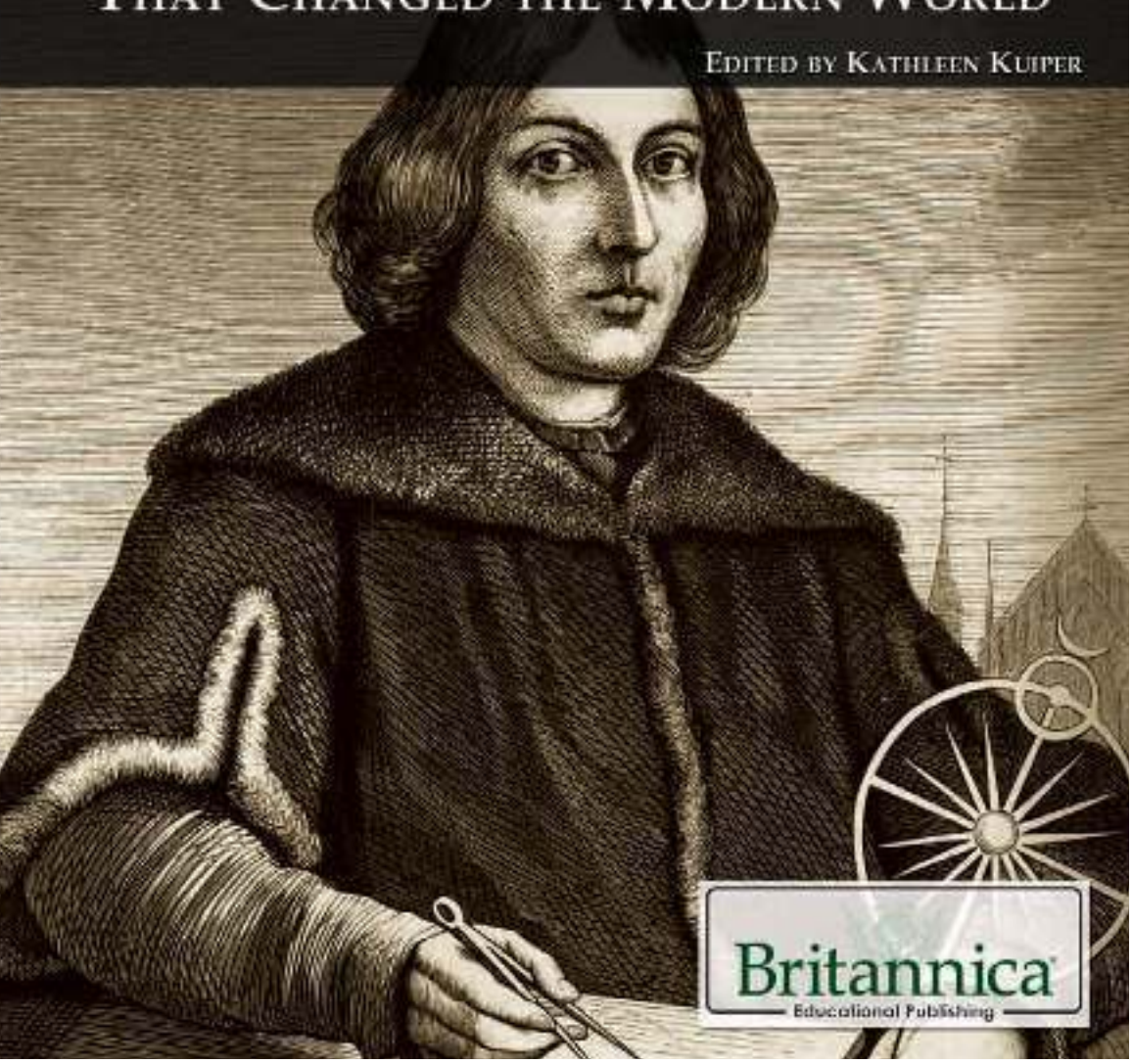
Turning Points in History

The Britannica Guide to Theories and Ideas That Changed the Modern World

Edited by Kathleen Kuiper



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THE BRITANNICA GUIDE TO THEORIES AND IDEAS THAT CHANGED THE MODERN WORLD

