

THE GIANT EHAP REVIEW OUTLINE!

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The Scientific Revolution

Definition of the Scientific Revolution

- The Scientific Revolution (1543 – 1687) was a period of time in which many breakthrough discoveries were made in science and philosophy, as well as an era in which the Europeans' perception of the universe and their role in it was changed forever.
- Although the SR began by only affecting the scientific and intellectual elite (5 % of the population or so) the concepts that originated during the SR eventually spread to all of the population.

Science Before the Scientific Revolution

- Prior to the SR, all scientific concepts came from either the Bible or ancient scientists. Since, during the Middle Ages, most of the works of other ancient scientists were lost, Aristotle, Ptolemy, and Galen became the only, and therefore ultimate, authorities, on their fields. The old beliefs came from:
 1. **The Bible** → naturally, the main source of information, in all respects, was the Bible, whose teachings were taken literally (for example, if a story stated that the world stopped spinning, Europeans believed that the world actually did stop spinning).
 2. **Aristotle** → was the greatest philosopher of ancient times. He was viewed as the absolute authority on physics, although many of his theories were clearly wrong! His theories included the belief that there was *no movement without a mover* (which fit in perfectly with church philosophy since it made it obvious that God was necessary to move the Earth) and that *in their natural state all objects were at rest* (i.e. all objects wish to be at rest, motion is an unnatural state which must be accounted for by an outside force at all times). He explained motion by the fact that each of the four elements (earth, air, fire and water) wished to return to its natural place (for example, a stone falls because it wants to return to the earth). Air and fire, he said, always wished to go upwards and earth and water wished to fall downwards. Aristotle believed in *teleological* (based on the fact that everything is made for a purpose).
 3. **Ptolemy** → a great astronomer from ancient times, he stated that the earth was the center of the universe and that the sun and all the planets moved around in *crystalline spheres*. Since this alone was not able to mathematically explain *retrograde motion* Ptolemy added in *epicycles* (circles within circles), which, through some very complicated calculations, could approximate planetary motion.
 4. **Galen** → though his influence was far lesser than that of Aristotle and Ptolemy, Galen's medical and anatomical theories dominated the scientific world for years even though they were proved wrong by dissections.

Causes of the Scientific Revolution

- One cause was that scientists were simply beginning to take note of the inadequacies of the standard theories, and, although they greatly preferred to make slight changes to the theories (vs. abandoning them) some scientists were beginning to question the old authorities.
- Still, it is unlikely that the scientists would have challenged the established theories without the influence of the other ancient scientists, especially Archimedes, (who were rediscovered during the Renaissance due to the humanists' efforts to find ancient works) that disagreed with the old theories.
- Another influence was the interest in what is now regarded as magic, but was then seen as serious science. These branches of science included alchemy and astrology, and were linked by the belief that the world could be understood through several secret truths (like Neoplatonism). These sciences contributed to the outpouring of new ideas, the questioning of the old theories, and the use of math.
- Lastly, the European interest in technology both stimulated and made possible the SR. New instruments and devices (printing press, telescope, vacuum pump, thermometer, barometer and microscope), often made for other purposes, were used in science and made possible many of the new discoveries. The interest in technology was actually stimulated by the competition between the different nations b/c applied technology was used in warfare.

The Major Scientific Discoveries

- **Nicolaus Copernicus** (1473 – 1543) → was a Polish priest and astronomer who shook the foundations of European beliefs. He challenged Ptolemy's system simply because it was *too complex* and he felt that there had to be a better system mathematically. So, based on mathematics, he developed a new, sun-centered system that placed earth as the third planet rotating around the sun. This system eventually ended up requiring

complex mathematics as well, but Copernicus was a great mathematician who easily defended his theory. Copernicus even began developing the concept of gravity, for he stated that *large masses have their own attractive forces*. However, he kept the crystalline spheres and did not account for the stars. His major work was *The Revolution of Heavenly Bodies* (1543 – start of scientific revolution), which, fearing the Church, he did not publish until his deathbed. The book sparked a major controversy, but, because of the Church, it was dangerous to express Copernican views openly.

