities
      ii. The last kings of Babylonia: internal dissension and early relations with Persia, surrender to Cyrus II the Great (539 bc)
   b. The Anatolian kingdom of Lydia (c. 700–c. 547 bc): early relations with Assyria, the Cimmerian invasions, suzerainty over the Greeks in Anatolia, Greco-Lydian culture, growth of independent Cilicia in the late 7th century, conquest by Persia
   c. Saite Egypt (26th dynasty, 664–525 bc) and its reassertion of independence after Assyrian rule; revival of traditional Egyptian culture, subjection to Persia
   d. The Kingdom of the Medes in Iran (c. 700–550 bc) and the establishment of the Achaemenid Persian Empire
      i. Conjectured origins of the Median state, expulsion of the Scythians, extension of control over the other Iranian peoples and into Armenia and eastern Anatolia after the downfall of Assyria
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   b. Emergence of Carthage as the leading western Mediterranean power: conflicts with the Greeks in the western Mediterranean, extension of Carthaginian power into Spain and the clash with Rome in the Punic Wars resulting in the destruction of Carthage (146 BC)
   c. Roman penetration into North Africa: the native kingdoms of Numidia and Mauretania and their eventual incorporation into the Roman Empire

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with early peoples and civilizations of Southwest Asia and Egypt, the Aegean, and North Africa

Afghanistan  Israel  North Africa  Transcaucasia
Arabia  Jordan  Palestine  Turkey and
Egypt  Lebanon  Prehistoric Peoples  Ancient Anatolia
Greek and Roman Civilization, Ancient  Mesopotamia, The History of  Syria
Iran

MICROPAEDIA: Selected entries of reference information

General subjects

Anatolia, Cyprus, and the Aegean:

Aegean civilizations

Anatolia
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f. The initial cooperation of Octavian and Mark Antony in the Triumvirate and Octavian’s achievement of sole power (43–31 BC): the annexation of Egypt and its administration

g. Roman law during the late republic: the development of new procedures, the role of magistrates, the law of succession

h. Culture in the late republic: oratory and philosophy, the arts

E. The Roman Empire (31 BC–AD 395)

1. Consolidation of the empire under the Julio-Claudians (31 BC–AD 68)
   a. Augustus’ establishment of the principate (27 BC–AD 14): the role of the princeps; the imperial administration, fiscal and military reforms, and the founding of new colonies; social and religious legislation; economic growth

   b. The Roman Empire at the time of Augustus: provincial administration, the imperial frontiers, the western provinces, the eastern provinces, the economic unification of the Mediterranean

   c. Foreign policy: Roman relations with Parthia and the other states in the East; the southern, western, and northern frontiers

   d. The culture of the Augustan Age: contributions of Livy, Virgil, Horace, and Ovid; religion; the visual arts

   e. The empire under Tiberius (AD 14–37), Caligula (AD 37–41), Claudius I (AD 41–54), and Nero (AD 54–68): internal and frontier policies, the annexation of Britain, Tacitus’ accounts, civil war and revolt in “the year of the four Emperors” (AD 69)

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   a. The Flavian emperors (AD 69–96): Vespasian’s fiscal and provincial reorganization, military and frontier policies, Titus and the suppression of the Jewish revolt, Domitian’s despotism, military development and frontiers

   b. The Antonine emperors (AD 96–192): the reigns of Nerva, Trajan, Hadrian, Antoninus Pius, Marcus Aurelius, and Commodus; the beginning of imperial decline after AD 180

3. The zenith of the Roman Empire in the late 1st and 2nd centuries AD
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   b. Greco-Roman culture of the late 1st and 2nd centuries AD: developments in philosophy, religion, technology, and the arts

4. Changes and crises in the Roman Empire in the 3rd and 4th centuries AD
   a. Civil wars, conflict with Parthia, the growth of bureaucracy, and militarization of government under the Severan dynasty (AD 193–235)

   b. Religious and cultural life: the public religions under the empire, the rise and spread of Christianity and other Eastern religions, official persecution of Christianity

   c. The transformation of Greco-Roman culture in late antiquity (3rd and 4th centuries AD), Greek revival and growth of Christian theology

   d. Military anarchy and disintegration of the Roman Empire (AD 235–270): the Gordians, the beginning of Germanic invasions, loss of eastern provinces, economic and social crisis
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f. The Roman Empire under the 4th-century successors of Constantine to Theodosius I (AD
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g. The provinces under the later empire and the eclipse of the empire in the West: Germanic
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles and biographies dealing with peoples of ancient Europe and
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[For Part Nine headnote see page 343.]

The outlines in the four sections of Division II deal with the civilizations directly descendant from those of the ancient Near East and of Classical antiquity, which are treated in the two sections of Division I. The general period covered in Division II is the Middle Ages, beginning with the death of Theodosius I in AD 395, conventionally taken as marking the permanent division of the Roman Empire into East and West, and extending to c. 1500, conventionally taken as the starting point of modern history.

The sectional organization of this division and the outlines in its four sections reflect significant cultural and political interaction between the Eastern Christian, Western Christian, and Islamic spheres, and also involve some breaking points in the history of each sphere.

**Section 921. Western Europe, the Byzantine (Eastern Roman) Empire, and Eastern Europe from AD 395 to c. 1050**

A. The study of medieval and Byzantine history: the historical sources, historiographic problems, chronological outline

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      ii. The Anglo-Saxon kingdoms in England and the Celtic kingdoms in Ireland
      iii. The Franks under the Merovingians and early Carolingians: the successors of Clovis, rise and establishment of the Carolingians under Charles Martel and Pepin III the Short (714–768), Carolingian relations with the papacy and entry into Italian affairs; origins of the Papal States
   c. Effects of the rise of Islam on western Europe
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   2. Persistence of Greco-Roman society in the East in the 5th century: the empire from the death of Theodosius I to the accession of Heraclius (610)
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      b. Ecclesiastical controversies, Syrian and Egyptian disaffection, and the beginning of conflict with the Western Church
      c. The empire at the end of the 5th century: internal tensions, political and economic policies under Anastasius I
      d. The reigns of Justin I (518–527) and Justinian I (527–565): realignment with the Roman Church, Code of Justinian, military campaigns in the West, effects of the plague, later campaigns
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      f. Justinian's successors (565–610): relations with the barbarians and with the Persians, revolt of the army
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         ii. The Frankish world: society, institutions, economic life, the church (triumph and reform of Benedictine monasticism, birth of the Cluniac order), literature (Carolingian renaissance) and the arts
3. Germany, Burgundy, and Italy: development of the Holy Roman (German) Empire (911-1056)

a. Revival of central authority in Germany and intervention in Italy by the Saxon dynasty: Conrad (911-918), rise of the nobility, early opposition from Arnulf of Bavaria, drive against Magyars and Slavs, Germanic kingship

b. Promotion of the German church under Otto I (936-973): his conquest of Italy and establishment of the Holy Roman Empire (962), early Salian kings (1024-56)

c. Development of medieval Italy: political, economic, and social developments on the peninsula and in Sicily

   i. Growth in power of the papacy; early years of the commercial cities of Venice in the north and Gaeta, Naples, Sorrento, and Amalfi in Campania; the Arabs in Sicily

   ii. Cities and countryside: persistence of an urban tradition despite the exodus to rural areas, the role of bishops in urban life, economy and society

4. The Kingdom of France under the early Capetians (987-1180): the relative weakness of the monarchy vis-à-vis the great feudatories, establishment of an Anglo-French domination in western France under the Plantagenets (Normandy, Anjou, Aquitaine), Capetian attempts to expand the royal domain

5. Growth of the Christian states in northern Spain (Asturias–Leon–Castile, Navarre, Aragon–Catalonia): their relations with one another and with the Muslims in Spain, the first phase of the Reconquista to the fall of Toledo (1085)

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2. The eastern European states and peoples within the Byzantine orbit

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   b. The Balkans: the migration of the Croats and Serbs into the Balkans and their subsequent relations with the Bulgars and Byzantium to c. 1050

   c. Exploration and the rise of the Rus raids on Constantinople, development of trade routes, Khazar state north of the Black Sea

   d. The princes of Novgorod (end of the 9th century)

   e. The state of Kiev Rus (c. 980-1054): Slavic-Varangian (Scandinavian) origins, economic decline, social and political institutions

3. Eastern European states within the orbit of Western Christendom
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   i. Unification of Greater Moravia under Mojmir (814): religious conflicts with Frankish clergy and temporary adherence to the Eastern rite, political expansion
   ii. The early Premysl rulers of Bohemia: capital at Prague, ties with Bavaria and the Saxon dynasty. Boleslav I (929–967), Boleslav II (967–999), annexation of Moravia under Bretislav (1034–55)

b. The Avar Empire and the early Magyar (Hungarian) kingdom to c. 1050: alliance with the Carolingian ruler Arnulf, establishment of the Árpád dynasty, settlement of the central plain, conversion to Christianity, reign of Stephen I (997–1038)

c. Development of the Kingdom of Poland in the 10th century and Polish conversion to Western Christianity under the dynasty of the Piasts, civil strife and later restoration under Casimir I (1039–58)

F. The zenith and incipient decline of the Byzantine Empire (717–1081), the growth of Venice

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   b. Culture and administration: legal reforms under Basil I and Leo VI
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3. Byzantine decline and subjection to Western influences: 11th-century weakness, arrival of new enemies, the schism with Rome (1054)
4. Venice: the development of its institutions, commerce, and naval power in the early Middle Ages

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with Western Europe, the Byzantine (Eastern Roman) Empire, and eastern Europe from AD 395 to c. 1050:

Austria  France  Ireland  Steppe, The
Balkan States  Germany  Istanbul  History of the
Baltic States  Greek and Roman  Italy  Eurasian
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      ii. The Umayyad caliphate under 'Abd ar-Rahmān an-Nāṣir III: relations with Arabs,
          Berbers, and the Christian states in Spain; conquest of Morocco by his successors: the
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      iii. Social and economic life in Muslim Spain: the culture of Muslim Spain, developments
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   b. The Fāṭimid state of North Africa and Syria from 909 to c. 1055: the foundation of the
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   d. The Śamānīd dynasty of Khorāsān (875–999) and its role in the Islamization of the Turkic
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Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with the Empire of the Caliphate and its successor states to c. AD 1055

- Arabia
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      iii. The decline of German imperial control in northern Italy and the continued development of the communes (e.g., Milan, Pisa, Florence, Siena): their internal and external conflicts.
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   ii. New concepts and techniques in painting, sculpture, and architecture; patronage of the arts by the papacy
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c. Late medieval intellectual developments: political theory, law, and the decline of ideals of imperial unity and papal supremacy; the rising power of national monarchies; decline of Scholasticism; science; witchcraft

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      ii. Richard II (1377–99): the Peasants' Revolt (1381), the influence of John Wycliffe, later political struggles and Richard's deposition
      iii. Henry IV (1399–1413), Henry V (1413–22), and Henry VI (1422–61 and 1470–71): rebellions under Henry IV and his relations with Parliament, domestic rivalries and the loss of France under Henry VI, Cade's rebellion and the Wars of the Roses
      iv. The reigns of Edward IV (1461–70 and 1471–83) and Richard III (1483–85): England in the late Middle Ages
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   ii. Spanish explorations and territorial acquisitions: colonial policy in the New World, the Atlantic trade

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      i. The Mongol invasions (1241–42) and reestablishment of the Kingdom of Poland (1253–1382): Władysław I and the struggle with the Teutonic Order; Casimir III and Louis I of Hungary; social classes, the church, and policies toward the Jews

      ii. The Jagiellon dynasty (1382–1492): the union of Poland and Lithuania (1385–86), extension of the empire, growth of parliamentarianism dominated by the nobility

Suggested reading in the Encyclopaedia Britannica:

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- European politics and polity:
  - Agincourt, Battle of
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For each nation or group of peoples covered in this division, the outline treats first of the geography and ethnography and then moves into the chronology of the respective civilization. Sections 931 and 932 outline the Chinese dynasties from the Ch'in through the late Ch'ing (mid-19th century).

Section 933 deals with the peoples of inner Asia and the steppe and covers the early histories of Manchuria, Turkistan, and Afghanistan; of the Mongol Empire and its successor states; and of Tibet and Nepal.

Section 934 outlines the character and achievements of the Japanese and Korean civilizations from their beginnings until the Meiji Restoration of 1868 and the Japanese annexation of Korea in 1910.

Sections 935 and 936 treat of the civilizations of the Indian subcontinent, of the early political units of India and Ceylon, the period of Muslim hegemony, the Mughal and Marāthā empires, and, for Ceylon, the arrival of the Portuguese in 1505.

Section 937 deals with the peoples and civilizations of Southeast Asia, including the histories of Burma, Siam, Cambodia, Vietnam, and Malaya, as well as the islands of the Indonesian Archipelago, until c. 1600.

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Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with China to the beginning of the late T'ang (AD 755)
- Asia
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- ancient cultures and historic sites: Ch'in tomb, Great Wall of China, Hsiung-nu, Lung-shan culture, Pan-p'o-ts'un, Sha-ch'ing, dynastic capitals: Ch'i-chia culture, China, Kao Tsung, An-yang
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Suggested reading in the *Encyclopaedia Britannica:*

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with inner (Central and Northeast) Asia to c. 1750

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with Japan to the Meiji Restoration (1868), and Korea to 1910

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the Indian subcontinent and Ceylon to c. AD 1200
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Suggested reading in the Encyclopaedia Britannica:

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the peoples and civilizations of Southeast Asia to c. 1600
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The history of North Africa, because of its early involvement with Europe and Islam, is dealt with up to c. 1480 in Sections 911 and 924; and it is carried to the 19th century in Section 962. The history of Nilotic Sudan to c. AD 550 and of Ethiopia to c. AD 650 is dealt with in Section 911.

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C. The precolonial period of European activity (c. 1400–c. 1885): exploration, development of the slave trade, and eventual collapse of indigenous states
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with West Africa to c. 1885
   Africa
   Western Africa

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General subjects

| Akan states | British West Africa | Hausa states | Songhai empire |
| Akwamu | Dahomey | Kanem-Bornu | Tukulor empire |
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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with the Nilotic Sudan and Ethiopia from c. AD 550 to c. 1885
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Suggested reading in the *Encyclopædia Britannica*:

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Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with Central Africa to c. 1885
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   b. Establishment of the Orange Free State, the British colonies of Natal and Cape Colony
7. The era of mineral discoveries and confederation: diamonds and gold. Transvaal–Pedi and Zulu wars
8. Portuguese loss of control in Angola and Mozambique in the mid-19th century. Portuguese reemergence of control in the early 20th century. German annexation of South West Africa (1884)

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with Southern Africa to c. 1885
   Africa
   Southern Africa

MICROPAEDIA: Selected entries of reference information

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Division V. Peoples and Civilizations of Pre-Columbian America

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The subject in Section 951 is Andean civilization to c. 1540. The outline begins with the character and achievements of Andean civilization, with the ethnography and geography of the Andean region, and with archaeological and documentary historical sources. It goes on to the history of the pre-Inca cultures and states in the Andean region. It then deals with the empire of the Incas to the time of the Spanish conquest (1532-40).

The subject in Section 952 is Meso-American civilization to c. 1540. The outline begins with the geography and ethnography of Meso-America and with the character and achievements of Meso-American civilization. It goes on to the history of Meso-American civilizations until their conquest and destruction by the Spanish.

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Section 951. Andean Civilization to c. AD 1540

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B. Pre-Inca cultures and states

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2. Initial (c. 1800-c. 1000 bc) and Early Horizon, or Chavin and Paracas (c. 1000-c. 200 bc), cultures in Peru: development of textiles, pottery, and ceremonial architecture

3. Early Intermediate (Florescent, or Classic) Period (c. 200 bc-c. AD 600): metallurgy, pottery, and textile production in the Nazca and Moche cultures

4. Middle Horizon Period (c. AD 600-c. 1000): the Huari and Tiahuanaco cultures, urban settlements, cultural decline after c. AD 800

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   b. The reigns of Capac Yupanqui, Inca Roca, Yahuar Huacac, and Viracocha Inca: Inca expansion into the Urubamba Valley and Titicaca Basin, the Chancas invasion (1438)

   c. Inca victory over the Chancas (1438), Incan civil war between Cuzco and Calca factions, Cuzco victory and reign of Pachacuti Inca Yupanqui (1438-c. 1471), renewed battles with Chancas (c. 1445), further conquest of Titicaca Basin region, victory over Chimu Empire

   d. Inca conquests during the reign of Topa Inca Yupanqui (c. 1471-c. 1493): annexation of highland Bolivia, northern Chile, northwestern Argentina, and southern Peru

   e. Reign of Huayna Capac (c. 1493-c. 1525): conquest of northeastern Peru and northern Ecuador, Atahualpa’s victory (1532) over Huascar in civil war

   f. The Spanish conquest of the Incas (1532-40): Pizarro’s execution of Atahualpa and support of Topa Huallpa (1533), later support of Manko Inca (1533-35); Manko’s rebellion and defeat (1536), Spanish consolidation of power

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   a. Divine monarchy and the royal corporations, administrative hierarchy, taxation, the census and the quipu system of numerical records

   b. The settlement of people loyal to the Incas in newly conquered territories, the spy system, religious practices, military policy and organization, technology, agriculture, transportation system, calendar, oral narratives
Suggested reading in the *Encyclopædia Britannica:*

**MACROPÆDIA:** Major articles dealing with Andean civilization to c. AD 1540

- Argentina: Latin America, The History of Lima
- Bolivia: Peru
- Chile: Pre-Columbian Civilizations
- Colombia: Ecuador

**MICROPÆDIA:** Selected entries of reference information

**General subjects**

- Andean civilization
- Araucanian
- Atacama
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- Almagro, Diego de
- Atahualpa
- Huascar
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      ii. The Cotzumalhuapa culture in the Maya highlands, Tzakol and Tepeu cultures in lowland Maya civilization (c. AD 300–c. 900)

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2. The development of the Aztec state and extension of Aztec rule over the Valley of Mexico (c. 1325–1519): military campaigns of Itzcoatl, Montezuma I, and Ahuitzotl; administrative techniques under Montezuma II (1502–20)

3. Aztec culture and society up to the time of the Spanish conquest; e.g., agriculture and technology, political organization, governmental structure, militarism, economy, religion, art and architecture

D. The Spanish conquest of the Aztec state and the Yucatán Peninsula (1519–c. 1540): destruction of Aztec government and culture, imposition of Spanish colonial policies and religion

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with Meso-American civilization to c. AD 1540
- Latin America, The History of
- Mexico
- Mexico City
- Pre-Columbian Civilizations

**MICROPAEDIA**: Selected entries of reference information

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The theme of western expansion, imperialism, and colonialism pervades Division VI. The separation of the history of the modern world (c. 1500–c. 1920) into eleven sections reflects conventional regional analyses of modern history, and, within each of those sections, conventional judgments regarding turning-point dates of the regional histories.

