CHART OF THE SCIENCES.

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Subdivision of the activities of the newly formed Scientific Society in this School into groups suitable for carrying on the work among the members raised the question of just which sciences to select and which to combine for group work. A simple and tentative division was finally decided upon, but the question caused two of the members to consider in some detail all subjects which might properly be included under the general head of "Science" and how they should be grouped. We got together sufficient material to warrant putting it in the form of a large chart to hang on the wall of the Society room. For the present the matter has been typewritten and the different sections of the chart thumb-tacked to a large sheet of compo board; this enabled us to insert the proper lines to show the division and subdivision of the subject-matter. The name of each science or subdivision of a science is accompanied by a suitable definition. Various books on science, some encyclopedias and dictionaries, Herbert Spencer's pamphlet on the classification of the sciences and a recent report of the Washington Academy of Science constituted the chief sources of information.

The main layout of the chart is shown in the accompanying very simple diagram. Under each separate science mentioned in the diagram we have put in the chart itself a rather detailed list of subdivisions with definitions. These different lists are printed in this article as solid text, following the order as given in the diagram.

We do not claim completeness for this chart. Without doubt many readers will differ from us on the selection of titles and on certain definitions. It must be remembered that we could find nothing like this chart in print, so had to judge as best we could and select accordingly.

If there develops a call for this material in printed chart form as we have drawn it up for our wall chart, we shall probably put it in such printed chart form. Any criticisms or suggestions will be gratefully received by the compilers and may be sent to the second named author.

The different lists comprising the chart and following the outline given above are as follows:

SCIENCE is knowledge reduced to order and so classified and arranged as to be easily remembered, readily referred to and advantageously applied.

Science	Knowledge of Space and Time		{ Mathematics
	Knowledge of Matter and Energy		{ Astronomy Physics Chemistry Physiography Geology Geography
	Knowledge of Matter, Energy and Life		{ Botany Zoology Anatomy
	Knowledge of Mankind	Knowledge of Physical Man	{ Anthropology
		Knowledge of Mind	{ Philosophy Logic History
		Knowledge of Society	{ Ethnology Political Economy Philology

No one classification of the sciences is wholly satisfactory, so much depends upon the point of view.

Sosman says: "Science is not divisible sharply into little compartments labelled Chemistry, Botany and the like. There is one vast field of human knowledge, and facts concerning any part of that field have a bearing on every other part."

Comte classified sciences in order ranging from those dealing with the simplest phenomena to those dealing with the most complex, e. g. from mathematics to sociology.

Spencer classified sciences into three groups: the abstract (e. g. mathematics), the abstract-concrete (e. g. mechanics), and the concrete (e. g. geology).

A later classification divides the sciences into the Theoretical Sciences and the Practical Sciences.

In any system there is bound to be a certain amount of overlapping of subjects.

The main purpose of the classification presented below is to give a bird's-eye view of the field covered by scientific effort.

KNOWLEDGE OF SPACE AND TIME comprises the first of the four big subdivisions and includes only mathematics.

MATHEMATICS: The science of quantity. Further subdivided into:

Mensuration, the art of measuring or determining quantity.

Arithmetic, the science of numbers and art of computation.

Algebra, the science which employs letters in reasoning about numbers.

Plane Geometry, the science of figures in space of two dimensions.

Solid Geometry, the science of figures in space of three dimensions.

Descriptive Geometry, the theory of making projections of figures on two planes.

Analytical Geometry, geometry in which lines, planes and solids are represented by algebraic symbols and equations.

Plane Trigonometry, treats of the relations of the sides and angles of plane triangles.

Analytical Trigonometry treats of trigonometric functions by algebraic operations.

Spherical Trigonometry, the computation of spherical triangles.

Differential Calculus, the science of variable quantities.

Integral Calculus deals with the summation of series of differences in variables.

Absolute Calculus, a new branch of mathematics developed in connection with the Einstein theory.

Navigation, the science of directing the course of vessels.

Mechanics. See Physics.

KNOWLEDGE OF MATTER AND ENERGY, sometimes called *Natural Science*, comprises the second of the four big subdivisions. It includes Astronomy, Physics, Chemistry, and Physiography, the last named being subdivided into Geology and Geography.

ASTRONOMY: The science of the heavenly bodies. Further subdivided into:

Solar Astronomy, study of the sun and the planets revolving about it.

Siderial Astronomy, study of heavenly bodies outside the solar system.

Descriptive Astronomy, description of phenomena exhibited by the heavenly bodies.

Practical Astronomy, the study of how to observe these phenomena.

Physical Astronomy, the science of the laws governing the motions of the heavenly bodies.

Nautical Astronomy, that part of astronomy which is applied to navigation.

