hist-3a notes

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aristotle

before true understanding can be reached, we need to understand the causes of the object. there are 4 causes:

1. material cause: the materials an object is comprised of. (eg. table -> wood).
2. efficient cause: what effects brought about the object. (eg. table -> carpenter)
3. final cause: the purpose of the object, what it will become (eg. seed -> tree).
4. formal cause: the platonic form of the object, what makes the object the object. (eg. table -> design?)

medieval world: hierarchy, and order

aristotelianism

7 liberal arts

1. trivium, more 'liberal arts'. grammar,
2. quaternium, more 'mathematical'. music, etc.

math wasn't really held in a good light, bc it predicted but didn't tell us the reasons.

hierarchal worldview was supreme; the more separation between components, the better. this didn't hold up well as the town 'commoners' began to acquire economic power. their ideology of 'everyone knows their place' didn't exactly coincide with the real world and its warlike inhabitants. as the worldview of the people became larger and they saw more imperfections in the world around them (such as the black death, which killed hordes in 3 days), their view began to crack. - peasant rebellions after black death, justified by "we're all children of adam and eve", put cracks in the natural order. however, they were *always* suppressed quickly; none of them had ideas of alternative societal setups, just grievances with the current ones. with nothing to fight *for*, they lost.

those who opposed the aforementioned way of life were known as 'humanists'. they looked back at antiquity and the ancient world, and tried to bring about a revival. prominent humanists included petrarch, poggio bracciolini, and erasmus.

the humanist challenge

at the time, education was somewhat elitist; mainly focused on obscure points about christian theology (eg. 'angels on a pin', etc). they insisted on proper transations in obscure languages, etc. humanists weren't a fan of this; they believed education should cover how to live a good life, and should be applicable to all. they cited precedents set by cicero and other ancients, who thought of rhetoric more as a core value rather than a 'base' topic. the idea that one's intellectual and philosophical views should be applicable towards one's daily behavior formed the core tenet of a movement known as *civic humanism*.

reformation

geneva tried to establish an ideal christian community; 'city on a hill'.

john calvin

- ideas spread organically, not sponsored by the state (as happened to martin luthor). known as hugenots in france.
- more radical than luthor.
- his chair had a rigid back. looks uncomfortable.

the catholic henry viii was married to catherine of aragon. catherine couldn't give him an heir, so he sought to get his marriage anulled (retroactive: 'your marraige never existed in the *first place*). unfortunately, charles v (catherine's uncle) didn't like this, so he put pressure on the pope. the pope refused, so henry made his own church with himself as his head (church of england, anglican church). his original goal was to copy everything from catholicism *except* the pope, but over time the anglican church became more protestant-style anyways (eventually codified in 'elizibethan compromise'. culturally, looked towards geneva.

after the reformation started overthrowing the existing religious hierarchy, the people thought that overthrowing the *social* order followed naturally. there was a peasant uprising in germany, and the peasants called themselves 'lutherans'. martin luther wasn't pleased. he wanted to spread his religion through political allies; he wasn't interested in peasants rising against their 'betters'. he denounced them, and was by all accounts pretty happy when they were crushed.

a similar splinter movement, the anabaptists believed *they* were god's elect; only those who *chose* to go with them (by baptizing themselves as adults, not as children (as is common)). they took over the city of 'munster', instituted communism, polygamy, and a bunch of other radical ideas. they violently suppressed all other views, and were taken down by a protestant-catholic prince alliance.

reformation: was a 4-fold crisis

1. religious crisis: authority of rome was challenged, no good way to tell which of of the 'only way's was true.
2. political crisis: when political power is derived from religious power, this lead to political crises.
3. this led to a social crisis: the church set the framework for the current social order (this is the way!). once it was challenged, peasant rebellions began.
4. more fundamentally, these were all *intellectual* crises.

