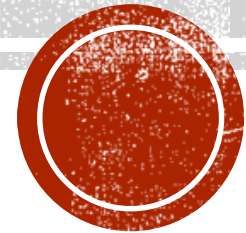


CC8: RISE OF THE MODERN WEST -II

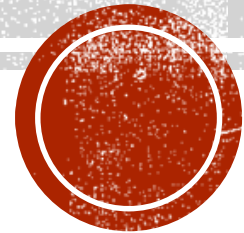
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TOPICS TO BE DISCUSSED

Module IV

- a) Scientific Revolution**
- b) Emergence of scientific academies**
- c) Origins of Enlightenment**



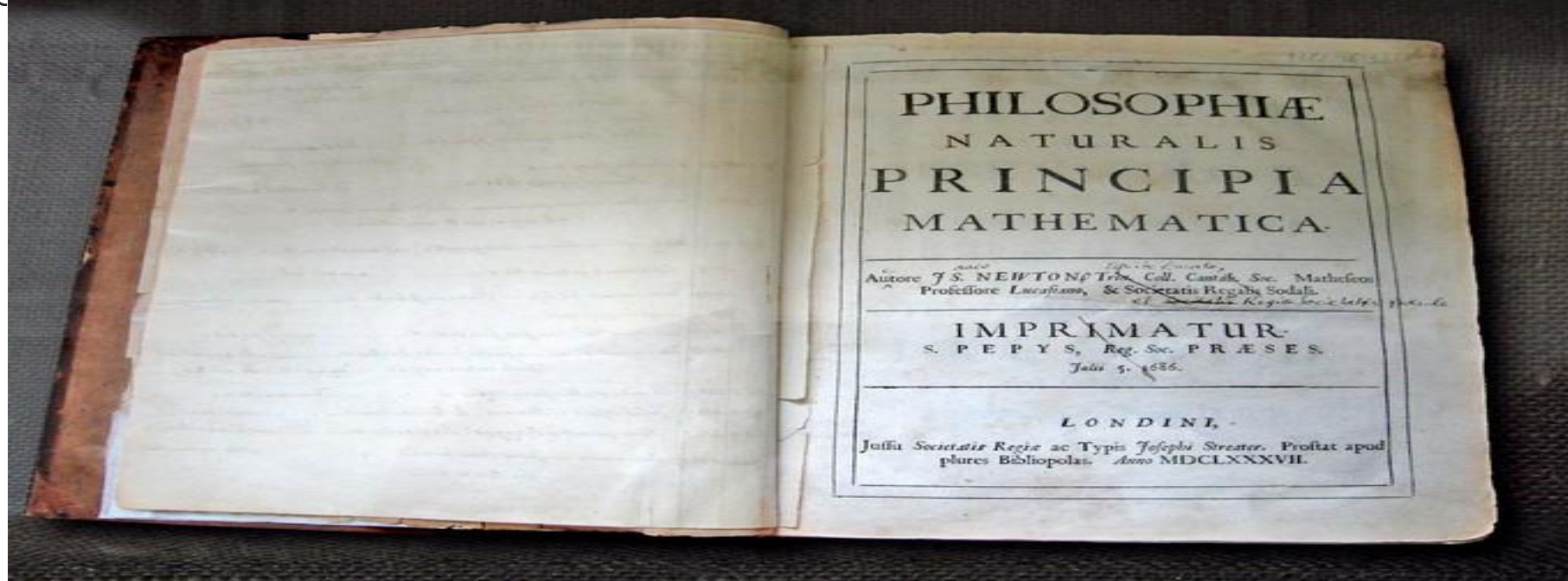
a) **SCIENTIFIC REVOLUTION**

The scientific revolution, which emphasized systematic experimentation as the most valid research method, resulted in developments in mathematics, physics, astronomy, biology, and chemistry. These developments transformed the views of society about nature.

- ❖ The scientific revolution was the emergence of modern science during the early modern period, when developments in mathematics, physics, astronomy, biology (including human anatomy), and chemistry transformed societal views about nature.
- ❖ The change to the medieval idea of science occurred for four reasons: collaboration, the derivation of new experimental methods, the ability to build on the legacy of existing scientific philosophy, and institutions that enabled academic publishing.



বৈজ্ঞানিক বিপ্লব হল কয়েকটি ক্রমিক ঘটনাবলী, যা প্রাক আধুনিক যুগে আধুনিক বিজ্ঞানের আবির্ভাবের সূচনা করেছিল, এই সময় গণিত, পদার্থবিদ্যা, জ্যোতির্বিদ্যা, জীববিদ্যা (মানব শারীরস্থান সহ) এবং রসায়নের বিকাশ প্রকৃতি সম্পর্কে সমাজের দৃষ্টিভঙ্গির পরিবর্তন ঘটায়। রেনেসাঁ পর্বের শেষের দিকে ইউরোপে বৈজ্ঞানিক বিপ্লব সংঘটিত হয়েছিল এবং ১৮ শতকের শেষের দিক পর্যন্ত এটি অব্যাহত ছিল যা পরবর্তী বৌদ্ধিক সামাজিক আন্দোলন জ্ঞানদীপ্তির যুগকে প্রভাবিত করে। যদিও বৈজ্ঞানিক বিপ্লবের আঞ্চলিক সূচনাপর্ব নিয়ে বিতর্ক রয়েছে, তবে ১৫৪৩ সালে নিকোলাস কোপার্নিকাসের ডি রেভেলিউসনিবাস অর্বিয়াম কোয়েলেস্টিয়াম (অন দ্য রেভোলিউশনস অফ দ্য হেভেনলি স্ফিয়ারস) এর প্রকাশনাকেই সাধারণত বৈজ্ঞানিক বিপ্লবের সূচনা হিসাবে উল্লেখ করা হয়।