Spherical Astronomy, the application of geometry and trigonometry to ascertaining the apparent positions of celestial bodies.

Theoretical Astronomy, the investigation of orbits and motions of celestial bodies.

PHYSICS: The science of forces and motions. Further subdivided into the study of:

Mechanics, the mathematical doctrine of the motions and tendencies to motion of particles and systems under the influence of forces and constraints.

Heat, the kinetic energy of molecules.

Thermodynamics treats of the relations between heat and work.

Calorimetry, the measurement of the quantity of heat in thermal units.

Light, the form of energy which acting upon the organs of sight renders visible the objects from which it proceeds.

Optics treats of the nature, properties and behavior of light, and of instruments used in connection therewith.

Sound, the vibration of the air or other medium manifesting itself on the ear.

Acoustics, the study of the cause, nature and phenomena of sound.

Magnetism, the property of attraction and repulsion exhibited by certain substances.

Electricity, the cause of attraction and repulsion and of certain chemical decompositions.

Pneumatics treats of the mechanical properties of gases.

Dynamics, the science of forces.

Statics deals with forces at rest.

Kinematics deals with forces in motion.

Hydrostatics, the mathematical theory of the pressure and equilibrium of incompressible fluids.

Wireless Telegraphy and Wireless Telephony, the transmission of signals by long ether waves.

Electro-Chemistry. See Chemistry.

CHEMISTRY: The science of the composition of substances and changes they undergo. Further subdivided into:

Theoretical Chemistry deals with the laws governing chemical action.

Inorganic Chemistry, the study of inert substances.

Organic Chemistry, the study of the carbon compounds.

Analytical Chemistry, the determination of the composition of substances either qualitatively or quantitatively, or both.

Electrochemistry treats of the behavior of substances when subjected to electricity.

Thermochemistry treats of the relations existing between chemical action and heat.

Physical Chemistry treats of the borderland between Physics and Chemistry.

Applied Chemistry, the application of chemical laws to the arts and manufactures.

Agricultural Chemistry treats of the composition of soils, plants, manures, etc.

Physiological Chemistry treats of tissues and functions of animals and plants.

Pharmaceutical Chemistry treats of plants used as medicines.

Metallurgical Chemistry treats of metals and metallic compounds.

Radiochemistry treats of radioactive substances.

Photochemistry treats of chemical changes taking place in photographic processes.

PHYSIOGRAPHY, sometimes called *Physical Geography*, treats of the physical features of the earth's surface. It is subdivided into *Geology* and *Geography*.

GEOLOGY, science of the past and present condition of the earth. Further subdivided into:

Astronomical Geology treats of the earth as a planet.

Historical Geology, study of chronological succession in development of rock forms and of organisms.

Stratigraphy treats of the order and position of the stratified groups.

Paleontological Geology treats of the life of former geological periods.

Physical Geology, study of geological changes in the earth's surface.

Structural Geology treats of the position of materials in the earth's crust.

Petrology, the study of rocks.

Mineralogy, the study of minerals.

Crystallography, the study of different forms of crystals.

Economic Geology treats of geological relations of useful minerals, rocks and ores.

Agricultural Geology treats of soils, subsoils, subjacent strata and mineral manures.

Dynamic Geology treats of the causes of geological changes.

Lithology deals with the composition, structure and history of the earth's rocky shell.

Seismology, the science of earth disturbances.

GEOGRAPHY, science of the present earth's surface and things on it. Further subdivided into:

Hydrology treats of the oceans, lakes, ponds and rivers.

Oceanography, that branch of hydrology which treats of the ocean.

Commercial Geography treats of commerce, location of commodities, local conditions, routes of trade, etc.

Political Geography treats of the present division of the earth's surface among different governments.

Historical Geography treats of the past division of the earth's surface among different governments.

Biblical Geography treats of countries mentioned in the Bible.

Meteorology, the scientific study of weather and climate, their causes, changes, relations and effects.

Atmology. A better name for meteorology.

KNOWLEDGE OF MATTER, ENERGY AND LIFE.

Sometimes called *Biology* and together with Knowledge of Matter and Energy sometimes called *Natural Science*. It includes Botany, Zoology and Anatomy.

BOTANY: The science of plants. Further subdivided into:

Morphological Botany treats of the structure of plants.

Histological Botany treats of the structure and tissues of plants.

Cytology deals with the structure, development and functions of the cell.

Embryology deals with the development of plant cells.

Physiological Botany treats of the history and functions of plants.

Phytopathology treats of plant diseases.

Ecology treats of environmental influences on plants.

Phytogeography treats of the distribution of plants.

Taxonomy treats of classification of plants.

Economic Botany includes Agriculture, Forestry, Horticulture, etc.

Paleobotany treats of fossil plants.