- **Giordano Bruno** (1548 – 1600) → though Bruno did not actually develop any additional theories, he made the mistake of openly supporting Copernicus and ridiculing the old philosophy. The church arrested him, and after his refusal to recant, burned him at the stake, making him a lesson for others.
- **Tycho Brahe** (1546 – 1601) → stargazer who meticulously recorded star data for years.
- **Johann Kepler** (1571 – 1630) → a brilliant mathematician who developed the first theories of motion. With the aid of Brahe's star data (which he acquired since he was Brahe's assistant), Kepler came up with the theory that the planets moved in ellipses, and that they did not move at a steady rate. Instead, as they came closer to the sun, they accelerated, and they slowed down as they moved away. So, Kepler's First Law of Motion stated that the planets moved in elliptical orbits, and his Second Law stated that the planets sweep through an equal area of space in an equal amount of time.
- **Galileo Galilei** (1564 – 1642) → was the first scientist to use the telescope. With the telescope, he saw Jupiter's moons (the existence of which proved that not everything orbited the earth, as was previously thought) and the craters on the moon (which proved that heaven was not perfect). Based on his observations, Galileo concluded that the principles of terrestrial physics could be applied to the heavens as well. In 1610, he wrote the *Starry Messenger* and subsequently got in trouble with the Spanish Inquisition, which stated that it was not allowed to openly support Copernicus. So, in 1632, he wrote the *Dialogue on the Two Great World Systems* (supposedly a work of fiction, but obviously supported Copernicus). But this did not fool the church, for they forced him to recant in 1633 and made him spend the last years of his life under house arrest. There, he developed his *Theory of Inertia*, which stated that things in motion remain in motion unless acted upon by another force (implies that God is not necessary to move planets), which he published in *The Two New Sciences* in 1638. Galileo is really considered to be the first modern scientist, for he developed the scientific method of experimentation and was one of the first *mechanists* (how, not why).
- **Isaac Newton** (1642 – 1727) → brought to a climax all the previous works in his masterpiece, *The Principia*, which described three laws of motion (in the absence of force, motion continues in a straight line; the rate of change of the motion is determined by the forces acting on it; action and reaction between two bodies are equal and opposite) and a law of *universal gravitation* (which applied the concept of gravity to both the earth and the heavens). Newton also supported observation and experimentation, and helped further develop the scientific method.

The New Epistemologies

- The SR allowed many new epistemologies (theories of knowledge) to develop. First, the belief in *mechanism*, which stated that scientists should question how (not why) things worked, became more widespread, especially through Galileo and Newton. The opposite philosophy to mechanism is *teleology*, which stated that everything is made for a purpose, and was used by Aristotle.
- Mainly, however, the discoveries helped the scientific method develop. The scientific method, which was a new theory on how to obtain and verify knowledge, stressed experience, reason, and doubt and rejected all unsubstantiated authority. The scientific method revolutionized science, and made measurement of data, and mathematics, essential parts of science. From the SR onwards, science was based on pure fact – the acquisition of data and the testing of theories.
- The scientific method was actually a combination of two theories of knowledge:
 1. **Empiricism** (a.k.a. induction) → was advocated by **Francis Bacon** (who wrote *New Atlantis* a description of an ideal society based on science) and supported going from particular knowledge (observation) to general knowledge.
 2. **Rationalism** (a.k.a. deduction) → was advocated by **Rene Descartes** (who wrote the *Discourse on the Method of Rightly Conducting the Reason and Seeking Truth in the Sciences*) who stated that *senses can lie* and that the only way to find truth was to start from one fact, which was “I am doubting” and proceed to deduce all other statements – “I think, therefore I am.” Descartes also stated that there was an essential divide between the world of thought and reality (tangible objects). In other words, he took Bacon's statement that religion (faith) and science (fact) should be separate and turned it into a far-reaching divide between the reality of the world and our perception of it – i.e. The Matrix!