- ❖ Under the scientific method, which was defined and applied in the 17th century, natural and artificial circumstances were abandoned and a research tradition of systematic experimentation was slowly accepted throughout the scientific community.
- ❖ During the scientific revolution, changing perceptions about the role of the scientist in respect to nature, and the value of experimental or observed evidence, led to a scientific methodology in which empiricism played a large, but not absolute, role.
- ❖ As the scientific revolution was not marked by any single change, many new ideas contributed. Some of them were revolutions in their own fields.
- ❖ Science came to play a leading role in Enlightenment discourse and thought. Many Enlightenment writers and thinkers had backgrounds in the sciences, and associated scientific advancement with the overthrow of religion and traditional authority in favor of the development of free speech and thought.



•**empiricism:** A theory stating that knowledge comes only, or primarily, from sensory experience. It emphasizes evidence, especially the kind of evidence gathered through experimentation and by use of the scientific method.

•**Galileo:** An Italian thinker (1564-1642) and key figure in the scientific revolution who improved the telescope, made astronomical observations, and put forward the basic principle of relativity in physics.

•**Baconian method:** The investigative method developed by Sir Francis Bacon. It was put forward in Bacon's book *Novum Organum* (1620), (or *New Method*), and was supposed to replace the methods put forward in Aristotle's *Organon*. This method was influential upon the development of the scientific method in modern science, but also more generally in the early modern rejection of medieval Aristotelianism.

•**scientific method:** A body of techniques for investigating phenomena, acquiring new knowledge, or correcting and integrating previous knowledge, through the application of empirical or measurable evidence subject to specific principles of reasoning. It has characterized natural science since the 17th century, consisting in systematic observation, measurement, and experiment, and the formulation, testing, and modification of hypotheses.

•**British Royal Society:** A British learned society for science; possibly the oldest such society still in existence, having been founded in November 1660.



- ❖ The scientific revolution began in Europe toward the end of the Renaissance period, and continued through the late 18th century, influencing the intellectual social movement known as the Enlightenment. While its dates are disputed, the publication in 1543 of Nicolaus Copernicus 's *De revolutionibus orbium coelestium (On the Revolutions of the Heavenly Spheres)* is often cited as marking the beginning of the scientific revolution.
- ❖ The scientific revolution was built upon the foundation of ancient Greek learning and science in the Middle Ages, as it had been elaborated and further developed by Roman/Byzantine science and medieval Islamic science. The Aristotelian tradition was still an important intellectual framework in the 17th century, although by that time natural philosophers had moved away from much of it. Key scientific ideas dating back to classical antiquity had changed drastically over the years, and in many cases been discredited. The ideas that remained (for example, Aristotle 's cosmology, which placed the Earth at the center of a spherical hierarchic cosmos, or the Ptolemaic model of planetary motion) were transformed fundamentally during the scientific revolution.



The change to the medieval idea of science occurred for four reasons:

- ❖ Seventeenth century scientists and philosophers were able to collaborate with members of the mathematical and astronomical communities to effect advances in all fields.
- ❖ Scientists realized the inadequacy of medieval experimental methods for their work and so felt the need to devise new methods (some of which we use today).
- ❖ Academics had access to a legacy of European, Greek, and Middle Eastern scientific philosophy that they could use as a starting point (either by disproving or building on the theorems).
- ❖ Institutions (for example, the British Royal Society) helped validate science as a field by providing an outlet for the publication of scientists' work.



New Methods

- ❖ Under the scientific method that was defined and applied in the 17th century, natural and artificial circumstances were abandoned, and a research tradition of systematic experimentation was slowly accepted throughout the scientific community.
- ❖ The philosophy of using an inductive approach to nature (to abandon assumption and to attempt to simply observe with an open mind) was in strict contrast with the earlier, Aristotelian approach of deduction, by which analysis of known facts produced further understanding.
- ❖ During the scientific revolution, changing perceptions about the role of the scientist in respect to nature, the value of evidence, experimental or observed, led towards a scientific methodology in which empiricism played a large, but not absolute, role. The term British empiricism came into use to describe philosophical differences perceived between two of its founders—Francis Bacon, described as empiricist, and René Descartes, who was described as a rationalist. Bacon's works established and popularized inductive methodologies for scientific inquiry, often called the *Baconian method*, or sometimes simply the scientific method.