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      iii. Relations between Spain and the independent states of Italy: Savoy, Genoa, Tuscany, Venice, and the Papal States

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      ii. Political and economic decline during the reigns of Philip III (1598–1621) and Philip IV (1621–65): expulsion of the Moriscos (1609), Olivares’ administration, loss of Portugal (1640)

   c. Portugal from c. 1500 to 1640: domination of East Indian trade, union with Spain (1580), independence under House of Bragança (1640)

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      ii. Henry VIII (1509–47): foreign and domestic policies; the divorce question, the English Reformation, and the establishment of the Church of England; Edward VI (1547–53) and Mary I (1553–58)
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      iv. James I (1603–25) of England (James VI of Scotland) and establishment of the Stuart dynasty: developments in religious doctrine, foreign relations, economic policy, and the arts; conflicts between crown and Parliament
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v. Charles I (1625–49) and the English Civil War (1642–51): economic and political disputes between crown and Parliament; royal personal rule (1629–40); persecution of Puritans; the Long Parliament, Oliver Cromwell, and the Civil War; execution of Charles I (1649)

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vii. Ireland in the 16th and 17th centuries: subjugation of Ireland by Henry VIII and Elizabeth I, the Irish revolt of 1641, Cromwell’s invasion and anti-Catholic policies during the Commonwealth

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ii. The Protestant Reformation and the French Wars of Religion (1562–98): the reigns of Catherine de Médicis (1560–74) and Henry III (1574–89), religious compromise and restoration of strong monarchy under Henry IV of Bourbon (1589–1610)

iii. The reign of Louis XIII (1610–43) and Cardinal de Richelieu: suppression of the Huguenots and the nobles, French success in the Thirty Years’ War

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ii. Ferdinand I (1556–64) and Maximilian II (1564–76), internal disunity under their successors, the Thirty Years’ War (1618–48), political and religious settlements of the Peace of Westphalia (1648)

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   ii. The "price revolution": the relationship between the influx of precious metals from the Americas to Europe and the price rise in the 16th century
   iii. Growth of mercantilism: theories and policies of economic nationalism developed by European powers, the concept of the balance of trade
   iv. Increase in volume of world trade: the growth of the luxury trade (silks, spices, precious metals), the agricultural trade (tobacco, sugar, and coffee), the raw materials trade
   v. Development and importance of the slave trade
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   ii. The Seven Years' War (1756–63) and France's defeat and loss of colonial territory in the Americas
   iii. French recovery and Franco-Spanish cooperation (1778–81) against Britain in the U.S. War of Independence, Russian-Prussian partition of Poland (1772)

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   ii. Limited monarchy under William III (1689–1702) and Mary II (1689–94) and Anne (1702–14); growth of Whig and Tory political parties (1689–1714); the Hanoverian succession and emergence of the cabinet system under George I and George II; Whig supremacy and political stability to 1760: ministries of Walpole, Pelham, and Pitt
   iii. Early years of George III's reign (1760–1820) to c. 1790; eclipse of Whig power and political instability (1760–70), failure of colonial policies and U.S. War of Independence, beginning of parliamentary and reform movements
   iv. Economic, cultural, and social developments: agricultural innovations, population growth, origins of the Industrial Revolution and factory system, influence of Methodism
   v. Formal union of England and Scotland (1707). Edinburgh's status as an intellectual centre, Protestant Ascendancy in Ireland and growth of Irish patriotism among the Anglo-Irish, Wales in the 18th century
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i. The Fronde, Louis XIV’s minority (1643–61), and Mazarin’s control of government to 1661

ii. The Age of Louis XIV (1661–1715): development of the central government, the Versailles court, military policies, mercantilist policies of Colbert

iii. Louis’s religious and political policies: revocation (1685) of the Edict of Nantes and the Huguenot emigration, political influence of Jansenism, royal absolutism

iv. French cultural development in the 17th century

v. The ancien régime (1715–89): the close relationship between society and the state, the new urban class, the decline of the monarchy under Louis XV (1715–74) and Louis XVI (1774–92), power of the parlements, agricultural and industrial growth, domestic and colonial trade

vi. The reform movement: the influences of nationalism and individualism; attacks on political, social, and economic policies of the ancien régime; conflict between the nobility and bourgeoisie; the financial crisis and attempts at reform by Necker and Turgot; the States General and the beginning of the Revolution (1789)

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ii. Frederick II the Great (1740–86): War of the Austrian Succession (1740–48), Seven Years’ War (1756–63), partitions of Poland (1772–95), development of Idealism (Kant), enlightened reform and benevolent despotism

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ii. The viceregency of Naples and the kingdom of Sicily: economic and social unrest, rule of Charles VI in Sicily, transfer of Naples and Sicily to Charles III in 1734, the Bourbon regime

g. The United Provinces of the Netherlands from 1648 to 1789; economic and political stagnation; the first (1650–72) and second (1702–47) stadholderless periods; the patriotic movement; social, religious, and cultural development

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b. Expansion in the 18th century: the spread of religious, political, economic, and scientific theories in western Europe; cultural developments

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles and biographies dealing with western Europe from c. 1500 to c. 1789

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and biographies dealing with eastern Europe, Southwest Asia, and North Africa from c. 1480 to c. 1800

Afghanistan  Cairo  Istanbul  Saint Petersburg
Africa  Cyprus  Jerusalem  Steppe, The
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Suggested reading in the *Encyclopædia Britannica*:

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Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA:** Major articles dealing with Australia and Oceania to c. 1920

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Suggested reading in the *Encyclopaedia Britannica*:

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**Section 969. Southeast Asia Under the Influence of European Imperialism to c. 1920**

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      ii. The Ethical Policy and the rise of nationalism: social and economic benefits, formation of nationalist organizations

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with Southeast Asia under the influence of European Imperialism to c. 1920

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   b. Problems in establishing effective colonial regimes: military problems, control of the territories, reliance on Africans and development of indirect rule

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   b. The consolidation of central governmental power in Ethiopia: Tewodros II (1855–68), Yohannes IV (1872–89), and Menilek II (1889–1913); struggles against Egypt, the Sudan, and Italy

4. East Africa and Madagascar: German, British, French, and Italian conquests and establishment of colonies; relations with indigenous peoples

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   b. King Leopold II's colonial enterprise in the Congo: establishment of the Belgian Congo (Congo Free State) and Belgium's Congo policies until World War I
   c. The French colonies and colonial administration until World War II

6. The scramble for southern Africa, the British–Boer conflict and the establishment of the Union of South Africa (1910), curtailment of economic and political rights of Africans and Asians, the Botha (1910–19) and Smuts (1919–24) governments and National Party opposition under Hertzog

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with Southwest Asia and North Africa (c. 1800–1920), and sub-Saharan Africa (1885–c. 1920) under the influence of European imperialism: the early colonial period

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North Africa:
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Afghanistan:
`Abdor Raḥmān Khan Dōst Moḥammad Khan Ḥālibollāh Khan Shāh Šojā Shīr ʿAlī Khan

Egypt:
Cromer, Evelyn Baring, 1st Earl of Ismāʿīl Pasha Kamīl, Muṣṭafā Muḥammad ʿAlī Nubar Pasha Saʿīd Pasha ʿUrābi Pasha

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D. Economic developments from 1940

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA**: Major articles dealing with international affairs since 1920

- European History and Culture
- International Relations, 20th-Century
- United Nations
- World Wars, The

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b. Social conditions in the 1920s: prohibition, growth of organized crime, and the jazz age
c. Hoover's administration (1929–33) and the Great Depression: the stock market crash, domestic and international repercussions, Hoover's attempts to effect economic recovery

2. The effects of the New Deal and World War II: the presidency of Franklin D. Roosevelt (1933–45)
   a. Comprehensive New Deal measures for economic recovery, relief, and reform
   b. Reform measures of the second New Deal
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      ii. Labour legislation and union activity: strengthening of the Democratic coalition
   c. Foreign policy between the World Wars: isolationism and neutrality, opposition to Japanese expansionism in Asia and economic sanctions against Japan, lend-lease aid to Britain (1940–41), the "Good Neighbor Policy" in Latin America
   d. The U.S. in World War II: wartime mobilization, regulation of production and manpower, the role of U.S. forces in defeating the Axis powers in Europe and the Pacific, U.S. military occupation of Japan and participation with the Allies in occupation of Germany

3. The beginning of the Cold War: the U.S. from the end of World War II to 1961
   a. The Truman administration (1945–53)
      i. Foreign policy aimed at the containment of Communism: the Truman Doctrine and the Marshall Plan, the Point Four Program, the creation of NATO, U.S. support of Nationalist China
      ii. Programs of the Fair Deal: the conversion to a peacetime economy, labour disputes and inflation, the Taft–Hartley Act (1947), social and economic legislation
      iii. McCarthyism and the "Red Scare"
      v. Maintenance of a large postwar military establishment: collaboration of science and industry
   b. The Eisenhower administrations (1953–61)
      i. Intensification of the civil rights movement and innovative decisions of the Warren court, passage of the Civil Rights acts of 1957 and 1960
      ii. Foreign policy during the Eisenhower years: sponsorship of military coups in Iran (1953) and Guatemala (1954), the Suez crisis (1956), U.S. entry into the space race (1958), intervention in Lebanon (1958), continued support of Nationalist China, the U-2 affair

4. The U.S. in the late 20th century: continuation of East–West hostilities, détente, the end of the Cold War
   a. The Kennedy administration (1961–63): the Cuban missile crisis (1962), the Nuclear Test-Ban Treaty (1963), military aid to South Vietnam, the assassination of John F. Kennedy
   b. The Johnson administrations (1963–69)
      i. Civil Rights Act of 1964, Medicare and other social welfare legislation, inflation and increased governmental economic activity
      ii. Increasing alienation among the youth and minority groups: protests in cities and on campuses, the assassinations of Robert F. Kennedy and Martin Luther King, Jr. (1968), the anti-Vietnam War movement
      iii. Foreign policy: Gulf of Tonkin Resolution (1964) and subsequent expansion of U.S. involvement in the Vietnam War, invasion of the Dominican Republic (1965–66), commencement of Paris peace talks (1968), military and economic aid to Middle Eastern and Latin-American countries
   c. The Nixon administrations (1969–74)
      i. Foreign policy: the continuing Vietnam War and the Paris peace talks, the invasion of Cambodia (1970), rapprochement with the People's Republic of China, Vietnam War cease-fire agreement (1973)
ii. Inflation, high unemployment, and temporary price and wage controls; cabinet reorganization; antiwar demonstrations

iii. The Watergate scandal, the resignation (1973) of Vice President Spiro T. Agnew and appointment of Gerald R. Ford, the resignation (1974) of Nixon

e. The Carter administration (1977–81): foreign policy emphasis on human rights, Camp David Accords between Egypt and Israel (1978), Panama Canal treaties (1977), Iranian hostage crisis; attempts to alleviate the energy crisis and to reform electoral, welfare, and Social Security bureaucracies; poor relations between president and Congress

f. The Reagan administrations (1981–89)

i. Increased military spending, cuts in social welfare programs, reduction and simplification of personal income tax rates, rapid growth of federal deficit, Supreme Court shift to the right, Iran-Contra Affair

ii. Anticommmunist foreign policy stance, sponsorship of Contra insurgency in Nicaragua and support for government forces in Salvadoran civil war from 1981, invasion of Grenada (1983), initial decline in U.S.-Soviet relations and improvement during Gorbachev era from 1985

5. The U.S. from the end of the Cold War (c. 1989)


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1. Canada between the World Wars

a. The Liberal government under King (1921–30): Commonwealth relations, nationalism and the return to isolationism

b. The Great Depression and relief measures of the Conservative government (1930–35): return of Liberal government (1935); foreign trade, welfare legislation, financial reforms, minor political parties

2. Canadian participation in World War II: mobilization of manpower and production, development of armed forces

3. Canada since 1945

a. Postwar foreign policy: North American continentalism and collective security: participation in NATO, the UN, and the Korean War; leading role in UN peacekeeping efforts; U.S.-Canadian economic relations and free-trade agreement

b. Involvement in British Commonwealth affairs: relations with Third World nations

c. Franco-Canadian relations and French separatism in Quebec: conflicts between French- and English-speaking Canadians

d. Postwar prosperity: expansion of manufacturing and mining industries; economic nationalism; relations with Indians, Eskimo, and Métis


Suggested reading in the *Encyclopedia Britannica*:

MACROPAEDIA: Major articles and a biography dealing with the United States and Canada since 1920

- Arctic, The
- Canada
- North America

Roosevelt, Franklin D.
United States of America
**MICROPAEDIA:** Selected entries of reference information; see also Sections 965 and 971

### General subjects

**Canada:**
- Canada Act
- Co-operative Commonwealth Federation
- Liberal Party of Canada
- New Democratic Party
- Parti Québécois
- Progressive Conservative Party
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**U.S. domestic affairs and social programs:**
- Adkins v.
- Children's Hospital
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- black nationalism
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**Biographies**

**Canadians:**
- Bennett, Richard
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- Trudeau, Pierre
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**U.S. government and diplomatic figures:**
- Acheson, Dean
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**U.S. military leaders:**
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**Cold War**
- Cuban missile crisis
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2. Cárdenas’ Six-Year Plan (1934–40): social and economic reforms, reorganization of the National Revolutionary Party, expropriation of foreign petroleum industry (1938), election of Ávila Camacho (1940)  
3. Mexico during World War II: economic and military cooperation with the United States, wartime industrialization  
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   a. Political, economic, and social developments: dominance of the Institutional Revolutionary Party (PRI); woman suffrage (1958); industrialization and urbanization; emergence as a major oil and gas producer; oil boom of the 1970s and debt crisis of the early 1980s; economic crises and reforms in the 1980s and early 1990s; revolt of the Zapatista National Liberation Army in Chiapas state, assassination of PRI presidential candidate Luis Donaldo Colosio and election of Ernesto Zedillo Ponce de León (1994), currency devaluation (1995) and severe recession, economic recovery  

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g. Belize since 1920: progress toward independence, government of George Price, achievement of independence in 1981

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i. Fulgencio Batista’s dictatorships (1933-44; 1952-59), growth of the military and middle classes, foreign control of the economy and widespread rural poverty

ii. The Cuban Revolution of 1959: Fidel Castro’s program for Cuban Socialism

iii. Cuba under Castro: nationalization of foreign-owned property, alignment with the Soviet bloc, attempts to foment revolution in other Latin-American states in the 1960s, improvements in education and medical care, extensive civilian foreign-assistance missions, military involvement in Africa and renewed support of leftist movements in Central America, collapse of the Soviet bloc and ensuing political isolation and economic hardship


d. The new nations of the Caribbean region: Antigua and Barbuda, The Bahamas, Barbados, Dominica, Grenada, Jamaica, St. Christopher and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago; efforts toward development and regional cooperation; U.S. involvement in the region; U.S. invasion of Grenada (1983)

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2. Colombia since 1930
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a. The overthrow of Leguía (1930); Sánchez Cerro’s administration (1931–33); the Aprista uprising and Sánchez Cerro’s assassination; Benavides’ administration (1933–39), social reforms, and the outlawing of the Apristas
b. Prado’s first administration (1939–45); wartime cooperation with the U.S. and economic prosperity, legalization and re-outlawing of the Apristas during Bustamante’s administration (1945–48), Odría’s military dictatorship (1948–56) and suppression of Apristas

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b. Military coup (1936), rise of MNR and PIR political parties, 1943 military coup and the Villaruel dictatorship (1943–46), political instability to 1951, military junta (1951–52)

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b. Economic crises during the 1930s: brief return to civilian rule under Montero Rodríguez, military coup and 100-day rule of Socialist Republic, Alessandri Palma’s second administration (1932–38)
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2. Chile from 1938 to 1952: the era of the Radical Party presidencies
   a. The administrations of Cerda (1938–41) and Ríos (1942–46): agrarian reforms, Chilean
      neutrality until 1942, economic prosperity
   b. González Videla’s administration (1946–52): strengthened economic ties with the U.S.,
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3. Chilean politics since 1952
   a. Ibáñez del Campo’s administration (1952–58) and strong presidential leadership,
      administration of Alessandri Rodríguez (1958–64), social and economic problems,
      proliferation of leftist political parties and realignment of conservative parties
   b. Frei’s administration (1964–70) and nationalization of the economy, Allende’s Marxist
      administration (1970–73), military coup (1973) and military rule under Pinochet
      (1973–90), political repression, continued economic difficulties, presidential election of
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      and violence in the 1930s, neutrality in World War II
   b. The Perón era (1943–55): his rise to and fall from power, economic policies
   c. Argentina since 1955: attempts to restore constitutionalism, military dictatorships, civil wars
      and Peronista resurgence, return (1973) and death (1974) of Perón, military coup (1976),
      excesses and economic failures of military rule, invasion of the Falkland Islands and defeat
      by Britain (1982), return to civilian rule under Alfonsín (1983), foreign-debt problems,
      election (1989) and reelection (1995) of Peronist Carlos Saúl Menem

2. Uruguay since 1929
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      (1938), Uruguayan neutrality in World War II, economic boom and political reforms
   b. Post-World War II developments: the constitution of 1951 and the plural executive,
      recession (1954–58), 1958 election of Nationalists (Blancos), return of Colorado Party and
      return to presidential system (1966), Tupamaro guerrilla insurgency, dismissal of Congress
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   b. Political instability and economic retardation: Stroessner’s dictatorship from 1954 to his
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G. Brazil since 1930: the Second Republic

1. The Getúlio Vargas dictatorship (1930–45): the revolution of 1930, the constitutions of 1934
   and 1937, Vargas’ consolidation of power (1937), social and economic legislation, Allied
   participation in World War II, Vargas’ forced resignation (1945)

2. Political, social, and economic developments in Brazil since 1945
   a. Election of Eurico Gaspar Dutra (1945) and the constitution of 1946, reelection of Vargas
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   b. Election of Jânio Quadros as president (1960), Quadros’ resignation (1961), parliamentary
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      Goulart full presidential powers, social and economic unrest and nationalization of oil
      refineries, revolution and exile of Goulart and the beginning of military rule (1964)
   c. Presidency of Castelo Branco (1964–67): legislative restrictions on civil liberties and political
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      enhancement of executive power, the constitution of 1967
   d. Presidencies of Costa e Silva, Médici, Geisel, and Figueiredo after 1967: continued
      repression amid increasing opposition to military rule, end of artificial two-party system and
      formation of new parties (1979), gains by opposition parties in 1982 elections, inflation and
      foreign-debt problems from the early 1980s

H. Development of Latin-American literature, music, and visual arts in the 20th century: the intermingling of European, Indian, and African cultures

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles dealing with Latin-American and Caribbean nations since c. 1920

- Argentina
- Bolivia
- Brazil
- Buenos Aires
- Central America
- Chile
- Colombia
- Ecuador
- Guyana
- Havana
- Latin America
- Lima
- Mexico
- Mexico City
- Paraguay
- Peru
- Rio de Janeiro
- São Paulo
- South America
- Suriname
- Uruguay
- Venezuela
- West Indies

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

- Communist Party of Cuba
- Cuban missile crisis
- Sandinista
- 26th of July Movement
- West Indies

- Mexico:
  - Indigenismo
  - Institutional Revolutionary Party
  - Sinarquism
  - Chaco War

- South America:
  - Estado Novo
  - Falkland Islands War
  - Perónist
  - Rio de Janeiro Protocol
  - Shining Path
  - Tupamaro

**Biographies**

- Noriega, Manuel
- Somoza family
- Torrijos, Omar
- Trujillo, Rafael
- Ubico, Jorge
- Mexico:
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  - Calles, Plutarco
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- South America:
  - Allende, Salvador
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   a. Early power struggles: Chinese involvement in World War I
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   b. Modernization and the growth of nationalism: the new intelligentsia, riots and protests

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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with East Asia: China in revolution, the era of Japanese hegemony, and the influence of the United States in the 20th century

Asia          Japan          Nanking          Tientsin
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- Indian National Congress
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**Indian subcontinent:**
- Abdullah, Sheikh Muhammad
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- Bandaranaike, S.W.R.D.
- Bhutto, Benazir Bhutto
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Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with Australia and Oceania since 1920

Australia Pacific Islands
Melbourne Sydney
New Zealand United States of America: Hawaii

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General subjects
Australian Democrats New Zealand National Party
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Australia:

Bruce, Stanley
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iii. Crises of colonial rule in the 1950s: Mau Mau resistance in Kenya; independence movements in Uganda, Tanganyika, and Zanzibar

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ii. Economic cooperation among the formerly British East African nations: the East African Community and its end (1977)

iii. Tanzania (formerly Tanganyika and Zanzibar): revolt against Arab control in Zanzibar (1964), Nyerere and introduction of *ujamaa* socialism, tension with Uganda and invasion in support of revolt against Amin (1979), economic difficulties and subsequent reforms beginning in the late 1980s

iv. Uganda: independence (1962) and economic growth, the Obote and Amin governments, reign of terror and economic decline, deposition of Amin (1979), reinstatement (1980) and overthrow (1985) of Obote, government of Museveni from 1986, constitution of 1995


c. Madagascar: the French administration, independence (1960) and subsequent domestic politics and foreign relations