EDITED BY KATHLEEN KUIPER, MANAGER, ARTS AND CULTURE

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On the cover: *Nicolaus Copernicus's heliocentric concept of the solar system is but one of the theories and ideas that have had a profound effect on humankind throughout the ages.* Kean Collection/Hulton Archive/Getty Images

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Introduction

At choice moments throughout time, individuals have posed new ideas or theories that have gone against the grain. Someone decided what is known is not enough and asked—sometimes demanded—that the world look at an issue, circumstance, or traditional method in a whole new way. The story of humanity is rife with such turning points. Some have begun as small changes but reverberated, building in strength until their impact on the world became tremendous. Others were so essential that they were expressed almost immediately on a global scale.

This book examines the theories and ideas that have inextricably altered the foundation of existence—atomic theory, evolution, absolutism, Modernism, and natural law among them. The players behind each concept are highlighted throughout, and each chapter includes information about the climate and cultural perspectives from which each crucial moment sprang.

The biological sciences have engendered any number of theories designed to explain the origin, structure, function, and evolution of living organisms. In this discipline, ideas are continually put to the test through research and experimentation, then challenged and enhanced as new facts come to light. For instance, the ancient Greek belief that life was spontaneously generated gave way to the conceit that every living creature emanated from a fertilized egg.

Although scientists had begun observing and cataloguing various kinds of cells as early as the 1600s, it wasn't until much later that they truly began to understand their nature, how they functioned and reproduced. Cell theory—the notion that all living things are made from cells, and that all vital functions occur within them—was formulated in the 1800s by two German scientists, Theodore Schwann and Matthias Schleiden.

The situation was much the same when it came to germ theory. Since at least 100 BCE, investigators had suspected that disease was cause by tiny invaders. But it wasn't until the 19th century, when Italy's Agostino Bassi showed that a particular silkworm disease was caused by a fungus, that this theory was proved. Such studies underscored the need for stringent sanitary standards to combat the specific bacteria and viruses that threatened the health and well being of humans and animals. French chemist Louis Pasteur took this concept one step further, developing vaccines to contain or prevent the spread of diseases such as anthrax, cholera, and rabies. In this way, cell theory and germ theory helped save untold millions of lives.

Other biological science turning points have centred on the subject of diversity. Evolutionary theory charts the progression of life from a single progenitor, generally moving from simple to complex forms all the while. Evolution makes distinctions among various species. Genetics, on the other hand, concentrates on variations within species. The ability to determine the transmission of individual inherited traits by studying genes—or, in modern times, mapping links on the DNA chain—has yielded life-altering breakthroughs in the way humans grow food, solve crimes, reproduce, and, perhaps most important, treat disease.

The physical sciences have witnessed their fair share of momentous change due to ideas wrought from observation and conjecture. Several well-known, fundamental theories and scientific concepts are associated with the study of nonliving entities: Albert Einstein's theory of relativity ($E = mc^2$); the legend of Isaac Newton getting konked on the head by an apple, which illustrates laws governing the universal force of attraction known as gravity.

Many turning points in human comprehension of the universe have come about through the study of astronomy, a field that itself stemmed from ideas conceived by curious stargazers. Astronomy and mathematics, a field that makes good use of the theoretical in order to solve problems, are closely linked. Ancient astronomers believed the order of the universe was fundamentally mathematical in nature, and used arithmetic to predict celestial movements. As time went by, astronomers (who were also frequently mathematicians by trade) honed equations and progressions to get a more accurate reading of the night sky. The development of calculus in the late 1600s made it possible to gauge area and volume and predict the movement patterns of distant celestial objects. Today calculus is the basic entry point for anyone wishing to study physics, chemistry, biology, economics, finance, or actuarial science.