New Ideas

Many new ideas contributed to what is called the scientific revolution. Some of them were revolutions in their own fields. These include:

- The heliocentric model that involved the radical displacement of the earth to an orbit around the sun (as opposed to being seen as the center of the universe). Copernicus' 1543 work on the heliocentric model of the solar system tried to demonstrate that the sun was the center of the universe. The discoveries of Johannes Kepler and Galileo gave the theory credibility and the work culminated in Isaac Newton's *Principia*, which formulated the laws of motion and universal gravitation that dominated scientists' view of the physical universe for the next three centuries.
- Studying human anatomy based upon the dissection of human corpses, rather than the animal dissections, as practiced for centuries.
- Discovering and studying magnetism and electricity, and thus, electric properties of various materials.
- Modernization of disciplines (making them more as what they are today), including dentistry, physiology, chemistry, or optics.
- Invention of tools that deepened the understating of sciences, including mechanical calculator, steam digester (the forerunner of the steam engine), refracting and reflecting telescopes, vacuum pump, or mercury barometer.





The Shannon Portrait of the Hon. Robert Boyle F. R. S. (1627-1691): Robert Boyle (1627-1691), an Irish-born English scientist, was an early supporter of the scientific method and founder of modern chemistry. Boyle is known for his pioneering experiments on the physical properties of gases, his authorship of the *Sceptical Chymist*, his role in creating the Royal Society of London, and his philanthropy in the American colonies.





Galileo Galilei (1564-1642) improved the telescope, with which he made several important astronomical discoveries, including the four largest moons of Jupiter, the phases of Venus, and the rings of Saturn, and made detailed observations of sunspots. He developed the laws for falling bodies based on pioneering quantitative experiments, which he analyzed mathematically.



Key Points

- ❖ The development of astronomy during the period of the scientific revolution entirely transformed societal views about nature. The publication of Nicolaus Copernicus' *De revolutionibus* in 1543 is often seen as marking the beginning of the time when scientific disciplines gradually transformed into the modern sciences as we know them today.
- ❖ Copernican heliocentrism is the name given to the astronomical model developed by Copernicus that positioned the sun near the center of the universe, motionless, with Earth and the other planets rotating around it in circular paths, modified by epicycles and at uniform speeds.
- ❖ For over a century, few astronomers were convinced by the Copernican system. Tycho Brahe went so far as to construct a cosmology precisely equivalent to that of Copernicus, but with the earth held fixed in the center of the celestial sphere, instead of the sun. However, Tycho's idea also contributed to the defense of the heliocentric model.
- ❖ In 1596, Johannes Kepler published his first book, which was the first to openly endorse Copernican cosmology by an astronomer since the 1540s. Kepler's work on Mars and planetary motion further confirmed the heliocentric theory.
- ❖ Galileo Galilei designed his own telescope, with which he made a number of critical astronomical observations. His observations and discoveries were among the most influential in the transition from geocentrism to heliocentrism.
- ❖ Isaac Newton developed further ties between physics and astronomy through his law of universal gravitation, and irreversibly confirmed and further developed heliocentrism.



Uniting Astronomy and Physics: Isaac Newton

- ❖ Although the motions of celestial bodies had been qualitatively explained in physical terms since Aristotle introduced celestial movers in his *Metaphysics* and a fifth element in his *On the Heavens*, Johannes Kepler was the first to attempt to derive mathematical predictions of celestial motions from assumed physical causes. This led to the discovery of the three laws of planetary motion that carry his name.
- ❖ Isaac Newton developed further ties between physics and astronomy through his law of universal gravitation. Realizing that the same force that attracted objects to the surface of Earth held the moon in orbit around the Earth, Newton was able to explain, in one theoretical framework, all known gravitational phenomena. Newton's *Principia* (1687) formulated the laws of motion and universal gravitation, which dominated scientists' view of the physical universe for the next three centuries.



The Medical Renaissance

- ❖ The Renaissance period witnessed groundbreaking developments in medical sciences, including advancements in human anatomy, physiology, surgery, dentistry, and microbiology.
- ❖ During the Renaissance, experimental investigation, particularly in the field of dissection and body examination, advanced the knowledge of human anatomy and modernized medical research.
- ❖ *De humani corporis fabrica* by Andreas Vesalius emphasized the priority of dissection and what has come to be called the “anatomical” view of the body. It laid the foundations for the modern study of human anatomy.
- ❖ Further groundbreaking work was carried out by William Harvey, who published *De Motu Cordis* in 1628. Harvey made a detailed analysis of the overall structure of the heart and blood circulation.
- ❖ French surgeon Ambroise Paré (c. 1510-1590) is considered one of the fathers of surgery and modern forensic pathology, and a pioneer in surgical techniques and battlefield medicine, especially in the treatment of wounds.
- ❖ Herman Boerhaave (1668-1738) is regarded as the founder of clinical teaching, and of the modern academic hospital. He is sometimes referred to as “the father of physiology.”
- ❖ French physician Pierre Fauchard started dentistry science as we know it today, and he has been named “the father of modern dentistry.”