Descriptive Botany treats of description and nomenclature of plants.

Medical Botany treats of plants used as medicines.

ZOOLOGY: The science of animals. Further subdivided into:

Metazology, the science of metazoa or many-celled animals.

Mammalogy, science of mammals.

Ornithology, science of birds.

Herpetology, science of reptiles.

Ichthyology, science of fishes and lower aquatic vertebrates.

Conchology, science of molluscs.

Crustaceology, science of crustaceans.

Entomology, science of insects.

Arachnology, science of spiders, scorpions, etc.

Helminthology, science of worms.

Echinology, science of sea urchins, etc.

Zoophytology, science of Zoophytes.

Spongology, science of sponges, etc.

Protozoology, science of protozoa or single-celled animals.

Systematic Zoology considers animals in morphological relations to each other.

Paleozoology, study of the life of former geologic periods.

Paleontology. Another name for paleozoology.

ANATOMY: Science of the bodily structure of animals and plants. Allied subjects:

Physiology treats of the functions of living things.
 Hygiene treats of principles of promoting health.
 Histology treats of the microscopic structure of body tissues.
 Embryology treats of the development of embryos.
 Morphology treats of form and structure of plants and animals.
 Medicine treats of organic and inorganic substances and their action on body tissues.
 Osteology treats of the bones of the body.
 Surgery, the application of the knife and the principles of anatomy in the treatment of injuries.

KNOWLEDGE OF MANKIND subdivided into Knowledge of Physical Man, Knowledge of Mind and Knowledge of Society. *Knowledge of Physical Man* covers Anthropology. *Knowledge of Mind* is subdivided into Philosophy, Logic and History. *Knowledge of Society* is subdivided into Ethnology, Political Economy and Philology.

ANTHROPOLOGY: The science of the physical structure of man. Further subdivided into:

Physical Anthropology, the natural history of man.
 Ontageny treats of the embryo and the life of the individual.
 Anatomy treats of the body specifically and comparatively.
 Physiology treats of the functions of the body.
 Anthropometry treats of the form, color, weight, etc., of the body.
 Psychology treats of the nervous system in relation to thought and feeling. See Philosophy.
 Ethnology treats of the natural divisions of mankind.
 Cultural Anthropology treats of what man does artificially.
 Glossology treats of expressing thoughts.
 Technology treats of supplying wants.
 Esthetology treats of giving pleasure.
 Sociology treats of cooperating in life's ends. See under Ethnology.

PHILOSOPHY: Variouslly defined as: The body of highest truth; the organized sum of science; the science of which all others are branches; the science of the most fundamental matters. Further subdivided into:

Metaphysics, the philosophy of the real, or the science of the inward and essential nature of things.
 Epistemology, the theory of knowledge.
 Ontology, the theory of reality.
 Psychology, the science of the phenomena of mind.
 Materialism, the philosophy of the material.
 Idealology the philosophy of the ideal.
 Ethics, the science of right conduct and character.
 Aesthetics, the philosophy of the beautiful, leading to art and literature.

LOGIC: The science of the distinction of true from false reasoning, with whatever is naturally treated in connection therewith. Further subdivided into:

Methodology shows how the abstract principles of logic are to be applied to the production of knowledge; the science of method in scientific procedures.

Abstract Logic, the general theory of logic.

Concrete Logic, logic as an element of active thought in the prosecution of science.

Formal Logic, the principles and methods of deductive reasoning.

Symbolic Logic, formal logic expressed by mathematical symbols.

Several other kinds are recognized.

HISTORY: The narrative, oral or written, of past events, with the ascertaining and recording thereof. Further subdivided into:

Ancient History, the history of man from earliest authentic records to the destruction of the Roman Empire.

Classical History, the history of the Greeks and Romans.

Medieval History, the history of the middle ages, from A. D. 476 to about A. D. 1517.

Modern History, the history of the period from about 1517 to the present time.

Sacred History, the history recorded in the Bible.

Profane History, the history of secular events as distinguished from Sacred History.

Ecclesiastical History, the history of the Church from the beginning to the present time, including both Old and New Testament history.

Natural History, the study and description of animals, plants and minerals; also geology.

Archaeology, the science of antiquities.

Classical Archaeology relates to Greece and Rome.

Medieval Archaeology relates to the middle ages.

ETHNOLOGY: The science of the races of men, and of their character, history, customs and institutions. Further subdivided into:

Sociology treats of the general structure of society, the laws of its development, the progress of civilization and all that relates to society.

Ethnography deals with the description and classification of races of men.

Political Science treats of politics, and of government and its relation to public and private affairs.

Law, a system or collection of rules of action, prescribed by authority of a sovereign or of a state, and binding upon men.