7. Central Africa after World War II: the intensification of nationalist movements and the acquisition of independence by the former European colonies

a. The emergence of French and Belgian colonies as republics: internal divisions and the fate of the republics

i. The Democratic Republic of the Congo (Republic of Zaire since 1971): the Congolese nationalist movement and independence (1960), secession of Katanga province and UN intervention (1960–64), regime of Mobutu Sese Seko (1965–97)


iii. Republic of the Congo: independence (1960), ethnic rivalries, domestic politics and foreign relations

iv. Gabon: independence (1960), subsequent domestic politics and foreign relations

v. Burundi and Rwanda: independence (1960), warfare between Tutsi and Hutu

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ii. White-settler control of Southern Rhodesia: relations with Northern Rhodesia and Nyasaland and economic, social, and political discrimination against black Africans; Portuguese rule in Angola and Mozambique

iii. Indian, Coloured, and black African responses to discrimination: growth of local political organizations, separatist church movements, and mass nationalist movements

b. Southern Africa since 1945: political developments in white-controlled colonies and nations, emergence of black nations

ii. Namibia (formerly known as South West Africa): international and internal resistance to South African rule, revocation of UN mandate (1966) and international efforts toward independence, independence of Namibia (1990)


iv. British Central Africa: postwar economic development in Northern Rhodesia, Southern Rhodesia, and Nyasaland; the Federation of Rhodesia and Nyasaland (1953–63); rise of black nationalist movements; independence of Zambia and Malawi (1964), governments of Kaunda (1964–91) in Zambia and Banda (1964–94) in Malawi

v. Zimbabwe (formerly Southern Rhodesia): Rhodesian Front governments of Ian Smith (1964–79), the Unilateral Declaration of Independence (UDI; 1965), civil war, establishment of Zimbabwe (1980), rule of Mugabe from 1980

vi. Developments in the Portuguese colonies of Angola and Mozambique: economic advances, nationalist movements, and independence in the mid-1970s; civil war in Angola and intervention by South African and Cuban troops, prolonged guerrilla warfare in Angola and Mozambique in the 1980s; Mozambique-South Africa nonaggression pact (1984); short-lived peace agreements in Angola and withdrawal of Cuban troops (1991); multiparty Angolan elections (1992) and resumption of conflict; end of guerrilla war in Mozambique (1992)

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles and a biography dealing with Southwest Asia and Africa: the late colonial period and the emergence of new nations in the 20th century

| Afghanistan | Cyprus | Jordan | Syria |
| Africa | Eastern Africa | Lebanon | Transcaucasia |
| Arabia | Egypt | North Africa | Turkey and |
| Asia | Iran | Palestine | Ancient Anatolia |
| Ataturk | Iraq | Southern Africa | Western Africa |
| Central Africa | Israel | Sudan, The |

MICROPAEDIA: Selected entries of reference information; see also Section 96/11

General subjects

central Africa:
Belgian Congo
Moyen-Congo
Ruanda-Urundi
Rwanda

eastern Africa:
Buganda
German East Africa
Africans
Italian East Africa
Mau Mau
Somaliland

Ethiopia and the
Nilotic Sudan:
Anglo-Egyptian Condominium
Italian East Africa
Italo-Ethiopian War
Mahdist

Middle East:
Anglo-Egyptian Treaty
Arab Legion
Balfour Declaration
Ba`th Party

United Arab Republic
Wafd
Zionism
North Africa:
Algerian Reformist
Ulama
Association of
Cyrenaica
Democratic
Constitutional
Rally

National Action
Bloc
National
Liberation Front
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Rif War

Ottoman Empire and
Turkey:
Ankara, Treaty of
Greco-Turkish wars

Lausanne, Treaty of
Moscow, Treaty of

Forest, Congress
apartheid
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Democratic
National Party of
South Africa

New Republic Party
Pan-Africanist
Congress of
African National Congress
apartheid
banning

Likud
Mapam
Muslim
Brotherhood
Palestine
Palestine

Jewish Agency
Destour
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Rhodesia and
Nyasaland, Federation of
South African Party
South West Africa People’s Organization
United Party

Biographies

central Africa:
Boganda, Barthélémy
Bokassa, Eddine Ahmed
Éboué, Félix
Kasavubu, Joseph
Lumumba, Patrice
M’ba, Léon
Mobutu Sese Seko
Mutesa II
Nyerere, Julius
Obote, Milton
Tshombe, Moïse

eastern Africa:
Amin, Idi
Haile Selassie
Kenyatta, Jomo
Mboya, Tom
Mengisty
Haile Mariam
Odinga, Oginga

Iran:
Khomeini, Ruhollah
Mohammad Reza Shah Pahlavi
Mosaddeq, Mohammad
Rafsanjani, Hashemi
Reza Shah Pahlavi

Middle East—Egypt:
Farouk I
Fu‘ād I
Luṭfī as-Sayyid, Ahmad
Māhir Pasha, ‘Alī
Mubārak, Hosni
Naguib, Muḥammad

Middle East: Biafra
British West Africa

Middle East—Israel and Zionism:
Aḥad Ha‘am
Begin, Menahem
Ben-Gurion, David
Ben-Zvi, Itzhak
Dayan, Moshe
Herzl, Theodor
Jabotinsky, Vladimir
Meir, Golda
Peres, Shimon
Rabin, Yitzhak
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Sharon, Ariel
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‘Arafat, Yāsir
Assad, Ḥafiz al-Chamoun, Camille
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İnönü, Ismet
Menderes, Adnan
Ōzal, Turgut

western Africa:
Awolowo, Obafemi
Azikiwe, Nnamdi
Balewa, Sir
Abubaker Tafawa
Daddah, Moktar
Ould
Danquah, J.B.
Doc, Samuel K.
Gowon, Yakubu
Guèye, Lamine
Houphouët-Boigny, Félix
Jawara, Sir Dawda
Kairaba
Keita, Modibo
Margai, Sir Milton
Nkrumah, Kwame
Ojukwu,
Odumegwu
Olympio, Sylvanus
Rawlings, Jerry J.
Senghor, Léopold
Toure, Sékou
Tubman, William V.S.
Zinsou, Émile

other:
Amānollāh Khān
Makarios III
ZHārīr Shah, Mohammad

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The words universe and encyclopaedia have an obvious similarity of meaning. Both come from words—in the one case, Latin, in the other, Greek—that mean a totality or all-inclusive whole. Whether the universe is finite or infinite, and however it is constituted or organized, it embraces everything that is. Nothing lies outside it; everything that happens occurs within it. Can one say, with equal assurance, that the encyclopaedia is a similar totality or whole? Perhaps we cannot say that of any actual, historic encyclopaedia. But that is the ideal which all encyclopaedias attempt to embody.

It is not just the similarity of the universe and the encyclopaedia as totalities or wholes that interests us, but also how these two wholes are related to each other. One of them, the universe, embraces not only everything that is, but also everything that is knowable. The other, the encyclopaedia, sets for itself the goal of reporting everything that is and can be known about the universe. The one is mirrored or reflected in the other—the macrocosm in the microcosm.

The universe includes man—man a moving body, man a living organism, man a social animal, and man not only as a doer and seeker but also as a maker and knower of things. Among the things that man seeks to know and understand is his own knowledge—his abilities, efforts, and achievements in the sphere of knowing itself. Whether or not Aristotle was correct in saying that the highest form of intellectual activity is thinking about thinking itself, it is certainly true that "knowledge become self-conscious" is a distinctive characteristic of the human enterprise of knowing. We not only seek to know whatever can be known, but we also, reflexively, turn our knowing back upon itself when we pay attention to how we know what we know, the various ways in which we know, and the divisions or branches of our knowledge.

The organization of the encyclopaedia—the way in which the branches of knowledge have been distinguished from one another and related to one another—has changed remarkably from age to age. In antiquity, before there were any real encyclopaedias, learned men envisaged the whole of human knowledge as having a certain structure of related parts or subdivisions. The organization of knowledge in medieval encyclopaedias exhibited quite a different pattern. Later encyclopaedias introduced still other changes in the picture; and that picture has changed in important respects during the last century and is undergoing further changes today.

The new Britannica presents us with an outline of knowledge that is radically different in its fundamental framework and its organizational scheme from the outlines that might have been constructed for an ancient encyclopaedia—if there had been any such thing—or a medieval one. The Outline of Knowledge set forth in this Propledia volume is divided into ten parts, each of which is broken down into divisions and sections. Division by division, from Part One through Part Nine, the outline covers what we know about the universe with the help of such sciences as physics, chemistry, astronomy, geology, meteorology, biology, medicine, psychology, anthropology, sociology, political science, economics, and technology. It also covers what we know as a result of systematic study and scholarship in such fields as education, law, the arts, religion, and history.

The knowledge of the universe that we possess by means of the disciplines mentioned above is outlined in Parts One through Nine and expounded in the articles to which the outline refers. What about Part Ten—the part to which this essay is an introduction? Where and how does that fit into the picture?

To some extent the answer has already been given. Here in Part Ten we are concerned with "knowledge become self-conscious"—with knowledge about knowledge—with our knowing turned, reflexively, back upon itself. Here it is not the knowable universe we are considering. It is, instead, the world of knowledge itself: its diverse disciplines, modes of inquiry, fields of scholarship or systematic study—in short, as the title of Part Ten indicates, the branches of knowledge. Whereas the other nine parts of the Outline of Knowledge cover what we know about the knowable universe, the outline of Part Ten covers what we know about the sciences or other disciplines whereby we know that which we know.

The answer just given is not the whole answer to the question provoked by the special character of Part Ten. What we know about the various sciences and the diverse disciplines that compose the world of knowledge almost always includes an account of the methods of inquiry, verification or demonstration, and argument employed by scientists or scholars in a particular field of knowledge. While interest in such matters does not exhaustively represent the concerns of logic, the science of logic does provide the underpinnings for our study of the methodology of the other learned disciplines, including history and philosophy as well as the various sciences. What we know about logic itself as a science—its history and, as it were, the philosophy of it—therefore properly belongs in the outline of Part Ten, together with an indication of the scope and content of the science itself.

For a somewhat different reason mathematics is also treated here in the same way as logic. The knowledge attained by the mathematician has extraordinarily wide and diverse applicability in other spheres of inquiry and branches of knowledge—in most, if not all, of the natural sciences and in many of the social sciences. Like logic, mathematics belongs here not only for its usefulness in other sciences, but also for its own sake as a science. We
are concerned with its content as well as with its method, history, and philosophy.

In addition to logic and mathematics, two other disciplines occupy a special place in any consideration of the branches of knowledge. One is history; the other, philosophy.

History as a field of study includes more than the history of peoples, of nations, of cultures, and of social institutions. It includes the history of human learning itself, of all the branches of knowledge. It includes not only the history of the natural and social sciences, but also the history of logic, of mathematics, of philosophy, and of history itself as one of the learned disciplines. And, in addition to there being a history of the study of history (i.e., historiography), there is also a logic of history (its methodology) and a philosophy of history.

Like history, philosophy is operative in the study of all the other disciplines as well as of itself. Philosophy become self-conscious is concerned with questions about the nature and scope of philosophy, about whether it has a method or methods and a subject matter or subject matters peculiarly its own. Philosophy is also concerned about its own historical development and, in that history, about its changing relationship to other disciplines, especially to religion and to the sciences. As there is a history and a philosophy of history, so there is a philosophy of philosophy and a history of philosophy—a statement which probably cannot be made about any other two disciplines in the entire range of the branches of knowledge.

In addition, as each of the other disciplines has a history, so there is a philosophy of each of the other disciplines. We have already noted that there is a philosophy of logic and of mathematics. So, too, there is a philosophy of science in general and of the different sciences in particular; and also a philosophy of education, of law, of art, and of religion.

All of this, however, does not exhaust the content of philosophy, any more than the history of all the branches of knowledge exhausts the content of history, or any more than the application of logic and mathematics to other disciplines exhausts their content as disciplines with knowledge to offer. But in the case of philosophy, as not in the case of logic and mathematics, it is sometimes questioned whether it can rightly claim to offer us knowledge of the universe as well as knowledge about knowledge itself and an understanding of the various branches of knowledge. That question, together with the question of how the knowledge that philosophers claim to have stands in relation to other forms of knowledge, constitutes what is, perhaps, the most fundamental problem dealt with by philosophers when they philosophize about philosophy itself. Whether or not the knowledge they claim to have is comparable in its validity to the knowledge achieved in other spheres of inquiry, philosophy, like science, covers a wide range of subject matters and involves a large number of distinct subdivisions, each with its own problems and controversies (e.g., metaphysics, philosophy of nature, epistemology, philosophy of mind, philosophy of man, ethics, political philosophy, and aesthetics).

Concerning the whole range of disciplines that are represented in an exhaustive inventory of the branches of knowledge, three questions stand out as the most challenging. Of these, the first two have been debated over and over again—in earlier epochs as well as in our own century, and in the context of organizations of knowledge quite different from that which prevails or is acceptable today.

One is the question about whether the various branches of knowledge can or should be arranged in a hierarchical order, in an ascending scale from lower to higher, or from less to more fundamental. In antiquity they were so arranged; as, for example, in Aristotle's ordering of the speculative sciences, beginning with physics and rising through mathematics to metaphysics as the science of first principles and ultimate causes; and in his characterization of politics as the architectonic or controlling discipline in the sphere of practical knowledge, directive of human action. So, too, in the Middle Ages, a hierarchical organization prevailed, in which theology was regarded as queen of the sciences, philosophy as its handmaiden, with all the other disciplines contributing their portions of knowledge for the greater glory of God and for the better understanding of man's destiny under Divine Providence. If, in accordance with the prevailing view today, a hierarchical order is rejected, is there any other order to replace it, and in terms of what criteria or principles can such an alternative be constructed? Is there, as the introductory essay in this volume suggests, a circle of learning instead of a hierarchy of the branches of knowledge—a circle in which no point is either a beginning or an end, and lines can be drawn from any point to any other?

The second question, to which different answers have been given at different times and to which conflicting answers are still being given today, asks about the coherence of the world of knowledge as a whole. Do all its constituent parts—its various component disciplines or branches of knowledge—adhere together harmoniously, each somehow complementing the other? Or, on the contrary, is the world of knowledge torn asunder by irreconcilable conflicts—by territorial disputes, by conflicting claims to sovereignty, by assertions and denials of legitimacy? Underlying whatever answers may be given to these questions, a deeper difference of opinion may exist concerning the unity of truth itself. If, for example, there is some truth in science and some truth in philosophy or in religion, must these diverse approximations of whatever truth man can possess be consistent with one another? Or, on the contrary, can there be some truth in science and some in philosophy or in religion, even though the truth of the one stands in sharp conflict to the truth of the other? Can there be, in short, a multiplicity of truths, each of which deserves that name, but each of which must be kept out of contact with the others, by being isolated in logic-tight compartments?

Unlike the two preceding questions, the third is one that has come to the forefront only recently. It concerns what many contemporary commentators regard as an unfortunate rift in the realm of knowledge—the chasm between the sciences, on the one hand, and the humanities, on the other. In the long history of the latter term, different disciplines have been grouped together on the side of the humanities and in contradiction to the sciences. Today, the humanities group is generally thought to include language and literature, the fine arts, history, philosophy, and religion.

It is assumed that there are fundamental differences, in method or approach and in criteria of validity, between the
humanistic disciplines, on the one hand, and the sciences, both natural and social, on the other. Of course there are, but they are not entirely clear. By reference to methodology or to criteria of validity, certain of the disciplines called humanistic closely resemble those called scientific. For example, mathematicians and logicians do their work by sitting still and thinking, not by undertaking experiments or by going out into the field to collect data or do research. Philosophy is like them in this respect; but mathematics and logic are usually regarded as sciences, whereas philosophy is grouped with the humanities. Furthermore, the criteria of validity thought to be applicable to philosophy do not operate as criteria for judging the excellence of literature or of other fine arts, yet all three are classified as humanities.

Supposing that some line can be clearly drawn to divide the humanities from the sciences, the problem that agitates those who contemplate the world of learning is whether it is one world or two—whether the rift or chasm that separates the sciences from the humanities involves an iron curtain that prevents communication between them. It is not within the purpose or the province of this essay to provide an answer to that question. Nevertheless, an answer would appear to be suggested by the conception of the encyclopaedia as a totality, as an organized whole. That conception would seem to favour the view that, in the circle of learning, there are no impenetrable barriers to communication or unbridgeable breaks in continuity. Underlying it is the faith that the whole world of knowledge is a single universe of discourse.
Part Ten. The Branches of Knowledge

Several points should be noted about the relations of this part to the preceding parts. The results of investigations in the natural and social sciences, and in medicine and technology—their content or knowledge—are set forth in Parts One through Five, and in Part Seven. Accordingly, the outlines in the seven sections of Division III in this part are confined to questions about the history of these disciplines, and about their nature, scope, structure, methods, and principal problems or tasks. Direct historical accounts of the peoples and civilizations of the world are set forth in Part Nine, whereas Section 10/41 in Division IV of this part is confined to historical and analytical studies of the discipline of history itself, treating the history of historical writing, the methods of modern historical investigation and research, speculative philosophies of history, and philosophical analyses of the specific character of historical knowledge.

The case is different with Divisions I, II, and V—on logic, mathematics, and philosophy. The results of these disciplines have not been dealt with in previous parts. In the history of each of these disciplines, substantive developments have persistently involved, and issued from, positions taken not only within them, but also from positions taken about them. Accordingly, the outlines in the sections of Divisions I, II, and V treat the substantive results of logical, mathematical, and philosophical inquiry, on the one hand, and the historical and analytical studies of the nature, scope, branches, methods, and principal problems of logic, mathematics, and philosophy, on the other.

In Part Six on the arts and Part Eight on religion, the outlines include historical and analytic studies of knowledge and inquiry concerning the arts and religion. Such studies, then, are not included separately in Part Ten. They are, however, treated in Section 10/42 of this part, insofar as the study of the arts and of religion are, together with the study of language, history, and philosophy, component disciplines of the humanities—a group of disciplines traditionally distinguished from the natural and social sciences, and traditionally considered to have, taken together, a special educational and cultural role. Section 10/42 sets forth a historical review of the changing conceptions of the humanities and of humanistic scholarship, and treats issues about the definition and scope of the humanities, about their distinction from the sciences, and about their role in education and culture.

Division VI, which contains only one section, differs from other divisions in that it is not discipline-specific; to the contrary, it deals with the institutions and techniques used to preserve knowledge, and certain objects of knowledge, in all fields.

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Division I. Logic

The outlines in the two sections of Division I deal with the history and philosophy of logic and with the content of the disciplines of formal logic, metalogic, and applied logic.

The outline in Section 10/11 first treats the history of logic in the West and the history of Indian and Chinese logic; and then treats differing conceptions of the field and scope of logic, problems in the philosophy of logic concerning meaning, truth, and ontology, and the place of logic among the sciences and disciplines.

Section 10/12 deals first with formal logic, treating the propositional calculus, the predicate calculus, the theory of the syllogism, modal logic, and set theory and natural-number arithmetic. It goes on to the nature and elements of metalogic, which studies the syntax and semantics of formal languages, formal systems, and logical calculi. Finally, it deals with the applications of logic in different domains of inquiry and discourse.