The Famous Empiricists

- Empiricism was a very influential epistemology, and soon, it was beginning to be applied to other fields, not just science. Actually, several individuals used empiricism to develop political theories.

- **Thomas Hobbes** → was a radical Nominalist who stated that *there are no abstract ideas*. Therefore, he was also an atheist (since God is an abstract idea – he must not exist). He also did not believe in abstract good or evil. Instead, in his *Pleasure-Pain Philosophy* he stated that, since abstract good and evil do not exist, the only good things are ones that bring one pleasure and the only bad things are the ones that bring one pain. Mainly, however, Hobbes used empiricism to develop a political system. Because, according to him, in the *state of nature* (w/out any authority) there would be a constant war of all-against-all b/c of competition, diffidence (fear), and vain glory (desire to show off). Nobody could ever win the war, for, although a *law of nature* exists which states that *if you want respect then respect others*, people, the terrible beings that they are, will break the agreement to get what they want unless there is an outside authority enforcing the law. So, the only solution, Hobbes writes in his masterpiece, *The Leviathan* (1651) is ABSOLUTE MONARCHY! Hobbes' absolute monarchy is not based on divine right, but, instead, it is based on a *social contract* (an agreement between the people and their ruler) in which the people agree that, since anything is better than the war of all-against-all, they will give up their natural rights to the government in exchange for protection. So, the government is all-powerful, but, in theory, they will never need to actually use their power, it is only a threat.
- **John Locke** → the next significant empiricist, he was somewhat a reaction to Hobbes' negativity. Locke began with the assumption that, at birth, each person is born with a *tabula rasa* (blank slate) and that all human nature and knowledge comes from either direct experience or from reflection. Therefore, since all beliefs come from experience, all beliefs are open to criticism (this was one of the most powerful arguments for equality and tolerance yet). Clearly, Locke was a great supporter of equality, toleration, and education (make good environments). Locke also used his ideas to write a social contract, like Hobbes. Locke's social contract, however, as stated in *An Essay Concerning Human Understanding* (1690) and *Two Treatises of Government* (1689), had almost nothing in common with Hobbes. Locke stated that, in the state of nature, people are neutral, since it all depends on the environment. Based on this, he said that, at birth, each person has *certain inalienable rights of life, liberty and property*. Since people must be forced to respect e/others rights, government is formed, to protect the rights. In his contract, government must protect peoples' rights, but not more, and the people must obey the government so long as it does not do more than necessary. If it does, people have the right to rebel and establish another government. The Declaration of Independence is pretty much just paraphrasing JL's beliefs.
- **David Hume** → was the dead end of end of empiricism. He stated that there can't be any absolute knowledge if everything is based on the senses. So, people can know things through common sense, but not through philosophy (which he says is a joke) and he hates dogma.

The Effects of the Scientific Revolution

- People felt that human understanding of the universe could be reduced to mathematical laws.
- The universe was no longer appeared to be a mystery. In fact, people felt that it was orderly, rational, and, most importantly, could be understood by humans.
- People felt that humans were able to control their own destiny.
- The concept of *natural laws* developed. These laws, which were similar to the laws found in science by Newton, could govern other aspects of life as well, such as economics, politics, or ethics.
- Science gained wider appeal and unprecedented popularity. Additionally, science was institutionalized, and scientific societies sprung up throughout Europe, on both the national and personal level. The institutions greatly helped the rate of progress.
- **Positive effects of the SciRev** → gain of knowledge, greater toleration (both religious and scientific), less superstition and more scientific answers, and freedom to deviate from established theories, which opened the door for new, further developments.
- **Negative effects of the SciRev** → loss of innocence, loss of traditional faith, loss of faith in heaven, earth is no longer regarded as the center (God's pet project), skepticism, loss of personal/caring God.
- Overall, however, the SR was an **era of optimism** that gave way to an Age of Reason in the 18th century. People living during the SR felt that they had surpassed even the ancients and were at the peak of human knowledge, and ideas of progress dominated intellectual discussions.