The arts also lend themselves quite well to new ideas. In fact, finding new and creative ways of expression is the artist's stock in trade. With regard to the fine arts (painting, drawing, sculpting), this spirit of artistic innovation is evident in the various movements that have taken art in a variety of directions.

During the Renaissance—a time of great cultural change throughout Europe—painting and drawing literally took on a new dimension with the advent of perspective. Giving depth to objects in a way that makes them pop off the flat page, perspective was made popular by Filippo Brunelleschi. In his work as an architect and engineer, Brunelleschi reintroduced the concept of the vanishing point, which is a distant spot in a drawing or rendering where parallel lines converge. The eye is drawn to the vanishing point, creating the illusion of depth and three-dimensionality. Several influential Renaissance

artists, including Donatello and Fra Angelico, employed perspective in their work.

Other movements in the graphic arts that have served as turning points include Impressionism (accurately recording reality using light and colour) and Expressionism (distorted reality meant to arouse the viewer's emotions). In the 20th century, many artists abandoned realistic portrayals altogether in favour of abstraction. Instead of classic representational methods, abstract art uses lines, texture, and colour, rather than representation or figuration, to convey meaning.

One of the most far-reaching movements in the arts was Modernism. Coming on the heels of World War I, Modernism permeated every facet of the arts. Many creative people—writers, artists, philosophers, composers, and architects—used their creations to make a break with convention. Impressionism and Abstract Expressionism were modernist approaches to art. Modernist literature, exemplified by the works of T.S. Eliot, Virginia Woolf, Gertrude Stein, and James Joyce, among others, experimented with new forms and manners of expression. Dancers abandoned traditional steps for free-form movement, architects embraced clean lines and unadorned facades, and composers experimented with atonality.

Another important milestone, which changed the experience of music, is the incorporation of harmony into vocal and instrumental compositions. Church choirs in the 9th century are credited with the first usage of harmony. The fuller, richer sound afforded by voices rising in intervals was received so favourably by listeners that composers embraced the use of polyphony and favoured it over the unison musical line.

The visual replaces the aural when it comes to a key turning point in motion picture production—the montage.

In its broadest sense, montage means to assemble various elements to make a unified whole. The cinematic definition is a matter of the way in which film is edited to create a cohesive sequence of storytelling. This can be done narratively, by exploring a character or location from several angles or over time; graphically, using a method that links shots by physical appearance; or ideationally, where images are spliced together more or less by topic as a way of solidifying an idea the director is trying to get across in a certain scene. The introduction of montage occurred very early on in the history of filmmaking. Pioneering directors Edwin S. Porter and D.W. Griffith popularized the technique in America, while montage was refined and used to great effect by Russian directors in the early 20th century.

Turning points in the social sciences have sought to clarify and strengthen people's understanding of society and social relationships, why they work and why they fail. They constitute changes that have affected behaviour and human interaction. Mass production and the assembly line greatly altered the role of the worker, negotiations between employers and employees, and even international relations with regard to trade practices.

Other crucial social science turning points include the advent of psychoanalysis, including the study of child behaviour. Psychologists such as Sigmund Freud sought answers much deeper below the surface, revealing that human behaviour is the result of many factors, including repressed memories and desires. Beyond the psyche—or, more accurately, intertwined with it—is the idea that human beings have a conscience that guides their behaviour. The conscience gives rise to the notion of what is good and evil.