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   b. Aristotle and the logic of predicates: theories of the structure of language, theories of opposition and conversion, development of syllogistic and modal logic
   c. Later developments in the logic of predicates: contributions of Theophrastus and Galen
   d. Founding of the logic of propositions: contributions of Theophrastus and the Megarians, Stoic logic

2. Medieval logic
   a. Development of medieval logic: Arabic contributions, disputes between the “old logic” and the “new logic” after the translation of Aristotle's *Organon*, summations by William of Sherwood and Peter of Spain
   b. Medieval theories of language and their relation to the development of logic: the theory of categorematic and syncategorematic terms, the theory of supposition
   c. Medieval developments in formal logic: the logic of predicates, of propositions, and of modal expressions; logical fallacies and paradoxes

3. Modern logic from the Renaissance to the 20th century
   a. Logic in the Renaissance: the influence of Neoplatonism and of the rise of the natural sciences, the logics of Petrus Ramus and of Port-Royal
   b. The rise of mathematical logic during the Enlightenment: contributions of Leibniz (e.g., his general calculus of reasoning and general methodology), the search for clarity and the use of diagrams
   c. Development of mathematical logic in the 19th century: expansions of syllogistic, Boole's algebra of logic, refinements of the calculus, the study by Frege and Cantor of the relation between logic and the foundations of mathematics

4. Logic in the 20th century
   a. The conflict of Logicism, the view that mathematics is a continuation of logic, with Intuitionism and Formalism; Russell's Logicism and the theory of types, Brouwer's Intuitionism, Hilbert's Formalism
   b. Developments in the logic of propositions and in the logic of predicates
   c. Metalogical studies: the study of the properties of axiomatized systems, syntax and semantics as metalogical disciplines

5. Logic in the East
   a. Indian logic: its origins in the commentaries on the scriptural texts called *sūtras*, special problems in grammar and special types of inference, interest in the logical implications of the notion of negation
   b. Chinese logic: its origins in reflections on the characteristics of controversies between the major philosophies of Confucianism, Taoism, and Moism; its neglect after the establishment of Neo-Confucianism in the 11th century AD

B. Philosophy of logic

1. The organization of logic as a discipline
   a. The nature and varieties of logic: differing conceptions of its field and scope, varieties of logical symbolism
   b. Features and problems of logic: concerns with logical semantics or model theory, questions of the limitations of logic, Gödel's incompleteness theorems, the question of logic and computability

2. Issues and developments in the philosophy of logic
   a. Problems in meaning and truth: logical semantics of modal concepts, logic and informativeness
b. Problems of ontology: problems concerning individuation and existence
c. Alternative logics: modal logics, intuitionistic logic

3. The place of logic among the sciences and disciplines

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles dealing with the history and philosophy of logic

Logic, The History and Kinds of
Philosophies of the Branches of Knowledge

**MICROPAEDIA**: Selected entries of reference information

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See also Sections 10/51, 10/52, and 10/53

**INDEX**: See entries under all of the terms above

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**Section 10/12. Formal Logic, Metalogic, and Applied Logic**

**A. Formal logic**

1. The propositional calculus: the logic of unanalyzed sentences in combination
   a. General features of the propositional calculus: symbols employed for propositional connectives or operators (*i.e.*, "not," "and," "or," "if . . . then," "is equivalent to"), propositional variables
   b. Special systems of the propositional calculus

2. The predicate calculus: the logic of quantified functions of terms
   a. General features of the predicate calculus: individual variables and predicate variables, universal and existential quantifiers (*i.e.*, "any" or "all," "some" or "one")
   b. The lower predicate calculus: the logic of individual variables
   c. Higher order predicate calculi: the logics of classes of variables

3. Syllogistic: the theory of the syllogism

4. Modal logic: the logic of necessity, possibility, and contingency; systems of and validity in modal logic

5. Set theory and natural-number arithmetic

**B. Metalogic: the study of the syntax and the semantics of formal languages, formal systems, and logical calculi**

1. The nature and elements of metalogic

2. The nature of a formal system and of a formal language

3. Discoveries about formal mathematical systems: completeness and consistency, decidability and undecidability

4. Discoveries about logical calculi

5. Model theory: the study of the interpretations, or models, that satisfy the axioms of a given formal system
C. Applied logic

1. The critique of forms of reasoning
   a. Theory of argumentation: the new rhetoric
   b. Analysis of logical fallacies: material, verbal, and formal fallacies

2. Epistemic logic: logic dealing with the concepts of belief, knowledge, assertion, doubt, and question

3. Practical logic: logic dealing with the concepts of choosing, planning, commanding, and permitting

4. Logics of physical application

5. Hypothetical reasoning and counterfactual conditionals: logic involving consequents whose antecedents are known to be false

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with formal logic, metalogic, and applied logic

Logic, The History and Kinds of Rhetoric

MICROPAEDIA: Selected entries of reference information

General subjects

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See also Sections 10/51, 10/52, and 10/53

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The outlines in the three sections of Division II treat the history and foundations of mathematics, the branches of mathematics, and the applications of mathematics.

Section 10/21 deals first with the general history of mathematics, with the development of representative non-probabilistic areas of mathematics, and with the historical development of probabilistic areas. The treatment of the foundations of mathematics covers the axiomatic method, the genetic method, 20th-century rival formulations of the foundations of mathematics, and current investigations of the foundations of mathematics.

Section 10/22, the branches of mathematics, first treats set theory, arithmetic, elementary multivariate algebra, linear and multilinear algebra, and algebraic structures, including the subjects of homological algebra and universal algebra. It goes on to deal with Euclidean and non-Euclidean geometry, projective geometry, analytic and trigonometric geometry, differential geometry, and algebraic geometry. It then deals with the subdivisions of mathematical analysis: real analysis, complex analysis, differential equations, functional analysis, Fourier analysis, the theory of probability, and vector and tensor analysis. The outline next deals with combinatorics and combinatorial geometry, and with number theory. Finally, it treats topology: general topology, topological groups and differential topology, and algebraic topology.

Section 10/23, applications of mathematics, first treats mathematics as a calculatory science and then goes on to deal with statistics, numerical analysis, definitions and examples of automata and the development of automata theory, the mathematical theory of optimization, information theory, and the mathematical aspects of physical theories.

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Section 10/21. History and Foundations of Mathematics

A. History of mathematics

1. The development of mathematics in general, through ancient, medieval, and modern times
   a. Ancient and medieval periods
      i. Ideas and methods originating or developing in Mesopotamia and Egypt
      ii. Greek and Hellenistic mathematics
      iii. The Middle Ages: Islamic mathematics and its transmission to the West
   b. The modern period
      i. The 17th century: discovery of logarithms and analytic geometry, development of calculus by Newton and Leibniz
      ii. The 18th century: advances in geometry, algebra, and analysis; contributions of the Bernoulli family, Euler, Lagrange, Laplace, and others
      iii. The 19th and 20th centuries: development of non-Euclidean geometry by Bolyai, Lobachevsky, and others; contributions to the theories of groups, functions, and complex variables; development of algebraic geometry; influence of physical science on analysis; study of the foundations of mathematics

2. Historical development of representative nonprobabilistic areas of mathematics
   a. Numerals and numeral systems
      [see also 10/23.A.1.]
      i. Simple grouping systems: ancient Egyptian, Babylonian, Greek, and Roman numerals
      ii. Development of multiplicative, ciphered, and positional numeral systems
   b. Introduction of symbolic notations to represent mathematical quantities, operations, and relationships
   c. Calculatory science
      [see also 10/23.A.]
      i. The history of mathematical tables, including tables of logarithms
      ii. The evolution of analogue devices: origins of harmonic analyzers, differential analyzers, and the slide rule
iii. The evolution of digital devices: development of computational aids from the abacus to the modern electronic digital computer
[see 10/23.A.7.]

d. Geometry
[see also 10/22.C.]
  i. Egyptian, Babylonian, and Greek geometry
  ii. The algebraic approach: development of analytic geometry
  iii. Development of projective geometry
  iv. Development of non-Euclidean geometry
  v. Philosophical aspects of geometry
  vi. Modern ideas and topics in geometry: the axiomatic method; geometrical transformations; the concept of space, differential geometry, and topology

e. Algebra
[see also 10/22.B.]
  i. Babylonian, Egyptian, and Greek contributions
  ii. Contributions from the Orient, India, and the Islamic world
  iii. Medieval and modern European developments
  iv. Evolution of the theory of algebraic equations of one variable: solutions prior to and after Galois

3. Historical development of probabilistic areas of mathematics
[see also 10/22.D.6.]
  a. Development of the mathematical theory of probability
    i. The abstract calculus of probability: the common structure of theories of probability
    ii. Alternative views of probability: the frequency theory of probability, the range theory of probability and the principle of indifference, the belief theory of probability, subjective and objective notions of probability
    iii. Bernoulli's theorem, inverse probability, and asymptotic probabilities
  b. Development of mathematical statistics: the history of the theory of stochastic processes, origins of control theory

B. Foundations of mathematics

1. The axiomatic method: mathematical analysis based upon a set of axioms, or unproved statements
  a. Euclidean geometry
[see also 10/22.C.1.]
  b. Non-Euclidean geometry
[see also 10/22.C.2.]
  c. The formal axiomatic method

2. The genetic method: mathematical analysis based upon the orderly construction or generation of objects with unknown properties from objects with known properties
  a. Arithmetic and analysis
[see also 10/22.B.1.]
  b. The concept of cardinal number and the theory of sets
[see also 10/22.A.2.]

3. The crisis in the foundations of mathematics after 1900: reformulations in terms of the three alternative philosophical positions of Intuitionism, Logicism, and Formalism
  a. The paradoxes
  b. Intuitionism
  c. Logicism, Formalism, and the metamathematical method

4. Current directions in investigations of the foundations of mathematics
  a. Intuitionistic studies of the foundations of mathematics: application of formalistic procedures to Intuitionism
  b. Non-Intuitionistic studies of the foundations of mathematics: trends in recursion theory, proof theory, model theory, and set theory
MACROPAEDIA: Major articles and biographies dealing with the history and foundations of mathematics

Archimedes
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Mathematics, The Foundations of Mathematics, The History of
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Section 10/22. Branches of Mathematics

A. Set theory

1. Origins of set theory and the definitions of a set and a set element, or member
2. Introduction to set theory
   a. Fundamental set concepts
   b. Essential features of Cantorian set theory
3. Axiomatic set theory: formal analyses of set theory based upon certain fundamental assumptions or undefined notions called axioms
   [see also 10/21.B.3.b]
   a. Postulates of axiomatic set theory: the Zermelo–Fraenkel axioms, the von Neumann–Bernays–Gödel axioms
   b. Limitations of axiomatic set theory: failure of attempts to prove the consistency of axiomatic set theory, Gödel's theorem
   c. The present status of axiomatic set theory: profound changes in axiomatic set theory as a result of recent discoveries
B. Algebra

1. Arithmetic
   a. Fundamental definitions and laws: the concepts of natural number and integer; the binary operations of addition and multiplication; the commutative and associative laws of addition; the commutative, associative, and distributive laws of multiplication
   b. Theory of divisors: extension of natural number concepts to non-integers, fractions resulting from the binary operation of division
   c. Number systems and notation: use of the positional principle and the symbol zero to specify magnitude in sequences of digits; number systems having different bases—e.g., binary, decimal, and sexagesimal systems
   [see also 10/23.A.1.1]
   d. Arithmetic calculation with decimals: binary operations with decimals; divisibility rules; calculation of square, cube, and higher roots
   e. Logarithms: formal definition of logarithms, use of logarithms to reduce the operations of multiplication and division to the simpler operations of addition and subtraction
   [see also 10/23.A.4.b.]

2. Elementary and multivariate algebra
   a. Algebra as an extension and generalization of arithmetic
   b. Basic algebraic properties of numbers
   c. Polynomials and rational functions
   d. Solution of equations: the principal problem of elementary algebra

3. Linear and multilinear algebra
   a. Linear algebra
      i. Vector spaces
      ii. Matrices
      iii. Linear transformations and linear operators
      iv. Linear functionals and their relation to linear transformations
      v. Inner products and inner product spaces: self-conjugate, or Hermitian, matrices; unitary and orthogonal matrices
      vi. Linear operators in an inner product space: self-adjoint, or Hermitian, operators; unitary and orthogonal operators; the spectral theorem for normal operators
   b. Multilinear algebra

4. Algebraic structures
   a. Lattices
   b. Groups
   c. Fields
   d. Rings
   e. Categories
   f. Homological algebra
   g. Universal algebra

C. Geometry

1. Euclidean geometry
   a. Geometry as an abstract doctrine: the axiomatization of the foundations of geometry; axioms of order, incidence, congruence, parallels, and continuity and results derived from them
   b. The measure of polygons and polyhedra: the theories of equivalence and measure and their relation, Euclid's contribution and its modern extension and generalization
   c. Transformation geometry: reflection, rotation, and translation of geometric figures; homotheties and similitudes
   d. Geometric constructions: the equivalence between Euclidean constructions and existence theorems, gauge constructions, ruler and compass constructions, construction with compass only
e. Geometry of more than three dimensions: the generalization of Euclidean geometry

f. The concept of convexity and convex sets

2. Non-Euclidean geometry
   [see also 10/21.B.1.b.]
   a. Distinction between Euclidean and non-Euclidean geometry: hyperbolic geometry and elliptic geometry
   b. Geometric representations of the hyperbolic plane and hyperbolic space
   c. Coordinates in spherical and elliptical space: interpretations of four-dimensional Euclidean space
   d. Coordinates in the hyperbolic plane and hyperbolic trigonometry
   e. Transformations: hyperbolic geometry as characterized by its group of reflections

3. Projective geometry
   a. The procedure of projection as the foundation of projective geometry
   b. Homogeneous coordinates: location of points in space
   c. Complex geometry: introduction of complex numbers as homogeneous coordinates
   d. Abstract geometries: extension and generalization of projective geometry to space of any number of dimensions

4. Analytic and trigonometric geometry
   a. Plane analytic geometry: fundamental procedures and concepts
   b. Trigonometry
   c. Coordinates and transformation of coordinates
   d. Projective and solid analytic geometry: extensions of analytic geometry to the projective plane and to three or more dimensions
   e. Special curves: named curves that have been studied with regard to problems in mathematics or the physical sciences; e.g., the folium of Descartes, the lemniscate of Bernoulli, the cardioid, the cycloid, the catenary, the brachistochrone

5. Combinatorial geometry
   [see E.1.c., below]

6. Differential geometry
   [see also F.2.e., below]

7. Algebraic geometry
   [see also F.3., below]

D. Analysis

1. Real analysis
   a. Origins and concepts of real analysis
   b. Number systems and their properties
   c. Functions and differential calculus
   d. Measure and integral calculus

2. Complex analysis
   a. Theory of analytic functions of one complex variable
   b. Theory of analytic functions of several complex variables
   c. Potential theory

3. Differential equations
   a. Ordinary differential equations
   b. Partial differential equations
   c. Special functions that arise as solutions to differential equations; e.g., the hypergeometric function, Legendre polynomials, spherical harmonics, Bessel functions
   d. Dynamical systems on manifolds

4. Functional analysis
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5. Fourier analysis
   a. The theory of series
   b. Fourier series
   c. Harmonic analysis and integral transforms
   d. Representations of groups and algebras: Fourier analysis on non-Abelian groups

6. Theory of probability
   a. Heuristic introduction to probability: the need for a mathematically precise definition of probability
   b. Probability on finite dimensional spaces
   c. Probability on infinite dimensional spaces

7. Vector and tensor analysis
   a. Scalars, vectors, tensors, and the physical quantities that give rise to them
   b. Vector algebra and analysis
   c. Tensor algebra and analysis

E. Combinatorics and number theory

1. Combinatorics and combinatorial geometry
   a. The nature and scope of combinatorics: the definition of combinatorics as the branch of mathematics concerned with arrangements, operations, and selections within a finite or a discrete system
   b. Methods, results, and unsolved problems of combinatorial theory, exclusive of geometric considerations
   c. Combinatorial geometry

2. Number theory
   a. Elementary number theory: properties of the whole numbers, or integers [see B.1.a., above]
   b. Algebraic number theory: properties of algebraic numbers
   c. Analytic number theory
   d. Geometric number theory
   e. Probabilistic number theory

F. Topology

1. General topology
   a. Definition and basic concepts of topology; the subject matter and applications of topology as exemplified by certain simple topological problems and their solutions
   b. Topological spaces: methods for constructing topological spaces; Euclidean n-dimensional space, Hilbert space, Cartesian-product space, and other examples of topological spaces
   c. Topological properties
   d. Topological problems of current interest; e.g., the planar fixed-point problem, the polyhedral Schoenflies problem

2. Topological groups and differential topology
   a. Interaction between analysis and topology
   b. The theorems of Tikhonov and Ascoli: embedding of a topological space as a subspace of a compact space
   c. Continuous groups
   d. Analysis on manifolds: topological implications of problems in global analysis
   e. Differential topology [see also C.6., above]
3. Algebraic topology
[see also C.7., above]

a. The nature and scope of algebraic topology and its context within general topology, the basic
   concepts of topological spaces and maps
b. Invariants: unchanging quantities that play a central role in the classification of spaces and
   maps
c. Homotopy theory: homotopy classes and the concept of homotopy-equivalent spaces
d. Homology and cohomology theory: definition of a simplex, axiomatic homology theory
e. Homotopy groups: stability and suspension
f. Definition and properties of fibres, fibre bundles, and fibrings
g. Sheaf cohomology

h. Spectral sequences: Serre, Rothenberg–Steenrod, and Eilenberg–Moore spectral sequences
i. Further developments in homotopy theory. Eilenberg–MacLane spaces, the methods of
   killing homotopy groups, Serre’s C-theory
j. Generalized homology and cohomology theory: K-theory, the spectral sequence of
   G.W. Whitehead–Atiyah–Hirzebruch
k. Recent advances in algebraic topology

Suggested reading in the Encyclopaedia Britannica:

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Biographies

See Section 10/21

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Section 10/23. Applications of Mathematics

A. Mathematics as a calculatory science
   1. Numerical notations
      a. Aggregations, or units used to assist counting or grouping of objects
      b. Ancient numerical notations
      c. Decimal notation and modern notational developments
   2. Geometrical aids
      a. Early applications of geometry
      b. Instruments for observation and navigation
      c. Mapping
      d. Applications of geometry to celestial measurement
      e. Optical instruments
      f. Drawing instruments
   3. Mathematical models: physical constructions used to aid the visualization of mathematical ideas or relationships
   4. Calculatory aspects of algebra
      a. Algebraic notation
      b. Logarithms
      c. Slide rules
   5. Calculation using tables and graphs
      a. Mathematical tables
      b. Graphs and graphical procedures
   6. Analogue computation
      [see also 735.D.]
      a. Types of problems solvable by analogue computation
      b. Analogue computers
   7. Digital computation
      [see also 735.D.]
      a. Digital calculators
      b. Punched cards
      c. Programmed machines (digital computers)

B. Statistics
   1. The basic principles of statistical inference: application of the concepts and techniques of probability theory to the analysis of data
      a. The concept of a statistical experiment: mathematical description of experiments in terms of random variables
      b. Distribution functions and their properties: the median, mean, variance, and standard deviation of a distribution; the Gaussian or normal distribution
   2. Estimation: techniques for approximating the parameters of families of distributions of random variables
   3. Hypothesis testing: techniques for determining the correctness of alternative hypotheses concerning given data and an assumed probability model
   4. Structure in data: use of regression analysis to discover systematic patterns

C. Numerical analysis
   1. Introduction: definition, origins, and basic concepts of numerical analysis
   2. Errors: round-off and truncation
   3. Approximation of functions: linear and polynomial interpolation, least squares approximation
4. Solution of equations: linear, nonlinear, and differential equations

5. Applications and implementation of numerical analysis: optimization, large-scale scientific computation, mathematical software

D. Automata theory
[see also 712.A.6.]

1. Introduction: definition and examples of automata, development of the basic concepts of automata theory, the analogy between automata and the nervous systems of living organisms
2. Neural nets and automata
3. Probabilistic questions: random effects in the operation of automata
4. Classification of automata

E. Mathematical theory of optimization

1. The theory of games: analysis of the strategic features of conflict situations
2. Linear and nonlinear programming (mathematical programming)
3. Cybernetics
4. Control theory

F. Information theory
[see also 735.A.]

1. Origins and definitions of information theory
2. Central problems of information theory
3. Principles of information theory
4. Applications of information theory to cryptography, linguistics, and other fields

G. Computer science

1. Synthesis and analysis of algorithms
2. Theory of computation
3. Computer architecture
4. Programming languages and methodology
5. Numeric computation
6. Artificial intelligence

H. Mathematical aspects of physical theories

1. Mechanics of particles and systems
[see also 126.A.]
2. Fluid mechanics
[see also 126.F.]
3. Mechanics of solids
[see also 126.D.]
4. Statistical mechanics
[see also 124.A.9.]
5. Electromagnetic theory
[see also 127.E.]
6. Relativity theory: space and time as a four-dimensional continuum
[see also 131.D.]
7. Riemannian geometry
8. Quantum mechanics
[see also 111.A.4.c.]
9. Dimensional analysis
Suggested reading in the *Encyclopædia Britannica:*

**MACROPAEDIA:** Major articles dealing with applications of mathematics

- Automata Theory
- Computer Science
- Computers
- Game Theory
- Information Processing and Information Systems
- Numerical Analysis
- Optimization, The Mathematical Theory of
- Statistics

**MICROPAEDIA:** Selected entries of reference information

**General subjects**

**computers and other mathematical devices:**
- abacus
- analog computer
- calculator
- central processing unit
- computer programming
- language
- computer programs
- differential analyzer
- differentiator
- digital computer
- harmonic analyzer
- input/output device
- integrator
- microprocessor
- planimeter
- quipu
- slide rule
- supercomputer
- time-sharing
- numerical analysis:
  - difference equation
  - interpolation
  - numerical analysis
  - optimization:
    - control theory
    - cybernetics
    - game theory
    - linear programming
- mathematical programming
- queuing theory
- statistics:
  - decision theory
  - distribution
  - function
  - freedom, degree of inference
- other:
  - algorithm
  - artificial intelligence
  - automata theory
  - dimensional analysis
  - distortion
  - eigenvalue
  - fractal
  - gamma function
  - graph
  - graph theory
  - information theory
  - mathematical model

**Biographies**

- Babbage, Charles
- Boole, George
- Napier, John
- Pascal, Blaise
- Turing, Alan M.
- von Neumann, John
- Weyl, Herman

**INDEX:** See entries under all of the terms above

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**Division III. Science**

[For Part Ten headnote see page 479.]