The Arts During the Scientific Revolution

- **Mannerism** → a reaction to the glorification of humans seen in the Renaissance, Mannerism featured distorted human figures, strange perspectives and unnatural colors and lighting. Mannerism reached its peak during the instability of the Reformation, and it reflected the concerns of a troubled time. The major Mannerist painter was **El Greco** (1541 – 1614).
- **Baroque** → a reaction to Mannerism, the Baroque style occurred during the Counter Reformation, and it reflected the desire for grandeur and the wish to inspire and awe people with God's greatness. A famous baroque painter was **Caravaggio** (1571 – 1610) whose paintings were famous for their depictions of highly emotional moments. Other famous baroque painters were **Rubens** (1577 – 1640), and **Velázquez** (1599 – 1660),

who glorified church figures and rulers. **Bernini**, a baroque sculptor and architect, did the inside and outside of St. Peter's Cathedral in Rome.

- **Classicism** → like Baroque, Classicism attempted to awe the viewer. However, like the Renaissance, it attempted to awe the viewer with form and discipline – also they wished to return to ancient values. Big guy was **Poussin** whose paintings were more subdued than the baroque guys (he liked togas).
- **The Dutch** → b/c of Protestantism and republicanism, Dutch art was less religious (if religious only personal faith, not that of Church obviously) and more precise b/c big buyers were bourgeoisie (merchants not dumb nobles). Big dude was **Rembrandt** who pretty much just painted pictures of himself (pretty conceited, but really was just fascinated by human character and lighting).
- **Monteverdi** → invented concept of opera and orchestra, after many new instruments were invented. His masterpiece was *Orfeo* (1607).

The Literature During the Scientific Revolution

- **Michel de Montaigne** → invented the essay (what did he have to do that for?); influenced by *skepticism* (“What do I know?”) which eventually led to search for self-knowledge (“Know thyself”) and his belief that acting righteously is more important than following doctrine (sometimes).
- **Cervantes** → wrote *Don Quixote*, which illustrated the wide gaps between rich and poor and the difference between reality and fantasy of his time by poking fun at society and politics (he thought that politics disregarded human values).
- **Shakespeare** → wrote plays that made timeless statements about human behavior and covered a very wide range of topics and emotions. However, his plays also reflected his time as death, turmoil and change were always present. Also, the vigor in his plays showed the sense of achievement that also characterized the 1500s (don't ask what achievements, please!).
- **Corneille** → was the dominant French playwright of the 1600s whose work reflects the rise of classicism. At first, he refused to follow the three new set rules for drama (unity of time, location and plot). His masterpiece was *Le Cid* (1636) which was condemned by Richelieu b/c it did not follow the three rules. But, *Le Cid* was still very popular.
- **Racine** → the model classical dramatist who still generated very emotional stuff.

Social Patterns and Popular Culture During the Scientific Revolution

- Population decreased after the 16th century. In the 17th century, population began to rise again, leading to overcrowding in the cities, bigger armies, increased crime, more taxation (but food prices didn't rise = bad for peasants), and beggars (not enough food for peasants).
- Also, during the SciRev, social status became mobile because it became based on wealth and education as opposed to family heritage. The emphasis on education led to a higher literacy rate, which led to the start of newspapers and book sales. Woman also gained opportunities (in business).
- In the East, peasants were reduced to serfdom, and in the West, many were forced to go into the cities in search of a job (leading to chaos @ cities) and village unity decreased b/c of increased population and national intervention for law enforcement (intendants).
- In the village, ancient traditions held fast, for example, the belief in magic and the yearly festivals such as Charivari. Like Calvinism, villagers felt they couldn't control their own destiny (unlike SciRev, the beliefs of which had not spread to the village yet), which led to witch hunts that eventually subsided when the SciRev and Counter Reformation (b/c now better educated priests who knew what the hell – get it – they were talking about) spread to the village.