Religious concepts that have had an impact on human behaviour include the notions of sin and the soul. The

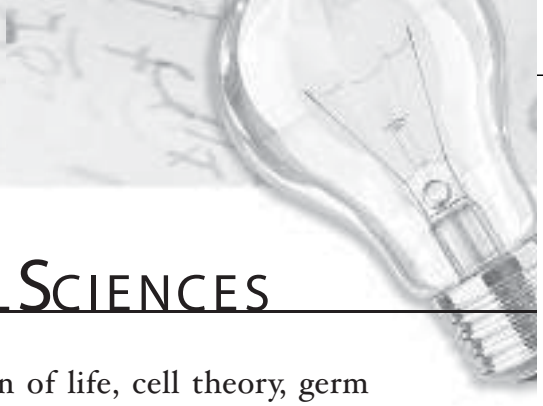
relation of the soul to the body has been a subject of philosophical debate for centuries. The ancient Greek theologian and philosopher Augustine of Hippo claimed that the body and soul were separate and that the latter contained the true essence of a person. In the Middle Ages, Thomas Aquinas contemporized the idea of the soul that had already long been pondered from the time of early Hebrews and ancient Greeks. Modern philosophers have held a number of opinions, anything from the soul being equivalent to the mind to it being merely a justification for the development of ethics.

Throughout history, ethical conceits such as right and wrong have given rise to ideas concerning fair and equal treatment. These include important universal concepts such as human rights and natural law, which is a theory that there is an innate, common set of rules that all people follow simply because of their basic nature as human beings. For instance, people everywhere understand that killing an innocent person is wrong; they don't need a written, man-made law to tell them that. However, societies throughout the world have always thought it was a good idea to institute what is known as "positive laws"—those that are decreed and agreed to by various cultures—as well. Many positive, or man-made, laws have been influenced by natural laws. Those who do not follow natural and positive laws, or otherwise behave in a manner that is contrary to the greater societal good, are subject to punishment.

In general, people follow rules, regulations, and laws that are created to bring about harmony in a society. When the rules are broken, so is the peace. Therein lies one of the most interesting turning points in political and legal thought, the social contract. To live within society, humans give up certain individual rights, entering

into an agreement with those in power in order to remain at peace. Great thinkers through the centuries, including Thomas Hobbes and Jean-Jacques Rousseau, have created works about the social contract that defined, and redefined, humans' understanding of their rights and place in society.

There is a common belief that laws should not be designed merely to protect life and property alone. Original ideas must and should be safeguarded as well. This is the theory behind intellectual-property law. Because ideas can be stolen, and can occur to more than one person at once, many societies have established laws to ensure a balanced legal approach to giving credit where credit is due. After a thorough examination of this book's contents, readers are sure to agree that theories and ideas are well worth protecting.



Chapter 1: The Biological Sciences

The probing of the origin of life, cell theory, germ theory, and genetic inheritance, as well as the ideas regarding evolution and ecology—the development of a sense of how living things interact and form a system of relationships—represent profound turning points in human history. This chapter addresses some of the discoveries that have affected the way we think about ourselves, other living things, and life's vital processes.

THE ORIGIN OF LIFE

If a species can develop only from a preexisting species, then how did life originate? Among the many philosophical and religious ideas advanced to answer this question, one of the most popular was the theory of spontaneous generation, according to which living organisms could originate from nonliving matter. With the increasing tempo of discovery during the 17th and 18th centuries, however, investigators began to examine more critically the Greek belief that flies and other small animals arose from the mud at the bottom of streams and ponds by spontaneous generation. Then, when the English physician William Harvey announced his biological theory *ex ovo omnia* ("everything comes from the egg"), it appeared that he had solved the problem, at least insofar as it pertained to flowering plants and the higher animals, all of which develop from an egg. But Antonie van Leeuwenhoek's subsequent disquieting discovery of animalcules demonstrated the existence of a densely populated but previously invisible world of organisms that had to be explained.