The results of investigations in the natural, social, and medical sciences and the achievements of technology are dealt with in Parts One through Five and in Part Seven. The outlines in the seven sections of Division III are concerned with inquiries that have viewed those sciences and technology as the objects of historical and analytical studies.

Section 10/31 deals with science taken generally. It first presents a synoptic history of Western and Eastern science. It then deals with the nature and scope of the philosophy of science, and with analyses of the empirical procedures and formal structures of science, of science’s modes of discovery, and of validating concepts and theories.

Section 10/32 is on the physical sciences. The outline first deals with the historical evolution of astronomy and astrophysics, of physics, and of chemistry. Then, for each of them, it treats issues about the nature, scope, component disciplines, methods, and principal problems of the discipline.

Section 10/33 is on the earth sciences. The outline first deals with the history of the several complementary Earth sciences, and then with studies of the nature, scope, methods, and principal problems of the geologic, hydrologic, and atmospheric sciences.

Section 10/34 is first concerned with the historical development of the biological sciences and with issues about the methodology, scope, and conceptual structure of biology as a whole. It then sets forth the work done at four levels of biological research: the molecular, cellular, organismic, and population levels. Finally, it treats issues in the philosophy of biology: issues about the nature of biological systems, issues concerning evolution and evolutionary theory, and biological issues with ethical implications.
Section 10/35 treats the history of medicine; the many specialized fields of medical practice and research; and such affiliated disciplines as dentistry, osteopathy, nursing, and pharmacy.

Section 10/36 is on the social sciences and psychology. It first deals with the general historical development of the social sciences. It then separately treats the development, nature, scope, and methods of the particular social sciences: anthropology, sociology, economics, and political science. Finally, it deals with the history, scope, and methods of psychology.

Section 10/37 treats the history of the technological sciences; the academic and professional aspects of engineering; the nature and scope of agricultural sciences; and the nature and scope of such recently developed interdisciplinary fields as bionics, systems engineering, and cybernetics.

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10/33. The Earth Sciences 499
10/34. The Biological Sciences 501
10/35. Medicine and Affiliated Disciplines 503
10/36. The Social Sciences and Psychology and Linguistics 506
10/37. The Technological Sciences 508

Section 10/31. History and Philosophy of Science

A. History of science

1. Introduction: problems and difficulties of tracing the development of science

2. Science in ancient and medieval Western civilization
   a. Science in Greek civilization
      i. Protoscience in Greece before the age of Pericles: empirical versus religious or mythological explanations of natural phenomena
      ii. Development of scientific attitudes: the beginning of disciplined observation, inference, definition, and classification; the Platonic versus the Aristotelian view of nature
      iii. Science during the Hellenistic Age: the emergence of Alexandria as the foremost centre of scientific research
   b. Science in Rome: the contrast between Roman success in law and technology and Roman failure in science
   c. Medieval science

3. Science in other civilizations: Islamic science; science in India, China, and Japan

4. European science in the early modern period
   a. The rebirth of science in the Renaissance
      i. The state of science in Europe in the early 15th century
      ii. The influence of advances in printing, mining, metallurgy, and other areas of technology: the demands placed upon science by increases in trade and exploration
      iii. The coexistence of new scientific discoveries and old philosophical views
   b. The revolution in natural philosophy
      i. The radical reformulation of the objects, methods, and functions of natural knowledge: the work of Bacon, Descartes, and Galileo [see also 10/42.A.3.]
      ii. Results of the new philosophy: establishment of scientific societies, progress in particular fields of science
   c. Characteristics of European science

5. Science in the age of modern revolutions
   a. Science during the Industrial Revolution
   b. Intellectual origins of revolution: the spirit of the Enlightenment
   c. The institutional organization of science under the French Revolution
   d. Romantic reaction and science: the proponents of Naturphilosophie

6. Science in the 19th century: difference in styles of research; progress in physics, chemistry, and biology
7. Science in the early 20th century: the social organization and style of science, the common pattern of advance in scientific research

8. Contemporary problems and prospects: the moral, political, and environmental difficulties facing science

B. Philosophy of science

[see also 10/52.B.2.]

1. The nature and scope of the philosophy of science and its relation to other disciplines: the diverse concerns of and methods of approach to the philosophy of science

2. Historical development of the philosophy of science

   a. Classical and medieval periods: the alternative viewpoints of the Stoics and Epicureans and of the Platonists and Aristotelians

   b. The 17th century: the debate about scientific methodology, Bacon’s inductive approach and Descartes’s deductive approach

   c. The 18th century: Empiricist, Rationalist, and Kantian interpretations of Newtonian physics

   d. From the beginning of the 19th century through World War I: the influence of Kant’s belief in the unique rationality of the classical synthesis of Euclid and Newton

   e. The 20th-century debate: responses to relativity, quantum mechanics, and other profound changes in the natural sciences; Logical Positivism versus Neo-Kantianism

3. Elements of the scientific enterprise

   a. Empirical, conceptual, and formal elements and their theoretical interpretation: diverse views of the relative importance of observation, theory, and mathematical formulation

   b. Empirical procedures of science: measurement, design of experiments, classification

   c. The formal structures of science: the problem of constructing a purely formal analysis of scientific inference, the distinction between scientific laws and empirical generalizations

   d. Conceptual change and the development of science: historical problems concerning the changing theoretical organization of science

4. Movements of scientific thought: the basic procedures of intellectual development in science

   a. Scientific discovery: the extreme positions of formalism, which emphasizes the rational elements of scientific discovery, and of irrationalism, which emphasizes the role of intuition, guesswork, and chance

   b. Validation and justification of new concepts and theories: the view that prediction is the crucial test of scientific validity; the view that coherence, consistency, and comprehensiveness are the essential requirements of a scientific theory

   c. Unification of the theories and concepts of separate sciences: attempts to construct an axiomatic system for all of natural science, the reductionist problem of achieving a consistent conceptual basis for two or more sciences

5. The philosophical status of scientific theory

   a. The status of scientific propositions and concepts of entities: diverse views of the epistemological status of scientific propositions and of the ontological status of scientific concepts

   b. The relationship between philosophical analysis and scientific practice: the application of different philosophical doctrines and approaches to different sciences

6. The relevance of scientific knowledge to other spheres of human experience and concern: the social significance of science and of scientific attitudes, limitations on the scientific endeavour

7. The relation between science and the humanities: questions of differences between scientific and humanistic methodologies

[see 10/42.B.3.]
Section 10/32. The Physical Sciences

A. History of the physical sciences: the evolution of astronomy, physics, and chemistry

1. History of astronomy
   a. Ancient astronomy
      i. Time reckoning and astronomical prediction: development of lunar and solar calendars, prediction of eclipses and of first appearances of the New Moon
      ii. Early cosmologies
      iii. Ancient astronomical records, treatises, and star catalogs
   b. Medieval astronomy: European and Islamic contributions
   c. Astronomy in the 16th and 17th centuries
      i. The geocentric and heliocentric world systems
      ii. The discovery of the laws of planetary motion
      iii. The invention and use of the telescope
      iv. The theory of universal gravitation
         [see 2 c., below]
   d. Astronomy in the 18th century
      i. Development of celestial mechanics: the calculation of orbits, the three-body problem, the dynamical stability of gravitational systems
      ii. Improvements in telescope design and increased accuracy of measurements: the discovery of the aberration of light
      iii. Speculations concerning the origin of the solar system, the nature of nebulae, and the structure of the universe
   e. Astronomy in the 19th century
      i. The discovery of Neptune and the asteroids, the search for a planet within the orbit of Mercury
      ii. Improved determinations of stellar positions and magnitudes; the first measurements of stellar parallax; the compilation of catalogs of nebulae, stars, and star clusters
      iii. Development of astronomical spectroscopy and the use of photography in observational work
   f. Astronomy in the 20th century
      i. Statistical studies of stars, nebulae, and galaxies
      ii. Theories of stellar structure and of stellar formation and evolution
      iii. Astronomical tests of general relativity: the gravitational red shift, the deflection of light, the precession of the perihelion of Mercury, the cosmological red shift
      iv. Relativistic cosmologies: the big bang model; open and closed models of the universe
      v. Major advances in solar-system astronomy: manned lunar missions; exploration of the planets and their satellites with unmanned space probes; analysis of micrometeoroids and meteorites
vi. Development of radio, X-ray, infrared, ultraviolet, and gamma-ray astronomy
vii. Identification of pulsars, quasars, cosmic background radiation, and possible black holes
viii. Advances in instrumentation and methodology: e.g., use of Earth-orbiting observatories; development of electronic radiation detectors; refinement of very long baseline interferometry

2. History of physics
a. Greek physics: speculations concerning the nature of space, matter, and motion
b. Medieval physics: the influence of Aristotle
c. Physics in the 16th and 17th centuries: discoveries and theories in mechanics and optics
d. Physics in the 18th and 19th centuries
   i. Development of theories of light: the wave theory versus the corpuscular theory, the search for the ether
   ii. Development of the theories of electricity, magnetism, and electromagnetic waves
   iii. Developments in thermodynamics: theories of heat, the laws of thermodynamics, the impossibility of perpetual motion, the kinetic theory of gases
   iv. Development of the atomic theory of matter: the discovery of the electron, the discovery of radioactivity and X-rays, the discovery of spectral regularities
e. Physics in the 20th century
   i. Development of the theory of relativity
   ii. Development of the quantum theory, wave mechanics, statistical mechanics, and related theories
   iii. Development of theories and laws concerning atomic structure, nuclear interactions, and elementary particles, including efforts to produce a unified field theory
   iv. Development of condensed-matter physics and its contributions to electronics
   v. Modern developments in physics: atomic beams, nuclear magnetic resonance, and electron spin resonance methods; development of nonlinear optics; the development of masers and lasers

3. History of chemistry
a. Chemistry before 1700
   i. The rise of alchemy: the goal of the alchemists—to prolong life and to transmute base metals to gold
   ii. The influence of the new mechanical philosophy on chemistry: the work of Boyle
b. Chemistry in the 18th century
   i. Studies of combustion and respiration: the phlogiston theory, the work of Lavoisier and Cavendish
   ii. Laboratory discoveries: isolation and identification of gases; discoveries of new elements, compounds, and chemical reactions
c. Chemistry in the 19th century
   i. Development of the periodic table of the elements: the work of Mendeleyev and Meyer
   ii. Discoveries of new elements, isotopes, and radioactive elements
   iii. Development of more accurate methods of analysis
   iv. Development of theories of molecular structure and chemical reaction
   v. Development of organic chemistry: introduction of the concept of valence, the study of aromatic compounds, development of the structural theory
   vi. Development of electrochemistry: the theory of chemical affinity in electrical terms
   vii. Development of industrial chemistry: the application of chemical principles and reactions to industrial processes
d. Chemistry in the 20th century
   i. Development of instrumental methods of chemical analysis
   ii. Explanation of chemical phenomena by principles of atomic and molecular structures
   iii. Application of quantum mechanics to chemical bonding

B. The nature and scope of astronomy and astrophysics: the major subject matters and principal problems
   [see also Part One, Division III]
   1. The nature of astronomy and methods of study
   2. Component disciplines of astronomy and their relationship to other sciences: planetary and lunar sciences; meteoritics; the study of comets, minor planets, and the origin of the solar system
   3. Investigation of the scale of the universe and of the distribution of objects within it: the determination of positions, the measurement of distances
   4. Orbit theory: its role in astronomy
   5. Astrophysics: the study of stars, galaxies, and the universe; cosmology and cosmogony

C. The nature and scope of physics: its major subject matters, methods, and problems
   [see also Part One, Divisions I and II]
   1. The nature of physics: its concern with matter and energy and their interactions
   2. Component disciplines of physics: mechanics, thermodynamics, heat, electricity, magnetism, sound, optics, quantum mechanics, states of matter, nuclear and atomic physics
   3. The experimental and theoretical methods of physics
   4. The relationship of physics to other disciplines
   5. Interdisciplinary fields of physics: astrophysics, biophysics, geophysics
   6. Philosophical problems in physics: at the formal level, quantum level, macrophysical level, and cosmological level

D. The nature and scope of chemistry: its major subject matters and problems
   [see also 121, 122, and 123]
   1. The nature of chemistry: its concern with the composition, properties, and changes of matter
   2. The subdivisions of chemistry: analytical, inorganic, organic, physical, polymer, and industrial chemistry and biochemistry
   3. The methods of chemistry
   4. The study of chemical transformations
   5. Interdisciplinary fields of chemistry: geochemistry, chemical engineering, medicinal chemistry

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles and biographies dealing with the physical sciences

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MICROPAEDIA: Selected entries of reference information

General subjects

major fields and component disciplines:

- cosmology
- fluid mechanics
- infrared astronomy
- mechanics
- mechanics
- optics
- physics
- quantum mechanics
- mechanics

radio and radar

methodology and instrumentation:

- astronomy
- statistical
- thermodynamics
- ultraviolet
- astronovity
- bubble chamber
- centrifuge
- chromatography
- cloud chamber
Biographies

**astronomers:**
- Ambartsumian, Viktor
- Banneker, Benjamin
- Bessel, Friedrich Wilhelm
- Bradley, James
- Brahe, Tycho
- Cassini, Gian Domenico
- Edington, Sir Arthur Stanley
- Eudoxus of Cnidus
- Gamow, George
- Halley, Edmund
- Herschel, Sir John
- Herschel, Sir William
- Hipparchus
- Hubble, Edwin Powell
- Kuiper, Gerard Peter
- Laplace, Pierre-Simon, marquis de
- Le Verrier, Urbain-Jean-Joseph
- Lovell, Sir Bernard
- Messier, Charles
- Newcomb, Simon
- Ptolemy
- Russell, Henry Norris
- Schwarzchild, Karl
- Struve, Otto

**physicists:**
- Alvarez, Luis Walter
- Arago, François
- Bardeen, John
- Becquerel, Henri
- Bethe, Hans
- Bragg, Sir Lawrence
- Bridgman, P.W.
- Broglie, Louis-Victor, 7e duc de
- Cavendish, Henry
- Dirac, P.A.M.
- Fermi, Enrico
- Feynman, Richard P(hillips)
- Gell-Mann, Murray
- Gibbs, J. Willard
- Henry, Joseph
- Hertz, Heinrich
- Hooke, Robert
- Huygens, Christiaan
- Kapitsa, Pyotr

**chemists:**
- Arrhenius, Svante
- Berthelot, Marcellin
- Berthollet, Claude-Louis
- Berzelius, Jöns Jacob
- Boyle, Robert
- Bunsen, Robert Wilhelm
- Cannizzaro, Stanislao
- Cori, Carl
- Curie, Marie
- Curie, Pierre
- Dalton, John
- Davy, Sir Humphry
- Debye, Peter Gay-Lussac
- Haber, Fritz
- Hahn, Otto
- Hodgkin, Dorothy Mary
- Joliot-Curie, Frédéric and Irène
- Kendrew, Sir John Cowdery
- Langmuir, Irving
- Lavoisier, Antoine-Laurent
- Liebig, Justus
- Liebig, Willard F.
- Freierr von Mendeleyev
- Dmitri Ivanovich Mulliken, Robert Sanderson
- Pasteur, Louis

**radio:**
- interferometer
- radio telescope
- satellite
- observatory
- sounding rocket

**spacecraft:**

**spectrochemical:**

**analysis:**

**star catalog:**

**telescope:**

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Section 10/33. The Earth Sciences

A. The history of the Earth sciences

1. The origins of the Earth sciences in prehistoric times
2. The Earth sciences from antiquity to the 16th century
   a. Geologic sciences
      i. Speculations about earthquakes and volcanic eruptions
      ii. Speculations about fossils
      iii. Study of landforms and land–sea relations
   b. Hydrologic and atmospheric sciences
      i. Theories of groundwater circulation and precipitation
      ii. The origin of the Nile and the cause of its floods
      iii. Study of the tides
3. The Earth sciences in the 16th, 17th, and 18th centuries
   a. Geologic sciences
      i. The beginnings of mineralogy: the study of ore deposits
      ii. The development of paleontology and stratigraphy
      iii. The controversy between the Neptunists and Plutonists: Earth history according to Werner and Hutton
   b. Hydrologic sciences
      i. Theories of spring discharge
      ii. The earliest quantitative investigations of the global water balances
   c. Atmospheric sciences
      i. The study of water vapour in the atmosphere
      ii. The study of atmospheric pressure, temperature, and circulation
4. The Earth sciences in the 19th century
   a. Geologic sciences
      i. The development of crystallography and the classification of minerals and rocks
      ii. The concept of faunal succession and organic evolution: the contributions of William Smith, Charles Darwin, and others
      iii. The concept of uniformitarianism: contributions of Charles Lyell and others
      iv. Evidence for an Ice Age: the work of Louis Agassiz
      v. The concept of geologic time and estimates of the age of the Earth
      vi. Concepts of landform evolution
      vii. The study of gravity, isostasy, and the Earth's figure
   b. Hydrologic sciences
      i. The study of groundwater flow and surface water discharge: Darcy's law
      ii. The beginnings of oceanography as a discipline
   c. Atmospheric sciences
      i. The study of the composition of the atmosphere
      ii. The study of clouds, fog, dew, and storms
      iii. The study of weather and climate: the origin of synoptic meteorology
5. The Earth sciences in the 20th century
   a. Geologic sciences
      i. Development of radiometric dating
      ii. The experimental study of rocks: experimental petrology
iii. Advances in geophysics: the development of seismology and the study of the internal structure of the Earth
iv. Astrogeologic research: the application of the Earth sciences to the investigation of the planets and their satellites
v. Advances in paleontology: the development of paleoecology and micropaleontology; the study of Precambrian life
vi. The theory of plate tectonics: a unification of the ideas of continental drift and seafloor spreading

b. Hydrologic sciences
i. The study of water resources and seawater chemistry
ii. The exploitation of oceanic resources: desalinization, tidal power, and minerals from the sea
iii. The charting of the ocean floors: progress in bathymetry
iv. The study of ocean circulation, currents, and waves
v. The study of glacier motion and high-latitude ice sheets

c. Atmospheric sciences
i. The application of modern technology to meteorology: ground-based remote-sensing instruments, orbiting satellites, computer models simulating atmospheric features
ii. Advances in weather forecasting and cloud physics
iii. The study of the properties and structure of the atmosphere
iv. The development of weather modification methods
v. The classification of climate

B. The nature, scope, and methods of the individual Earth sciences
[see also Part Two]

1. Physical geography: the study of the distribution and spatial patterns of soils, water, climate, landforms, and other Earth features
[see also 10/36.F.]