Government, the authoritative direction and restraint exercised over the actions of men in communities, societies or states; also the governing body exercising this authority.

Mythology, the science of myths and their interpretations with reference to peoples and their beliefs in gods.

POLITICAL ECONOMY: The science of the laws and conditions regulating the production, distribution and consumption of all products needed or used by man.

Economics. See Political Economy.

PHILOLOGY: The study of languages and their literatures for the light they throw on men's character, activity and history. Further subdivided into:

Comparative Philology, a comparative study of human languages and of the origin and history of words.

Linguistics. See Comparative Philology.

Oriental Philology, a study of Hebrew, Sanskrit and other Oriental languages as keys to their literatures.

Classical Philology, a study of language in connection with history or literature.

Modern Philology, a study of present day languages as keys to their literatures.

Grammar, a systematic account of the usages of a language, its parts of speech, inflections and formation of sentences.

Orthography, the art of spelling and writing words.

Etymology, treats of the derivation, history, classification and inflection of words.

Syntax deals with the sentence and the relations existing between the parts of which it is composed.

Phonetics deals with the pronunciation of letters and words.

Rhetoric deals with the use of language in speaking.

Paleography, the science of deciphering ancient documents.

APPLIED SCIENCE: The main chart is followed by a section on Applied Science with reference to the application of the pure sciences and with a list of the different kinds of engineering as follows:

APPLIED SCIENCE, sometimes called *Practical Science*, sometimes *Lucrative Science*, includes any of the *pure sciences* when applied to the industries as distinguished from their study as abstract or theoretical sciences. Nearly all science can be *applied*, but *engineering* is strictly applied science.

ENGINEERING: The art of making, building, and using engines and machines, or of executing civil or military works requiring a knowledge of the laws of mechanics.

Civil Engineering relates to the construction of roads, bridges, railroads, canals, harbors, aqueducts, steel frames for buildings, etc.

Structural Engineering. See Civil Engineering.

Architectural Engineering. Civil Engineering as applied to buildings.

Military Engineering relates to the construction and maintenance of fortifications and other war buildings and accessories.

Naval Engineering relates to the building and operation of ships and naval accessories.

Marine Engineering. See Naval Engineering.

Topographical Engineering relates to the surveying of land for ascertaining and recording variations in level and contour, etc.

Mining Engineering relates to selecting, testing, opening, and working mines.

Agricultural Engineering relates to the operation of large scale farms and the necessary accessories.

Sanitary Engineering relates to the structures and operations for promoting and guarding the health of communities.

Municipal Engineering. See Sanitary Engineering.

Chemical Engineering relates to the design, construction and operation of chemical plants and the manipulation of chemical processes.

Metallurgical Engineering relates to the design, construction and operation of plants extracting metals from ores.

Illuminating Engineering relates to the installation and operation of lighting systems.

Mechanical Engineering relates to the design, construction and operation of machines.

Hydraulic Engineering relates to the construction of water-works and hydraulic machinery, the improvement of waterways, etc.

Steam Engineering relates to the design, construction and operation of steam engines and accessories.

Dynamic Engineering relates to the generation and transmission of power.

Heating Engineering relates to the installation and operation of heating systems.

Aeronautical Engineering relates to the design, construction and operation of heavier-than-air and lighter-than-air machines.

Electrical Engineering relates to the production, transmission and use of electricity in producing light, heat and power and in metallurgical processes.

Radio Engineering relates to the design, construction and operation of radio plants.

TANGENT LINES AMONG THE GREEKS.

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Judging from Professor Cajori's article under the above heading, published on page 463 of this volume, it seems that I did not make it sufficiently clear why I regarded the following statement as not reasonably accurate: Roberval "broke off from the ancient definition of a tangent as a straight line having only one point in common with a curve." The inaccuracy of this statement appeared to me to be so obvious that a hint would be sufficient even for those who know only a little about the history of Greek mathematics. From the article noted above it appears that this hint was insufficient even for a professional mathematical historian and hence it may be desirable to furnish here some additional data in support of my conclusion.

On page 57 of the well-known *Aperçu historique des méthodes en géométrie* by M. Charles, second edition, 1875, one finds the following sentence: "The ancient geometers defined the tangent to a curve as a line which, having a point in common with the curve is such that one cannot draw through this point any other line between this one and the curve." In the definition quoted in the preceding paragraph the latter part of the definition just noted is omitted. By this omission the definition becomes inaccurate not only for the student of today, but it also fails to exhibit a very fertile field of Greek speculation relating to the angle of contact, or the horn-like angle, which is an instance where Greek geometers met with a magnitude which does not obey the so-called Archimedean postulate and hence is of unusual historic interest.¹

¹Cf. *Encyclopédie des Sciences Mathématiques*, tome 3, vol. 1, p. 136.