A 17th-century Italian physician and poet, Francesco Redi, was one of the first to question the spontaneous origin of living things. Having observed the development of maggots and flies on decaying meat, Redi in 1668 devised a number of experiments, all pointing to the same conclusion: if flies are excluded from rotten meat, maggots do not develop. On meat exposed to air, however, eggs laid by flies develop into maggots. But renewed support for spontaneous generation came from the publication in 1745 of a book, *An Account of Some New Microscopical Discoveries*, by John Turberville Needham, an English Catholic priest; he found that large numbers of organisms subsequently developed in prepared infusions of many different substances that had been exposed to intense heat in sealed tubes for 30 minutes. Assuming that such heat treatment must have killed any previous organisms, Needham explained the presence of the new population on the grounds of spontaneous generation. The experiments appeared irrefutable until Lazzaro Spallanzani, an Italian biologist, repeated them and obtained conflicting results. He published his findings about 1775, claiming that Needham had not heated his tubes long enough nor had he sealed them in a satisfactory manner. Although Spallanzani's results should have been convincing, Needham had the support of the influential French naturalist Buffon; hence the matter of spontaneous generation remained unresolved.

The Death of Spontaneous Generation

After a number of further investigations had failed to solve the problem, the French Academy of Sciences, in January 1860, offered a prize for contributions that would "attempt, by means of well-devised experiments, to throw new light on the question of spontaneous generation." In response to this challenge, Louis Pasteur, who at that time was a

chemist, subjected flasks containing a sugared yeast solution to a variety of conditions. Pasteur was able to demonstrate conclusively that any microorganisms that developed in suitable media came from microorganisms in the air, not from the air itself, as Needham had suggested. Support for Pasteur's findings came in 1876 from an English physicist, John Tyndall, who devised an apparatus to demonstrate that air had the ability to carry particulate matter. Because such matter in air reflects light when the air is illuminated under special conditions, Tyndall's apparatus could be used to indicate when air was pure. Tyndall found that no organisms were produced when pure air was introduced into media capable of supporting the growth of microorganisms. It was these results, together with Pasteur's findings, that put an end to the doctrine of spontaneous generation.

When Pasteur later showed that parent microorganisms generate only their own kind, he thereby established the study of microbiology. Moreover, he not only succeeded in convincing the scientific world that microbes are living creatures, which come from preexisting forms, but also showed them to be an immense and varied component of the organic world, a concept that was to have important implications for the science of ecology. Further, by isolating various species of bacteria and yeasts in different chemical media, Pasteur was able to demonstrate that they brought about chemical change in a characteristic and predictable way, thus making a unique contribution to the study of fermentation and to biochemistry.

The Origin of Primordial Life

In the 1920s a Soviet biochemist, A.I. Oparin, and other scientists suggested that life may have come from nonliving matter under conditions that existed on the primitive

Earth, when the atmosphere consisted of the gases methane, ammonia, water vapour, and hydrogen. According to this concept, energy supplied by electrical storms and ultraviolet light may have broken down the atmospheric gases into their constituent elements, and organic molecules may have been formed when the elements recombined.

Some of these ideas have been verified by advances in geochemistry and molecular genetics; experimental efforts have succeeded in producing amino acids and proteinoids (primitive protein compounds) from gases that may have been present on the Earth at its inception, and amino acids have been detected in rocks that are more than three billion years old. With improved techniques it may be possible to produce precursors of or actual self-replicating living matter from nonliving substances. But whether it is possible to create the actual living heterotrophic forms from which autotrophs supposedly developed remains to be seen.

Although it may never be possible to determine experimentally how life originated or whether it originated only once or more than once, it would now seem—on the basis of the ubiquitous genetic code found in all living organisms on Earth—that life appeared only once and that all the diverse forms of plants and animals evolved from this primitive creation.

ANTONIE VAN LEEUWENHOEK

(b. Oct. 24, 1632, Delft, Neth.—d. Aug. 26, 1723, Delft)

The Dutch microscopist Antonie van Leeuwenhoek was the first to observe bacteria and protozoa. In his youth he was apprenticed to a draper; a later civil position allowed him to devote time to his hobby: grinding lenses and using