2. The geologic sciences: mineralogy, petrology, economic geology, and geochemistry; geodesy, geophysics, structural geology, and volcanology; geomorphology; glacial geology; engineering, environmental, and urban geology; geochronology, historical geology, paleontology, stratigraphy, and astrogeology
[see also Part Two, Divisions I, III, and IV]

3. The hydrologic sciences: hydrology, limnology, glaciology, oceanography
[see also 222]

4. The atmospheric sciences: meteorology, climatology, aeronomy; the study of the atmospheres of other planets
[see also 221 and 223]

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with the Earth sciences
Earth Sciences, The
Geography

MICROPAEDIA: Selected entries of reference information

General subjects

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Section 10/34. The Biological Sciences

A. History of the biological sciences

1. Origin and early development of biological ideas
   a. Views of life and living things in ancient Eastern and Middle Eastern civilizations
   b. Biology in the Greco-Roman world: theories about mankind and the origin of life; Aristotelian concepts of classification, reproduction, heredity, and descent; botanical investigations; initial anatomical discoveries
   c. Biology in the Middle Ages: the influence of Arabian biologists, the development of botany and zoology as separate disciplines, further discoveries in anatomy
   d. Biology in the Renaissance: the influence of the craft of printing and artists’ illustrations on the dissemination of botanical knowledge, the beginning of the scientific study of anatomy through the use of dissection

2. Developments in the biological sciences in the 17th, 18th, and 19th centuries
   a. Biology in the 17th and 18th centuries
      i. The discovery of the circulation of blood
      ii. The establishment of scientific societies
      iii. The development of the microscope: the classical microscopists
      iv. The rise of modern taxonomy: the systematic classification of plants and animals
      v. The emergence of comparative biological studies
      vi. Experimental approaches to the origin of life: the theory of spontaneous generation
   b. Biology in the 19th century
      i. The effect of geographical explorations on the development of the biological sciences
      ii. The development of cell theory: the establishment of cellular biology
      iii. The theory of evolution: the impact of the concept of natural selection
      iv. The rise of embryology: discoveries concerning reproduction and development of organisms
      v. The emergence of genetics: the study of heredity and its mechanisms

3. Biology in the 20th century
   a. The establishment of molecular biology
      i. The one-gene, one-enzyme theory and its effects
      ii. The discovery of the genetic significance of DNA and RNA: deciphering the genetic code
b. The emergence of intradisciplinary specialties; e.g., cell physiology, cytochemistry, ecology, population biology

c. The application to biology of the concepts and techniques of other sciences: the development of biochemistry and biophysics, the importance of biological discoveries to medicine and agriculture

B. The nature, scope, and methodology of the biological sciences
[see also Part Three]
1. Molecular biology: biochemistry, biophysics, genetics
2. Cell biology: cancer research, microbiology, radiation biology, tissue culture, transplantation biology
3. Organismic biology: botany, ecology, embryology, ethology, eugenics, genetics, gnotobiology, morphology, paleontology, physiology, zoology
4. Population biology: biogeography, comparative psychology, ecology, population genetics
5. Taxonomy and methods of classification

C. Philosophy of biology
1. The range of topics in biophilosophy; e.g., old questions investigated anew in the light of biological advances and new standards of philosophical rigour
2. Issues concerning the nature of biological systems
3. Issues concerning evolution
4. Issues with ethical implications

Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles and biographies dealing with the biological sciences

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Section 10/35. Medicine and Affiliated Disciplines

A. History of medicine and surgery

1. Early medicine: Western medicine before 1800, Oriental medicine before c. 1900
   a. The medicine of prehistoric peoples
   b. The practice of medicine among the Babylonians, the ancient Egyptians, and the Hebrews
   c. Medicine and surgery in the Orient: the beginning of systematized medicine
      i. Medicine in India: the Vedic and Brahmanistic heritage, the influence of religious and magical beliefs, surgical practices
      ii. Medicine in China: the influence of the cosmic theory of Yin and Yang; the use of herbals, drugs, and acupuncture
      iii. Medicine in Japan: assimilation of Chinese and European practices
   d. The beginning of systematic medicine in the Greco-Roman world
      i. Early influences: mythological beliefs, the investigations and theories of early philosophers
      ii. The work of Hippocrates: theories on the nature and treatment of disease, the charter of medical conduct
      iii. The spread of Greek teachings to Rome: the acceptance of Galen as a medical authority
   e. Medicine from the fall of Rome through the Middle Ages
      i. Reservoirs of medical learning: the role of medieval monasteries in preserving the medical heritage of Greece and Rome, contributions of Arabian medicine
      ii. Establishment of the first organized medical school at Salerno
   f. Medicine in the Renaissance
      i. Improvements in anatomical theory and surgery
      ii. The control of medical practice in Britain
      iii. The work of Paracelsus and Fracastoro
   g. Medicine in the 17th century
      i. Discoveries concerning the circulation of the blood: use of the experimental method, importance of the microscope to medical studies
      ii. The iatrochemical and iatrophysical theories: the view of life as a series of chemical processes versus the view of life as a mechanism governed by physical laws
   h. Medicine in the 18th century
i. Genesis of the medical school and the hospital

ii. The beginning of medical specialties: emergence of surgery, obstetrics, and pathology as separate disciplines

iii. Improvement in techniques of vaccination and in the treatment of disease: the rise and decline of systems of animism and mesmerism

2. The rise of scientific medicine in the 19th century

a. New doctrines, laws, and concepts; e.g., the cell and cellular pathology, natural selection, homeostasis, pathogenesis, the Mendelian laws

b. Further advances in physiology

c. Establishment of bacteriology: verification of the germ theory, the identification of disease-producing organisms, the introduction of antisepsis

d. The discovery and use of anesthesia

e. Other advances: the discovery of the transmission of disease by insects, initial measures to control typhoid, the discovery of X-rays, the development of the ophthalmoscope and the stethoscope

3. Medicine in the 20th century

a. Advances in chemotherapy: the discovery, development, and use of antibiotics and synthetic drugs in the treatment of bacterial diseases

b. Advances in immunology

i. Improvements in vaccines that control bacterial diseases; e.g., typhoid, diphtheria, tetanus, tuberculosis

ii. The introduction and use of vaccines to control viral diseases; e.g., yellow fever, influenza, poliomyelitis, measles

c. Developments in endocrinology: the discovery of insulin and the control of diabetes, the use of cortisone as an anti-inflammatory agent, the study and use of sex hormones

d. Advances in other fields

i. Nutrition: the treatment of deficiency diseases through the discovery and identification of vitamins

ii. Cancer research: the treatment of abnormal cell growths through the application of various therapies

iii. Tropical medicine: the treatment of yellow fever, malaria, and leprosy through the discovery and application of synthetic organic compounds derived from quinine and other sources; the application of insecticides to control malaria and yellow fever

iv. Medical technology and biomedical instrumentation: the use of electronic devices to monitor physiological processes, to conduct automatic laboratory analyses, and to perform other diagnostic and therapeutic procedures

4. Surgery in the 20th century

a. The state of surgery prior to 1900: the importance of antisepsis, asepsis, and anesthesia to the development of modern surgery

b. The emergence of surgical specialties: the development of new surgical and diagnostic techniques

c. Improvements in the treatment of wounds; e.g., the development of plastic surgery, postsurgical rehabilitation

d. The use of blood transfusions and other intravenous techniques to reduce shock, treat fluid loss, and restore electrolyte balance

e. The introduction of inhalation anesthetic procedures; e.g., improvements in thoracic surgery

B. Fields of specialized medical practice or research

1. Hospital residency specialties

a. Radiology

b. Surgery [see also 423.C.2.a.]

c. Obstetrics and gynecology [see also 423.F.6.]
d. Urology
   [see also 423.F.3.]

e. Ophthalmology and otolaryngology
   [see also 423.F.9.f. and g.]

f. Neurology
   [see also 423.F.9.]

g. Psychiatry

h. Other hospital specialties; e.g., anesthesiology, pathology

2. Other clinical specialties

a. Aerospace medicine

b. Medical jurisprudence

c. Occupational medicine

d. Public health

e. Endocrinology

f. Immunology

g. Toxicology

h. Tropical medicine

3. Nonclinical specialties and the basic medical sciences: medical physiology and pathological
   physiology, nutrition, pharmacology and experimental therapeutics, gerontology

4. Ancillary medical disciplines: cytotechnology, medical records, medical technology, X-ray
   technology

C. Disciplines affiliated with medicine

1. History and practice of dentistry

2. History and practice of osteopathy

3. History and practice of nursing

4. History and practice of pharmacy

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Suggested reading in the *Encyclopaedia Britannica*:

**Macropaedia**: Major article dealing with medicine and affiliated disciplines

**Medicine**

**Microopaedia**: Selected entries of reference information

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**Biographies**

- Alexander, Franz
- Avicenna
- Barnard, Alfred
- Barnard, Claude
- Bekhterev, Vladimir
- Blackwell, Elizabeth
- Blalock, Alfred
- Carrel, Alexis
- Cohn, Ferdinand
- De Bakey, Michael
- Ellis
- Ehrlich, Paul
- Fleming, Sir
- Alexander
- Fracastoro, Girolamo
- Freud, Sigmund
- Galvani, Luigi
- Gesell, Arnold
- Harvey, William
- Hippocrates
- Jenner, Edward
- Jung, Carl
- Koch, Robert
Section 10/36. The Social Sciences and Psychology and Linguistics

A. History of the social sciences
1. Origins of the social sciences
   a. Precursors of the social sciences in the Middle Ages and the Renaissance
   b. Heritage of the Enlightenment: social reforms and revolution
2. 19th-century developments in the social sciences
   a. The influence of new concepts in social, political, economic, and scientific theories
   b. Development of the separate disciplines; e.g., economics, political science, anthropology, sociology, social statistics, human geography
3. 20th-century developments in the social sciences
   a. The influence of social upheaval in the non-Western world: the revolution of rising expectations
   b. The influence of Marxism
   c. The influence of Freudian ideas
   d. The changing character of the disciplines
      i. Specialization and cross-disciplinary approaches
      ii. The increasing professionalism of social scientists as consultants and decision makers in government and business
      iii. The introduction of mathematical and other quantitative methods: the use of computers
      iv. The influence of empiricism: the collection of data, the use of surveys and polls, the testing of theories
   e. Major theoretical influences: developmentalism, the social-systems approach, structuralism and functionalism

B. The nature of anthropology
[see also Part Five, Division I]
1. The background of anthropology
2. The scope and methods of anthropology: the division between cultural and physical anthropology

C. The nature of sociology
[see also Part Five, Division II]
1. The background of contemporary sociology
2. The methodology of contemporary sociology
3. The status of contemporary sociology
4. Emergent trends in sociology
5. Cognate disciplines: criminology, penology, social psychology, demography

D. The nature of economics
[see also Part Five, Division III]
1. Development of theories of economics
2. The scope and methods of the study of economics: microeconomics, macroeconomics
3. Cognate disciplines: mathematical economics, econometrics, accounting
E. The nature of political science
   [see also Part Five, Division IV]
   1. The history of political science
   2. The scope and methods of contemporary political science
   3. Cognate disciplines: the study of public opinion, public law, public administration, political
      systems, and international relations

F. The nature of geography
   [see also 10/33]
   1. The history of geography
   2. The scope and methods of geography: the division between physical, human, and regional
      geography

G. History and methods of psychology
   [see also Part Four, Division III]
   1. The history of psychology
   2. The nature and scope of psychology
   3. Special branches and cognate disciplines of psychology: physiological psychology, social
      psychology

H. The nature of linguistics
   [see also 514]
   1. The history of linguistics
   2. The nature and scope of linguistics
   3. Linguistics and other disciplines: psycholinguistics, sociolinguistics, linguistic anthropology,
      linguistic geography, computational linguistics, mathematical and statistical linguistics, 
      stylistics, and semantics

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles and biographies dealing with the social sciences and psychology and
linguistics

Freud
Geography
Linguistics

Marxism, Marx and
Smith, Adam
Social Sciences, The

MICROPAEDIA: Selected entries of reference information

General subjects

- anthropology and allied disciplines:
  - institutional economics
  - Keynesian economics
  - macrorconomics
  - managerial economics
  - welfare economics

- linguistics:
  - anthropological
  - comparative
  - computational linguistics
  - dialectology
  - ethnolinguistics
  - historical linguistics
  - neurolinguistics

- semiotics
- sociolinguistics
- structural linguistics
- synchronic linguistic
- political science:
  - geopolitics
  - political science

- psychology:
  - analytic
  - applied psychology
  - behaviourism
  - clinical psychology
  - comparative psychology
  - developmental psychology
  - educational psychology
  - experimental psychology
  - functionalism
  - Gestalt psychology
  - humanistic psychology
  - individual psychology
  - industrial psychology
  - physiological psychology
  - social psychology

other:
- criminality
- demography
- geography
- penology
- sociology
Biographies

**anthropologists:**
- Malthus, Thomas
- Robert
- Marshall, Alfred
- Marx, Karl
- Myrdal, Gunnar
- Oresme, Nicholas
- Pareto, Vilfredo
- Ricardo, David
- Samuelson, Paul
- Simonde, Sir
- Sismondi, J.C.L.
- Tawney, Richard
- Veblen, Thorstein

**linguists:**
- Chomsky, Noam
- Jakobson, Roman
- Jespersen, Otto
- Kimhi, David
- Lomonosov, Mikhail
- Vasilyevich
- Rask, Rasmus
- Saussure, Ferdinand
- Schleicher, August

**sociologists:**
- Beccaria, Cesare
- Comte, Auguste
- Cooley, Charles
- Horton
- Durkheim, Émile
- Frazier,
- E. Franklin
- Geiger, Theodor
- Juliaez
- Lazarsfeld, Paul
- Felix
- MacIver, Robert
- Morrison
- Mauss, Marcel
- Merton, Robert K.
- Mumford, Lewis
- Parsons, Talcott
- Ratzenhofer, Gustav
- Riesman, David
- Spencer, Herbert
- Tönnes, Ferdinand
- Weber, Max

**psychologists:**
- Bleuler, Eugen
- Bruner, Jerome S.
- Cattell, James
- McKeen
- Fechner, Gustav
- Theodor
- Fromm, Erich
- Hall, G. Stanley
- Hull, Clark L.
- James, William
- Köhler, Wolfgang
- Kraepelin, Emil
- Kretschmer, Ernst
- McDougall, William
- Menninger family
- Meyer, Adolf
- Piaget, Jean
- Rank, Otto
- Skinner, B.F.
- Thorndike, Edward L.
- Thurstone, L.L.
- Watson, John B.
- Wertheimer, Max

**linguists:**
- Chomsky, Noam
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**Section 10/37. The Technological Sciences**

A. History of the technological sciences

[see also Part Seven]

B. Nature and scope of engineering

1. Engineering as a profession: education and training; functions of the engineer; professional associations

2. Branches of engineering: civil engineering, aeronautical engineering, chemical engineering, electrical and electronics engineering, mechanical engineering, optical engineering, nuclear engineering

C. The nature and scope of agricultural sciences

1. History of the agricultural sciences

[see also 731.A.]

2. Subdivisions of the agricultural sciences: soil science, plant production, animal production, agricultural economics and management, agricultural engineering

[see also 731.B., C., and D.]

D. The nature and scope of recently developed interscience disciplines

1. Bionics
a. Mimicry of nature as the basis for bionics; e.g., the human brain as the paradigm for computer memory devices, construction of vehicles with articulated legs

b. The use of natural models to understand and solve engineering problems; e.g., natural neural networks as models for electronic circuits, the human brain as a model for computers and information-processing devices

2. Systems engineering and operations research
   [see 712.B.]

3. Cybernetics, control theory, and information science
   [see 10/23.E. and F.]

**Suggested reading in the *Encyclopaedia Britannica*:**

**MACROPAEDIA:** Major articles dealing with the technological sciences

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| Beach, Alfred Ely | Deming, W. Edwards |
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**Division IV. **

**History and the Humanities**

[For Part Ten headnote see page 479.]

The outlines in the two sections of Division IV deal with historiography and the study of history, and with the humanities and humanistic scholarship.

Section 10/41 first treats the history of historical writing in the major cultures of both East and West, and the disciplines and methods involved in modern historical investigation and research. It then treats the speculative philosophies of history that have appeared in the West and the East, and philosophical analyses of the specific character of historical knowledge.

Section 10/42 first sets forth a historical review of changing conceptions of the humanities and of humanistic scholarship, covering all the major periods and mutations, from the Greek ideal of *paideia* to contemporary developments. It then treats issues about the nature and scope of the humanities; about the relation of the component disciplines to one another; and about their distinction from the sciences, their validity as ways of knowing, and their role in education.

Section 10/41. Historiography and the Study of History 509

10/42. The Humanities and Humanistic Scholarship 511

**Section 10/41. Historiography and the Study of History**

A. Historiography: the types of historical writing

1. Development of historiography; the history of historical writing
   a. In the ancient world
   i. Near Eastern historiography
ii. Classical historiography: Greek and Roman
iii. Early Christian historiography

b. In the Middle Ages
   i. Western Christian historiography
   ii. Byzantine historiography

c. From the Renaissance to the present
   i. Renaissance historiography
   ii. Early modern historiography
   iii. Enlightenment historiography: the 18th century
   iv. 19th- and 20th-century historiography

d. Non-Western historiographical traditions
   i. Islamic historiography
   ii. East Asian historiography

2. Types of historical writing: diverse ways of distinguishing or classifying kinds of historical writing by method or function

3. Factors involved in the writing of history: the background of the author and his vantage point, method of work, and purpose

B. Modern historical investigation and research: sources and methods

1. Sources for historical writing: material remains, written materials, folklore, place-names

2. Auxiliary disciplines for ascertaining and interpreting the sources
   a. Anthropology
   b. Archaeology
   c. Bibliography
   d. Chronology
   e. Dendrochronology
   f. Diplomacy
   g. Epigraphy
   h. Genealogy
   i. Geography
   j. Heraldry
   k. Iconography and iconology
   l. Linguistics
   m. Palaeography
   n. Psychoanalysis
   o. Radiometric dating
   p. Sigillography
   q. Textual criticism

C. Philosophy of history: speculations about the historical process, philosophical analysis of the writing of histories

1. Conceptions of the philosophy of history

2. Speculative philosophy of history: diverse explanations of the pattern of historical events

3. Critical or analytical philosophy of history: the analysis of history as a discipline

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles dealing with historiography and the study of history

History, The Study of
Philosophies of the Branches of Knowledge
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   c. Plato and the Academy: the relation of theology to mythology, mathematics in the service of philosophy
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f. The growth of modern humanistic scholarship: the transition from the ideal of belles lettres to the scientific investigation of antiquity through archaeology and philology

g. The rise and development of the liberal arts college and the graduate school

h. The growth and proliferation of special disciplines: the knowledge explosion

i. The organization of the contemporary university: questions of its social responsibility, the profession of learning

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6. The humanities and humanistic scholarship in the East: in India, in China, in Japan

B. The humanities

1. Diverse views of the definition and scope of the humanities

2. The humanities as an educational program: the question of the humanities as a unified field of study

3. Theories of the humanities as a fundamental division of knowledge: the question of the distinction of the humanities from the sciences

4. Problems about the humanities

Suggested reading in the Encyclopædia Britannica:

MACROPAEDIA: Major articles and biographies dealing with the humanities and humanistic scholarship

Bacon, Francis
Erasmus

Humanism
Scholarship, Classical

MICROPAEDIA: Selected entries of reference information

General subjects

humanism
humanities

paideia
reason

Renaissance
Renaissance man

scholasticism
The outlines in the three sections of Division V treat the history of philosophy; the nature and the divisions of philosophy; and philosophical schools and doctrines.

The outline in Section 10/51 presents a synoptic history of philosophy. After treating the history of Western philosophy and of non-Western philosophies, the outline indicates other sections that treat philosophies associated with religions.

Section 10/52 first deals with theories about philosophy as a whole: theories about its nature, scope, methods, forms of exposition, and about the criteria of meaning and truth in philosophical thought. It then treats the traditional component disciplines of philosophy: metaphysics, the philosophy of nature, epistemology, the philosophy of mind, the philosophy of mankind, ethics, political philosophy, and aesthetics. In the case of each of these eight disciplines, the outline treats its historical development; its nature and scope; its relations to other branches of philosophy and other intellectual disciplines; and its principal problems. At the end, the outline of this section indicates other sections that treat disciplines involving philosophical studies of other subjects: language, logic, mathematics, art, science, religion, law, education, and history.

Section 10/53 begins by listing 25 major philosophical schools in the West. The section then deals with doctrinal differences between these schools on major philosophical issues, treating differences in theories about Being and existence; about thought, knowledge, and the faculties of the mind; and about human conduct.

Section 10/51. History of Philosophy 513
10/52. The Nature and the Divisions of Philosophy 517
10/53. Philosophical Schools and Doctrines 520

Section 10/51. History of Philosophy

A. History of Western philosophy

1. Ancient Greek and Roman philosophy

   a. The beginnings of philosophy in Greece: the Pre-Socratic philosophers
      i. Cosmology and the metaphysics of matter: theories of the origin and nature of the physical world, monistic and pluralistic cosmologies
      ii. The rise of problems in the theory of knowledge: problems about the real and phenomenal worlds
      iii. The metaphysics of number: Pythagorean speculations about number and the nature of reality, advances toward the foundation of quantitative science
      iv. Anthropology and relativism: the Sophists’ criticism of cosmological and metaphysical speculations, man as the measure of all things, the positions of the Sophists about the conventionality of law and justice

   b. The maturity of Greek philosophy
      i. The ethical concerns and positions of Socrates: the Socratic method of teaching, the influence of Socrates
      ii. The philosophy of Plato: his dialogues on issues in politics, ethics, metaphysics, epistemology, and cosmology; his emphasis on the relations of mathematics to philosophy
      iii. The philosophy of Aristotle: his criticisms of Platonic metaphysics and theory of knowledge; the corpus of his works on logic; his teleological positions in biology, ethics, and politics; his empirical researches in the natural sciences and on laws and political institutions

INDEX: See entries under all of the terms above
c. Hellenistic and Roman philosophy: developments from the time of Alexander III the Great to the closing of the philosophical schools in Athens
   i. The philosophy of the Stoics: the teaching of Zeno of Citium concerning the basis of human happiness, the further elaboration of Stoic thought by Cleanthes and Chrysippus, the role of Stoicism during the late Roman Republic and the empire
   ii. The philosophy of the Epicureans: the teaching of Epicurus concerning the universe, the role of pleasure, and man’s relationship to the gods
   iii. The philosophy of the Skeptics: the teaching of Pyrrhon of Elis concerning man’s lack of certainty in knowing, the role of the Skeptics in preserving the doctrines of ancient philosophers
   iv. The philosophy of the Neo-Pythagoreans and of the Neoplatonists: the teaching of Plotinus concerning the various levels of being, Neo-Pythagorean schools in Asia Minor
   v. Jewish and Christian philosophy during the Hellenistic Age: diverse attempts to relate the teachings of the Hellenistic and Roman schools to Jewish and Christian theology

2. Philosophy in the Middle Ages
   a. Early medieval philosophy
      i. The patristic period: Augustine’s use of Neoplatonist thought in his theology and his doctrine of man, the role of Boethius’ translations and commentaries, Anselm’s proofs of the existence of God, the methodology of Abelard
      ii. Philosophy and the liberal arts in the schools of the Christian West from the 9th to the 11th century
   b. The contribution of Arabic and Jewish philosophy: the role of the Islamic philosophers in increasing the influence of Aristotle in the West, the teaching of Solomon ibn Gabirol and Maimonides
   c. The age of the Schoolmen: the attempt to reconcile philosophy and theology, the teaching of Bonaventure and Albertus Magnus, Thomas Aquinas’ synthesis of Aristotelianism and Christian theology
   d. Philosophy in the late Middle Ages: new styles of philosophy and theology that vied with Thomism, the criticism of Aristotelian thought by Duns Scotus and Ockham, the speculative mysticism of Eckehart, Nicholas of Cusa’s doctrine of the “coincidence of opposites”

3. Modern philosophy
   a. Philosophy in the Renaissance
      i. Political theory: the views of Machiavelli, Bodin, Hobbes, Grotius, and others on the nature and moral status of political power
      ii. Humanism: the influence of the writings of Plato on moral theory and literary endeavour; renewed interest in Atomistic Materialism, ancient Skepticism, and Stoicism
      [for humanistic scholarship in the Renaissance, see also 10/42.A.3.]
      iii. Philosophy of nature: the pluralistic, machinelike, and mathematically ordered character ascribed to the natural world; the influence of discoveries in anatomy, physics, and astronomy on philosophy
   b. The early modern period: the rise of Empiricism and Rationalism
      i. Developments in the Empiricist tradition: Bacon’s attempt to formulate a new scientific method, Hobbes’s theory of knowledge
      ii. Developments in the Rationalist tradition: the antiempirical character of Descartes’s metaphysics and the dualism of his doctrine of man and the world, the speculative systems of philosophy provided by the writings of Spinoza and Leibniz
   c. Philosophy in the period of the Enlightenment, or the Age of Reason
      i. Epistemological issues: the attempt of Locke and Berkeley to inquire into the origin and nature of reason, Hume’s science of man, Kant’s critical examination of reason
      ii. Developments in the philosophy of science: Materialist views, the effect of scientific discoveries on philosophical thought
      iii. Social and political philosophy: the concern of Locke and Rousseau with the freedom and equality of citizens, developments in religious philosophy
   d. Philosophy in the 19th century
i. The resurgence of the metaphysical spirit: the Idealism of Fichte, Schelling, and Hegel

ii. Developments in the empirical and scientific tradition: Comte's Positivism and its subsequent influence on the philosophy of science, J.S. Mill's theory of knowledge and ethics, the dialectical Materialism of Marx and Engels

iii. The reaction against Rationalism: Kierkegaard's preoccupation with the states of consciousness, Schopenhauer's doctrine of cosmic will, the writings of Nietzsche

e. Philosophy in the 20th century

i. Independent speculative and social philosophies: Bergson's intuitionism, Whitehead's speculative philosophy, William James's and Dewey's Pragmatism

ii. Developments in Marxist thought: Lenin's metaphysical Materialism and his theory of knowledge, the continuing attempt to make theory serve practice

B. Non-Western philosophy

1. Indian philosophy

a. Early Indian philosophical thought: the role of Hindu and Buddhist sacred literature in presystematic philosophy, the concepts of Brahma and Atman in Hindu thought and of selflessness and Nirvana in early Buddhist writings

b. The beginning of system building in Indian philosophy: the role of the Sutra, metaphysical and epistemological concerns, ethical and political thought, the teaching of the Ajivikas and Carvakas

c. The further developments of systematic thought in India: Realism and Idealism in metaphysical and epistemological thought, the relation of pluralistic and monistic views to various linguistic philosophies

d. The schools of Vedanta: the contribution of Sankara and Ramanauja and their followers; the schools of Nimbarka, Vallabha, and Caitanya

e. The Vaishnava and Shaiva schools: philosophical systems based on the literature of Vaishnavism and Saivism

f. Later Indian philosophical thought: the influence of Islamic thought and European philosophy, recent trends

2. Chinese philosophy

a. The classical Chinese philosophical schools: e.g., Confucianism, Taoism, Yin-Yang, Mohism, Dialecticians, the Legalist school

b. Neo-Taoist and Buddhist thought

c. Neo-Confucianism: the development of the concept of principle

d. 20th-century Chinese philosophy: the effects of Western thought and of Maoism

3. Japanese philosophy

a. Early Japanese philosophical thought: the introduction of Buddhism and Confucianism, the Six Schools of Nara, Tendai and Shingon philosophy

b. Developments during the Kamakura and Muromachi periods: the origins and concerns of the Zen, Jodo (Pure Land), and Nichiren sects; tendencies in Shinto and Confucian thought

C. Philosophies associated with religion

1. Hindu philosophy

2. Buddhist philosophy

3. Confucian philosophy

4. Taoist philosophy

5. Jewish philosophy

6. Islamic philosophy

7. Christian philosophy
Suggested reading in the *Encyclopaedia Britannica*:

**MACROPAEDIA:** Major articles and biographies dealing with the history of philosophy

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**MICROPAEDIA:** Selected entries of reference information

**General subjects**

*Arabic philosophy:*
- Ahl al-Kitab
- Ba'ṭinīyah
- Dāhriyah
- fāyj
- ghaybah
- ikhtilāf
- kālām
- kasb
- Māturīdiyah
- Murji‘ah
- Mu’tazilah
- Qudariyah
- Rāfiḍah
- rahbaniyah
- rajm
- Salimiyah
- shirk
- tabhajud
- talbiyah
- taqīya
- tashbīh
- tawḥīd
- ziyyarah

*Chinese philosophy:*
- ch'ī
- Chinese philosophy
- hsien
- hsu
- jen
- Legalism
- Mohism
- p‘u
- T’ai Chi
- tao
- te
- T’ien Ming
- tzu-jan
- wu-wei
- yin-yang

*Greek philosophy:*
- apathy
- cosmopolitanism
- emanationism
- entelechy
- epoche
- first cause
- form
- hylomorphism
- logos
- microcosm
- Not-Being, denial of opposites, table of paradoxes of Zeno, sensationalism, virtue, teachability of.

*Indian philosophy:*
- Abhidharmakośa
- abhijñā
- Advaita
- ahankara
- ajiva
- Ājivika
- akrīyāvāda
- ālaya-vijñāna
- ānanda
- anumāna
- Artha-śāstra
- asana
- asrāva
- āstika
- ātman
- bhedabheda
- brahma
- brahmavijnāna
- cakra
- Čārvaka
draya
- Dvaita
- Haṭha Yoga
- Indian philosophy
- indriya
- jīva
- jnana
- kammaṭṭhāna
- karma
- Kashmir Śaivism
- kunḍalini
- Mādhyamika
- māyā
- Mīmamsa
- nirguna
- Nyāya
- paramitā
- prajñāpāti
- prakṛti
- prāmāṇa
- prāna
- prajñāyāma
- pratīti-samutpāda
- pratyakṣa
- pratyaya
- puruṣa
- Śāba
- Śāiva-siddhānta
- samadhi
- Śaṅkhyā
- samsāra
- sāṃvṛti-satya
- skandha
- śāntyupasthāna
- śāyāvāda
- tat tvam asī
- trisvabhāva
- upādhi
- Vaisheshika
- Vedānta
- Viśiṣṭādvaita
- yama
- Yoga
- Yogācāra

*Japanese philosophy:*
- Japanese philosophy
- Jojitsu
- Kegon
- Nichiren
- Buddhism
- Pure Land
- Buddhism
- Ritsu
- Shingon

*Zen philosophy:*
- a priori knowledge
- antinomy
- as if, philosophy of axiology
- categorical imperative
- cogito, ergo sum
- common sense, philosophy of concept
- constitution theory
- deconstruction
- deontological ethics
- deus otiosus
- dialectical materialism
- eudaemonism
- good-reason theory
- humanism
- ideal language
- identity theory
- innate idea
- interactionism
- irationalism
- I–Thou
- leap of faith
- mathematicism
- metaethics
- metalevel language
- methodic doubt
- mind–body dualism
- monad
- natural law
- normative ethics
Section 10/52. The Nature and the Divisions of Philosophy

A. The nature, scope, and methods of philosophy
[For the major philosophical schools in the West, see 10/53; for the development of non-Western philosophy, see 10/51.B.]

1. Diverse conceptions of philosophy
2. Diverse views of the methods of philosophy
3. The forms of philosophical exposition: e.g., dialogues, commentaries, histories, systematically ordered treatises
4. Criteria of meaning and truth in philosophical thought

B. The divisions of philosophy

1. Metaphysics, or speculative philosophy in general
   a. The history, nature, and scope of metaphysics
   [For schools of thought in metaphysics, see 10/53.B.1.]
   b. The relation of metaphysics to other parts of philosophy; e.g., ethics, logic, natural theology
   c. Problems in metaphysics
2. The philosophy of nature: the philosophical problems concerning the phenomena, laws, and theories of the natural sciences
   [See also 10/31.B.]
   a. The history, status, and scope of the philosophy of nature
   b. The relation of the philosophy of nature to science, the philosophy of science, and metaphysics
   c. The basic aspects of the natural order
   d. The philosophy of physics
   e. The philosophy of biology
3. Epistemology, or theory of knowledge
   a. The history, nature, and scope of epistemology
   [For schools of thought in epistemology, see 10/53.C.]
   b. The relation of epistemology to metaphysics, philosophy of mind, logic, and other disciplines
   c. Problems in epistemology
4. The philosophy of mind, or philosophical psychology
   a. The history, nature, and scope of the philosophy of mind
   b. The relation of the philosophy of mind to the empirical and mathematical sciences and to other philosophical disciplines
c. Problems in the philosophy of mind

5. The philosophy of man, or philosophical anthropology
   a. The history, nature, and scope of philosophical anthropology
      [for schools of thought in philosophical anthropology, see 10/53.B.3.]
   b. The relation of philosophical anthropology to physical and cultural anthropology and to
      other disciplines in philosophy and the social sciences
   c. Problems in philosophical anthropology

6. Ethics, or moral philosophy
   a. The history, nature, and types of ethics: the distinction between metaethics and normative
      ethics
   b. The relation of ethics to other philosophical disciplines or to other branches of knowledge or
      experience
   c. Problems in ethics

7. Political philosophy
   a. The nature and scope of political philosophy: its relation to political science
   b. The form of political statements and arguments
   c. The history of political philosophy

8. Aesthetics
   a. The nature and scope of aesthetics as a discipline
   b. The development of aesthetics: approaches to the study of the aesthetic experience
   c. Problems in aesthetics
   d. The relation of aesthetics to other disciplines

9. The philosophy of language
10. The philosophy of logic
    [see 10/11.B.]
11. The philosophy of mathematics
    [see 10/21.B.]
12. The philosophy of art
    [see 611.A.]
13. The philosophy of science
    [see 10/31.B.]
14. The philosophy of religion
    [see 811.A.]
15. The philosophy of law
    [see 551.A.]
16. The philosophy of education
    [see 561.A.]
17. The philosophy of history
    [see 10/41.C.]

Suggested reading in the *Encyclopædia Britannica*:

**MACROPAEDIA**: Major articles and biographies dealing with the nature and the divisions of
philosophy

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<th>Philosophical Anthropology</th>
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<td>Rousseau, Jean-Jacques</td>
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General subjects

aesthetics: eudaemonism
aesthetics: free will
epistemology: good-reasons
belief: philosophy of mind
belief: belief
a priori knowledge: identity theory
belief: identity theory
belief: mind
psychology: teleological ethics
reason: virtue

ethics: creative evolution
altruism: other minds
axiology: psychophysical parallelism
choice: Being
comparative ethics: teleological ethics
conscience: metaphysics
egoism: microcosm
ethical relativism: naturalism
effects: naturalism

Biographies

aesthetics: Campanella, Camille
Baumgarten, Alexander
Gottlieb
Bosanquet, Bernard
Croce, Benedetto
Santayana, George

epistemology: Geulincx, Arnold
Dühring, Eugen
Locke, John
Mill, John Stuart

ethics: Abelard, Peter
Cudworth, Ralph
Columbia, Richard
Hutcheson, Francis
Moore, G.E.
Scheler, Max
Whewell, William

metaphysics: Aurobindo, Sri
Berdaye, Nikolay
Aleksandrovich
Berkeley, George
Bradley, F.H.

See also Sections 10/51 and 10/53

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A. Major philosophical schools in the West
   1. Philosophical schools in antiquity and in the Middle Ages
      a. Pythagoreanism
      b. The Sophists
      c. Elaticism
      d. Atomism
      e. Platonism
      f. Aristotelianism
      g. Stoicism
      h. Epicureanism
      i. Skepticism
      j. Scholasticism
   2. Philosophical schools in the modern period
      a. Cartesianism
      b. Empiricism
         [for Empiricist tendencies in earlier philosophy, see A.1.b. and i., above; for contemporary Logical Empiricism, see 4.2.i., below]
      c. Rationalism
         [for Rationalist tendencies in ancient and medieval philosophy, see A.1.a., c., e., and j., above]
      d. Materialism
         [for dialectical Materialism, see A.2.j., below]
      e. Kantianism
      f. Idealism
      g. Hegelianism
      h. Utilitarianism
      i. Positivism and Logical Empiricism
         [for metalogical studies, see 10/12.B.; for studies in the foundations of mathematics, see 10/21.B.]
      j. Marxism
      k. Realism
      l. Pragmatism
      m. Phenomenology
      n. Existentialism
      o. Analytic and Linguistic philosophy

B. Theories of Being and existence
   1. Different types of metaphysical theory: Platonism; Aristotelianism; Thomism; Cartesianism; Idealism; Materialism—dialectical Materialism, Atomism, and Naturalism; Pythagoreanism; Organismic dynamism
   2. Different views concerning the existence, attributes, and knowledge of God: agnosticism, atheism, Deism, fideism, humanism, pantheism, theism
   3. Different conceptions of man as knower, doer, and maker: Existentialism, humanism, Phenomenology, Pragmatism, rationalism, irrationalism
   4. Different views concerning the existence of the mind and its relation to the body: Materialism, dualism, immaterialism

C. Theories of thought, knowledge, and faculties of mind
   1. Different conceptions of the object of knowledge: sense-datum theory, Phenomenalism, Idealism, Realism
2. Different conceptions of the validity of knowledge: Kantianism, positivism, pragmatism, Skepticism

3. Different views of the sources or foundations of knowledge: rationalism, Empiricism

4. Different views of the status of the universal: realism, conceptualism, nominalism

5. Different views of the epistemic status of scientific theories; e.g., realism, conventionalism, and operationalism; the Unity of Science movement; reductionism

D. Theories of conduct

1. Meteahtical theories: intuitionism, naturalism, noncognitivism, good reasons theories

2. Deontological theories: rationalism, intuitionism, Existentialism

3. Teleological theories: eudaemonism, Utilitarianism

Suggested reading in the Encyclopaedia Britannica:

MACROPAEDIA: Major articles dealing with Western philosophical schools and doctrines

Aristotelianism, Marx and, Religious and
Aristotle and Marx and, Spiritual Belief,
Cartesianism, Philosophical
Descartes and Schools and
Hegelianism, Doctrines,
Hegel and Western
Kantianism, Platonism,
Kant and Plato and

MICROPAEDIA: Selected entries of reference information

General subjects

Absolute Idealism eclecticism Neo-Hegelianism Skepticism
Academy Elacticism nominalism solipsism
Alexandrist Empiricism personalism Sophist
Analytic Epicureanism phenomenology Stoicism
atomism Ethical Culture positivism
Cambridge Idealism pragmatism
Platonists Latin Averroism Pythagoreanism
Cynic Logical Positivism Utilitarianism
Cyrenaic Materialism realism
Deism Megarian school scholasticism
determinism Naturalism sensationalism

Biographies

Albertus Magnus, Hume, David
Saint Husserl, Edmund
Apuleius, Lucius James, William
Athenagoras Jaspers, Karl
Berdogayev, Kierkegaard, Soren
Nikolay Lewes, George
Alessandroviich Henry
Bernard de Maine de Biran, Pico della
Chartres Malebranche, di Concordia
Boethius, Anicias Marie-Francois-Pierre
Manlius Maleval, William
Severinus Nicolas
Bosanquet, Marcel, Gabriel
Bernard Maritain, Jacques
Bradley, F.H. More, Henry
Buridan, Jean Ockham,

See also Sections 10/51 and 10/52

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Division VI.  Preservation of Knowledge

For Part Ten headnote see page 479.

Division VI, which contains only one section, deals with the various means, techniques, and institutions used to preserve knowledge and, by extension, the objects of knowledge. Because the preservation of knowledge is so closely bound up with technology, which has provided ever more efficient methods, there is much overlap between this section and various sections in Part Seven, and accordingly there are in the outline presented here many cross-references to that part.

Section 10/61.  Institutions and Techniques for the Collection, Storage, Dissemination, and Preservation of Knowledge

A. Protection and storage of objects and artifacts

1. Museums and galleries
   a. The management and maintenance of institutional collections
   b. Types of museum categorized by subject area
      i. General museums
      ii. Museums of natural history and natural science
          [see also 355.C.6.a.]
      iii. Museums of science and technology
      iv. Museums of history
      v. Museums of art and art galleries
          [see also 612.G.1.]
      vi. Museums concerned with particular vocations: e.g., farming, forestry, wine making
      vii. Other museums
   c. Other systems of museum classification
      i. By geographical coverage
      ii. By character of collection
      iii. By character of provider
      iv. By particular clientele

2. Libraries
   [see B.4., below]

3. Historic places and landmarks

4. Public and private collections of animals and plants
   [see also 355.C.6.]
   a. Zoological gardens and aviaries
   b. Aquariums
   c. Botanical gardens and arboretums

5. Parks and nature preserves
   [see also 355.D.]

B. Storage and retrieval of information

1. Dictionaries and lexicons
   [see also 735.H.2.c.i.]

2. Encyclopaedias
   [see also 735.H.2.c.ii.]

3. Atlases and map collections
   [see also 735.H.2.c.iii.]

4. Libraries
   a. Types of libraries
   b. The science of library systems
5. Archives

6. Bibliographic and numeric databases
   [see 735.H.1.b.]

7. Magnetic and optical recordings
   [see 735.F. and H.1.a.]

C. Institutions for the advancement and dissemination of knowledge

1. Educational institutions
   [see Part Five, Division VI]

2. Academies of learning, or societies established for the advancement of knowledge

3. Publishing: selection, preparation, and marketing of printed material
   a. Print publishing
      [see also 735.1.1.]
      i. Books
      ii. Newspapers
      iii. Periodicals
   b. Electronic publishing

4. Broadcasting
   a. Radio
      [see also 735.1.5]
   b. Television
      [see also 735.1.6]

5. Observatories and planetariums

Suggested reading in the Encyclopedia Britannica:

MACROPAEDIA: Major articles dealing with institutions and techniques for the collection, storage, dissemination, and preservation of knowledge

   Broadcasting
   Encyclopaedias and Dictionaries
   Libraries
   Museums
   Publishing

MICROPAEDIA: Selected entries of reference information

General subjects

academy  broadcasting  national forest  newspaper
aquarium  dictionary  national  syndicate
archives  encyclopaedia  monument  oceanarium
astronomical  gazette  national park  pamphlet
observatory  library  national seashore  pinacotheca
atlas  little magazine  nature preserve  planetarium
aviary  magazine  news agency  publishing
aviculure  museum  newscast  wall newspaper
book  musical societies  newsletter  newspaper
botanical garden  and institutions  zoo

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Board of Editors (1974–98)


PHILIP W. GOETZ. Executive Vice-Chairman, Board of Editors. Editor in Chief, Encyclopedia Britannica, 1979–91.

FRANK B. GIBNEY. Vice-Chairman, Board of Editors. Vice-Chairman, TBS-Britannica Company Ltd., Tokyo.

JACQUES BARZUN. University Professor Emeritus, Columbia University; Dean of Faculties and Provost, 1958–67.

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WARRen E. PREECE. The Editor, Encyclopedia Britannica, 1964–75.


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WARREN A. BEBBINGTON. Ormond Professor and Dean, Faculty of Music, University of Melbourne.

JOHN L. BERGGREN. Professor of Mathematics, Simon Fraser University, Burnaby, British Columbia.


GEOFFREY BLAINEY. Chancellor, University of Ballarat, Australia. Emeritus Professor of History, University of Melbourne.

ROBERT EUGENE BOGNER. Professor of Electrical Engineering, University of Adelaide, Australia.

MAURO CAPPELLETTI. Sheldon Professor of International Legal Studies, Stanford University, California. Professor of Law, University of Florence.

HANS DAAALDER. Chairman of the European Universities Advisory Committee. Emeritus Professor of Political Science, University of Leiden, The Netherlands.

FRANÇOIS DUCHESNEAU. Professor of Philosophy, University of Montreal.

MANFRED EIGEN. Director, Max Planck Institute for Biophysical Chemistry, Göttingen, Germany. Cowinner, Nobel Prize for Chemistry, 1967.

DAVID R. FRASER. Professor of Animal Science and Dean, Faculty of Veterinary Science, University of Sydney.

WILLIAM E. FREDEMANN. Cochairman of the Canadian Universities Advisory Committee. Emeritus Professor of English, University of British Columbia, Vancouver.

Law, University of Florence.

LEGAL Studies, Stanford University, California. Professor of


Managing Editor, Encyclopaedia Universalis, Paris.

Chancellor, University of Ballarat, Australia. Emeritus Professor of History, University of Melbourne.

Professor of Electrical Engineering, University of Adelaide, Australia.

Professor of International Legal Studies, Stanford University, California. Professor of Law, University of Florence.

Emeritus Professor of Political Science, University of Leiden, The Netherlands.

Emeritus Professor of Philosophy, University of Montreal.


Emeritus Professor of Animal Science and Dean, Faculty of Veterinary Science, University of Sydney.

Emeritus Professor of Constitutional and International Law, Simon Fraser University, Burnaby, British Columbia.

Emeritus Professor of Sociology, London School of Economics and Political Science, University of London.

Emeritus Professor of Sociology, London School of Economics and Political Science, University of London.

Emeritus Professor of Sociology, London School of Economics and Political Science, University of London.
Outline of Knowledge

Staff

MORTIMER J. ADLER (d. 2001). Editor.

CHARLES VAN DOREN. Associate Editor. Vice President, Editorial, Encyclopedia Britannica, Inc., 1973–82.

WILLIAM J. GORMAN (d. 1982). Associate Editor. Senior Fellow, Institute for Philosophical Research.

- Indicates persons who served as contributors to or consultants on the Outline of Knowledge.

Part One. Matter and Energy

EDWARD ANDERS. Horace B. Horton Professor Emeritus of Chemistry, Enrico Fermi Institute and Department of Chemistry, University of Chicago.

A.G.W. CAMERON. Professor of Astronomy, Harvard University.

EDWARD U. CONDON (d. 1974). Professor of Physics, University of Colorado, Boulder, 1963–70.


RAYNOR L. DUNCOMBE. Professor of Aerospace Sciences, University of Texas at Austin.

MORTON HAMERMESH. Professor of Physics, University of Minnesota, Minneapolis, 1975–86.

JOSEPH J. KATZ. Emeritus Distinguished Senior Scientist, Argonne National Laboratory, Argonne, Illinois; Senior Chemist, 1946–82.

MALCOLM H. MACFARLANE. Professor of Physics, Indiana University, Bloomington.

VINCENT E. PARKER. Emeritus Professor of Physics, California State Polytechnic University, Pomona; Dean, School of Science, 1967–77.

SIR BRIAN PIPPARD. Emeritus Professor of Physics, University of Cambridge; Cavendish Professor, 1971–82.


RUPERT WILDT (d. 1976). Professor of Astrophysics, Yale University, 1957–73.

MARK W. ZEMANSKY (d. 1981). Professor of Physics, City College, City University of New York.

Part Two. The Earth

- R.J. CHORLEY. Professor of Geography, University of Cambridge; Fellow of Sidney Sussex College, Cambridge.


PAUL EDWIN POTTER. Professor of Geology, University of Cincinnati, Ohio.

WILLIAM STELLING VON ARX. Senior Scientist, Woods Hole Oceanographic Institution, Massachusetts, 1968–78.

BRIAN F. WINDLEY. Professor of Geology, University of Leicester, England.

PETER J. WYLIE. Professor of Geology and Chairman, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena.

Part Three. Life on Earth

- N.J. BERRILL. Strathcona Professor of Zoology, McGill University, Montreal, 1946–65.

JOHN TYLER BONNER. George M. Moffett Professor Emeritus of Biology, Princeton University.

V.G. DETHIER (d. 1993). Gilbert L. Woodside Professor of Zoology, University of Massachusetts at Amherst, 1975–93.

PETER W. FRANK. Emeritus Professor of Biology, University of Oregon, Eugene.

CARL GANS. Professor of Biology, University of Michigan, Ann Arbor.

ERNEST M. GIFFORD. Emeritus Professor of Botany, University of California, Davis.
GARRETT HARDIN.
LOUIS S. GOODMAN, M.D.
ERNST WALTER MAYR.
THEODORE T. PUCK.
JOHN ALEXANDER MOORE.
PAUL B. WEISZ.
EMIL H. WHITE.
SIR WILFRID EDWARD LE GROS CLARK (d. 1971).
F. CLARK HOWELL.

Evanston, Illinois. Professor of Biological Sciences, University Pharmacology, University of Utah, Salt Lake City.

JOHN ALEXANDER MOORE. Emeritus Professor of Biology, University of California, Riverside.

THEODORE T. PUCK. Professor of Biochemistry, Biophysics, and Genetics and Distinguished Professor of Medicine, University of Colorado Health Sciences Center, Denver. Director, Eleanor Roosevelt Institute for Cancer Research.

G. LEDYARD STEBBINS. Emeritus Professor of Genetics, University of California, Davis.

JOHN W. THIERET. Professor of Botany, Northern Kentucky University. Highland Heights; Chairman, Department of Biological Sciences, 1973–80.

BIRGIT VENNELAND. Head, Vennesland Research Laboratory, Max Planck Society, 1970–78; Director, Max Planck Institute for Cell Physiology, Berlin, 1968–70.

PAUL B. WEIZ. Professor of Biology, Brown University. Providence, Rhode Island.

RALPH H. WETMORE. Emeritus Professor of Botany, Harvard University.

EMIL H. WHITE. D. M. Edson Johnson Professor of Chemistry, Johns Hopkins University, Baltimore, Maryland.

Part Four. Human Life

DONNA BERGEN, M.D. Associate Professor of Neurological Sciences, Rush University, Chicago.

WILLIAM CAMERON BOWMAN. Professor of Pharmacology, University of Strathclyde, Glasgow.

SIR WILFRID EDWARD LE GROS CLARK (d. 1971). Professor of Anatomy, University of Oxford.

ELIZABETH B. CONNELL, M.D. Professor of Gynecology and Obstetrics, Emory University, Atlanta, Georgia.

HARVEY J. DWORKEN, M.D. Emeritus Professor of Medicine, Case Western Reserve University, Cleveland, Ohio.

RUSSELL S. FISHER, M.D. (d. 1985). Chief Medical Examiner, State of Maryland, Baltimore. Professor of Forensic Pathology, University of Maryland Medical School, Baltimore.

MARK C. FISHMAN, M.D. Former Assistant Professor of Medicine, Harvard University.

CECIL A. GIBB. Emeritus Professor of Psychology, Australian National University, Canberra.

ROY R. GRINKER, SR., M.D. (d. 1993). Professor of Psychiatry, University of Chicago, 1969–85; Director, Institute for Psychosomatic and Psychiatric Research and Training, Michael Reese Hospital and Medical Center, Chicago, 1951–76.

NORMAN K. HOLLENBERG, M.D. Professor of Radiology, Harvard University.

F. CLARK HOWELL. Professor of Anthropology, University of California, Berkeley.


HOWARD F. HUNT. Clinical Professor of Psychology in Psychiatry, Cornell University Medical College, New York City.

AINSLEY IGOO. Professor of Veterinary Physiology, 1962–90. Dean, Faculty of Veterinary Medicine, 1974–77 and 1985–90. University of Edinburgh.

JEROME P. KASSIRER, M.D. Sara Murray Jordan Professor of Medicine, Tufts University, Boston.

WILLIAM KESSEN. Eugene Higgins Professor of Psychology, Professor of Pediatrics, Yale University.

GREGORY A. KIMBLE. Emeritus Professor of Psychology, Duke University, Durham, North Carolina.

ERICH KLINGHAMMER. Associate Professor of Psychology, Purdue University, West Lafayette, Indiana.

LOUIS LASAGNA, M.D. Dean, Sackler School of Graduate Biomedical Sciences. Dean for Academic Affairs, School of Medicine, Tufts University, Medford, Massachusetts.

WARREN STURGIS McCULLOCH, M.D. (d. 1969). Neuropsychologist, cybehneticist. Staff Member, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge, 1952–69.

WILLIAM J. McGUIRE. Professor of Psychology, Yale University.

W. BRYAN MATTHEWS, M.D. Emeritus Professor of Clinical Neurology, University of Oxford.


MICHAEL FRANCIS OLIVER, M.D. Professor, National Heart and Lung Institute, London. Duke of Edinburgh Professor of Cardiology, University of Edinburgh, 1979–89.

D. KEITH PETERS. Regius Professor of Physic, University of Cambridge.

KEN RAWNSLEY (d. 1992). Professor and Head, Department of Psychological Medicine, University of Wales College of Medicine, Cardiff, 1964–85.

DRUMMOND RENNIE, M.D. Professor of Medicine, University of California, San Francisco. Deputy Editor (West), The Journal of the American Medical Association.

JAMES SCOTT ROBSON, M.D. Emeritus Professor of Medicine, University of Edinburgh.

FRED S. ROSEN, M.D. James L. Gamble Professor of Pediatrics, Harvard University.

IRVING SARNOFF. Emeritus Professor of Psychology, New York University, New York City.

WILFRED SIRCUS, M.D. Senior Consultant Physician, Gastrointestinal Unit; former Reader in Medicine, University of Edinburgh.


ILZA VEITH. Emeritus Professor of Psychiatry and the History of Health Sciences, University of California, San Francisco.

MAXWELL M. WINTROBE, M.D. (d. 1986). Professor of Internal Medicine, University of Utah, Salt Lake City, 1943–70.

Part Five. Human Society

FRANCIS A. ALLEN. Huber C. Hurst Professor Emeritus of Law, University of Florida, Gainesville. Edson R. Sunderland Professor Emeritus of Law, University of Michigan, Ann Arbor.

CLEVELAND AMORY. Author and lecturer. President of The Fund for Animals.
CHARLES SZLADITS (d. 1986). Adjunct Professor of Comparative Law, Columbia University.


CHARLES RAYMOND WHITTLESEY. Emeritus Professor of Finance and Economics, University of Pennsylvania, Philadelphia.


Part Six. Art

RUDOLF ARNHEIM. Emeritus Professor of Psychology of Art, Carpenter Center for the Visual Arts, Harvard University.

JOHN ELY BURCHARD (d. 1975). Professor of Humanities and Dean, School of Humanities and Social Sciences, Massachusetts Institute of Technology, Cambridge, 1948–64.


CLIFTON FADIMAN. Writer and editor. Member, Board of Editors, Encyclopedia Britannica.

FRANCIS FERGUSSON (d. 1986). Professor of Comparative Literature, Princeton University, 1973–81. Professor of Comparative Literature, Rutgers University, New Brunswick, New Jersey, 1953–69.


JOHN GLOAG (d. 1981). Novelist and writer on architecture and industrial design.

OLEG GRABAR, Professor, School of Historical Studies, Institute for Advanced Study, Princeton, New Jersey. Aga Khan Professor of Islamic Art, Harvard University, 1981–90.


ROY McMULLEN (d. 1984). Author, critic, and art historian.


LEONARD B. MEYER. Benjamin Franklin Professor of Music and Humanities, University of Pennsylvania, Philadelphia.

RAY NASH (d. 1982). Professor of Art, Dartmouth College, Hanover, New Hampshire, 1949–70.

BRUNO NETTL. Professor of Music and of Anthropology, University of Illinois at Urbana-Champaign.


DOROTHEI MARGARET PARTINGTON (d. 1990). Literary critic and historian.


•GEORGE SAVAGE (d. 1982). Art consultant. Author of Porcelain Through the Ages; Pottery Through the Ages; and others.


WOLFGANG STECHOW (d. 1974). Professor of Fine Arts, Oberlin College. Oberlin, Ohio, 1940–63.


WALTER TERRY (d. 1982). Dance critic and editor, Saturday Review magazine. New York Herald Tribune; and others.

EVERARD M. UPIJHN (d. 1978). Professor of Fine Arts, Columbia University. 1951–70.


RENÉ WELLEK (d. 1995). Sterling Professor of Comparative Literature, Yale University, 1952–72.

GLYNNE WILLIAM GLADSTONE WICKHAM. Emeritus Professor of Drama, University of Bristol, England; Dean, Faculty of Arts, 1970–72.


PAUL S. WINGERT (d. 1974). Professor of Art History and Archaeology, Columbia University.

BRUNO ZEVI. Professor of Architectural History, University of Rome, 1963–79.

Part Seven. Technology

BRIAN D.O. ANDERSON. Professor of Systems Engineering and Director, Research School of Information Sciences and Engineering, Australian National University, Canberra.


•EUGENE S. FERGUSON. Emeritus Professor of History, University of Delaware, Newark. Curator of Technology, Hagley Museum, Greenville, Delaware, 1969–79.

NEAL FITZSIMONS. Principal, Engineering Counsel, Kensington, Maryland.


•MELVIN KRANZBERG. Callaway Professor of the History of Technology, Georgia Institute of Technology, Atlanta, 1972–88.


Part Eight. Religion


SALO WITTAYER BARON (d. 1989). Professor of Jewish History, Literature, and Institutions, Columbia University, 1950–68; Director, Center of Israel and Jewish Studies, 1950–68.


•ARTHUR LLEWELLYN BASHAM (d. 1986). Professor of Asian Civilizations, Australian National University, Canberra.


H. BYRON EARHART. Professor of Religion, Western Michigan University, Kalamazoo.

GEORGE WOLFGANG FORELL. Carver Professor Emeritus of Religion, University of Iowa, Iowa City.

JUDAH GOLDSN. Emeritus Professor of Post-Biblical Hebrew Literature, University of Pennsylvania, Philadelphia.

HERBERT V. GUENTHER. Emeritus Professor of Far Eastern Studies, University of Saskatchewan, Saskatoon.
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•JACQUES BARZUN. University Professor Emeritus, Columbia University; Dean of Faculties and Provost, 1958–67.

DAVID BIRMINGHAM. Professor of Modern History, University of Kent at Canterbury, England.

JOHN F. Cady. Distinguished Professor Emeritus of History, Ohio University, Athens.

AINSLIE T. EMBREE. Emeritus Professor of History, Columbia University.


HERBERT S. KLEIN. Professor of History, Columbia University.

PHILIP A. KUHN. Professor of History, Director, John King Fairbank Center for East Asian Research, Harvard University.

DONALD P. LITTLE. Professor, Institute of Islamic Studies, McGill University, Montreal.

DONALD M. LOWE. Emeritus Professor of History, San Francisco State University.

JAMES G. LYDON. Professor of History, Duquesne University, Pittsburgh.

PAUL T. MASON. Professor of History, Duquesne University, Pittsburgh.


DONALD MacGILLIVRAY NICOL. Koraös Professor Emeritus of Byzantine and Modern Greek History, Language, and Literature, King’s College, University of London. Director, Gennadius Library, American School of Classical Studies at Athens, 1989–92.

RICHARD E. PIPES. Frank B. Baird, Jr., Professor of History, Harvard University.

GORDON R. WILLEY. Bowditch Professor Emeritus of Mexican and Central American Archaeology, Harvard University.

GEORGE MACKLIN WILSON. Professor of History and of East Asian Languages and Cultures, Indiana University, Bloomington.

Part Ten. The Branches of Knowledge


•OTTO ALLEN BIRD. Emeritus Professor of Arts and Letters, University of Notre Dame, Indiana.

PETER G. BROWN. Professor of Public Policy; Director, Environmental Policy Programs, University of Maryland, College Park.


RODERICK M. CHISHOLM. Andrew Mellon Professor Emeritus of the Humanities and Emeritus Professor of Philosophy, Brown University, Providence, Rhode Island.

JAMES DANIEL COLLINS (d. 1985). Professor of Philosophy, St. Louis University, Missouri.


•WILLIAM H. DRAY. Emeritus Professor of Philosophy and of History, University of Ottawa.

ELDON DYER (d. 1993). Distinguished Professor of Mathematics, Graduate School, City University of New York, 1971–92.

•NORWOOD HANSON (d. 1967). Professor of Philosophy, Yale University, 1963–67.


•THE REV. ERNAN V. McMULLIN. Professor of Philosophy, University of Notre Dame, Indiana.


•ARTHUR NORMAN PRIOR (d. 1969). Fellow, Balliol College, University of Oxford. Professor of Philosophy, Manchester University, 1959–66.

•NICHOLAS RESCHER. University Professor of Philosophy, University of Pittsburgh. Editor, American Philosophical Quarterly.

MARK A. RONAN. Mason Professor of Pure Mathematics, University of Birmingham, England.


•SEYMOUR SCHUSTER. Professor of Mathematics, Carleton College, Northfield, Minnesota.

JULIUS R. WEINBERG (d. 1971). Vilas Professor of Philosophy, University of Wisconsin, Madison.
Authors of Propædia Essays

Part One

Part Two
PETER J. WYLLIE. Petrologist, educator, and author. Professor of Geology and Chairman, Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena. Author of Ultramafic and Related Rocks; The Dynamic Earth; and others.

Part Three
RENÉ DUBOS (d. 1982). Microbiologist, pathologist, and author. Professor of Pathology, Rockefeller University, New York City, 1957–71. Author of So Human an Animal; Mirage of Health; A God Within; and others.

Part Four

Part Five
HAROLD D. LASSWELL (d. 1978). Political scientist and author. Professor of Law, 1946–70, and of Political Science, 1952–70, Yale University. Author of Psychopathology and Politics; Politics: Who Gets What, When, How; A Pre-View of Policy Sciences; and others.

Part Six

Part Seven

Part Eight
WILFRED CANTWELL SMITH. Educator and author. Emeritus Professor of the Comparative History of Religion, Harvard University. Author of Islam in Modern History; The Meaning and End of Religion; Questions of Religious Truth; and others.

Part Nine
JACQUES BARZUN. Historian, educator, and author. University Professor Emeritus, Columbia University; Dean of Faculties and Provost, 1958–67. Author of Berlioz and the Romantic Century; Darwin, Marx, and Wagner; The House of Intellect; On Writing, Publishing, and Editing; and others.

Part Ten

Authors of Propædia Essays

NATHANIEL O. ABELSON. Former Map Librarian, Dag Hammarskjöld Library, United Nations, New York City.

IBRAHIM A. ABU-LUGHOD. Vice President, Birzeit University, West Bank. Former Professor of Political Science, Northwestern University, Evanston, Illinois, 1967–93.

GEORGE I. BLANKSTEN. Emeritus Professor of Political Science, Northwestern University, Evanston, Illinois.

NORTON S. GINSBURG. Emeritus Professor of Geography, University of Chicago.

CHAUNCY D. HARRIS. Samuel N. Harper Distinguished Service Professor Emeritus of Geography, University of Chicago.

HELVI A. KALMAN. Writer and Editor, Department of Public Information, United Nations, New York City, 1958–79.

C.W. MINKEL. Associate Vice-Chancellor; Dean, Graduate School, University of Tennessee, Knoxville.


G. ETZEL PEARCY (d. 1980). Professor of Geography, California State University, Los Angeles, 1969–73.

JOSEPH E. SCHWARTZBERG. Professor of Geography, University of Minnesota, Minneapolis.

IVOR G. WILKS. Melville J. Herskovits Professor of African Studies, Northwestern University, Evanston, Illinois.