- where does authority reside?
- who can we trust in a world of so many competing claims and creeds?
- how can one know anything anymore? the old authorities that describe everything we know are being turned on their heads. humanism undermined the teachings of the schools, exploration and sciences undermined the teachings of the ancients (scientific principles, world radius, etc.), the reformation undermined the current social/religious order. who do the people turn to? epistemological crisis.

the answer to the last question makes up the rest of the course. science filled the void.

astronomy

represented, in some ways, more fundamental questions about the natural world.

most stars seem to rotate around us every 24 hours. some (such as the sun and other 'stars' called *planets*) have other aberrations; they don't rotate *with* the others, but seem to slow and 'rotate' backwards in a phenomenon known as *retrograde motion* (earth's orbit catches up, parallax effects, etc).

geocentric system

planets rotate on fixed 'shells' around the earth. view of 'perfect' motion. very convenient from a theocratic perspective; god was 'above', in the perfect heavens, while disorder increases towards the middle (at the center, then, is hell). idea of clearly defined 'place' for everyone also fit in nicely with social hierarchies of the time. however, it didn't hold up well to the nuances of actual planetary motion (retrograde motion, irregular periods of planets, why inferior planets were always close to the sun, why planetary brightness changes, etc). because of this, they added some compensating factors to make sure the model could hold up to the real world.

- deferent: the celestial spheres don't rotate *exactly* around the earth, they rotate around another point. this circle system was the 'deferent'.

- epicycles: to account for retrograde motion, they thought the planet moved in a small loop as it orbited in the deferent (like the homer simpson fourier transform). these also (to some extent) explained changes of brightness (as the planet gets closer and farther from earth).
- eccentric: because the seasons aren't of the same length, the sun couldn't be orbiting us at a constant speed. if they assumed it orbited perfectly around a slightly *offset* point (ie. not in the earth), the math worked out.
- equant: planets don't seem to move at the same speed around the earth. assume a point 'q'. if you look at the orbits from this particular point, they will appear to be moving at a constant velocity (fixed angular velocity relative to the point). this point is the equant.

however, these compensating factors were hacks, and ugly ones at that; they led to contradictory results (eg. how can 2 circles of the same sizes that orbit different points somehow not intersect/crash into each other?). more generally, the system was descriptive and not prescriptive.

heliocentric system

puerbach and regiomontanus were astronomers that specialized in the ptolemaic systems; they began to think of the system less like a model and more of what 'is'.

nicholas copernicus: educated in krakow (a humanist learning center). became a relatively respected mathematician while working in an italian court. leading astronomical consultant, advised the pope on astronomical matters (mainly dealing with how to deal with the calendar's inaccuracies regarding the date of easter, etc). wrote a short manuscript about his views about the cosmos, but never published it — he feared his ideas were too radical, and would disturb his quiet life. the manuscript was passed around in academic circles, and copy landed in the hands of a catholic cardinal named schoenberg, who encouraged copernicus to publish. another clergyman named osieander eventually helped get the manuscript published, and added a foreword/disclaimer to the text: ~'this isn't how it actually works, just a calculating device'. the disclaimer is intended to shield copernicus from the ridicule and power of the church. copernicus didn't like this: his view was that astronomy was intended to *deduce* the structure of the universe, not just describe it (as per Aristotelian views).

copernican system also didn't work, because they assumed circular orbits. thanks to kepler, we know orbits are elliptical and vary in speed. this meant that copernicus actually needed *more* epicycles than ptolemy. it also seemed to imply that stars should have visible parallax (nobody at the time imagined the stars were as far away as we know them to be now).

that said, there were still advantages. it explained the varying period of the superior planets (because the orbit of the earth slightly offsets us from the outer planets. it also let us figure out the period of the inner planets.

magic

varieties of renaissance magic:

1. spiritual or demonic magic:
2. mathematical magic: this encompassed the science of automatons, numerological predictions, horology, and calculations.
3. natural magic: encompassed the forces in nature, such as lightning, the human body, and other 'unexplanable' phenomena. this could be understood with experimentation and authority.

this knowledge wasn't disseminated to all, because command of them was deemed too dangerous and because not all had the capability to learn. because of this, it was said that *magi* (singular: *magus*), learned men, had command of these magical forces. they gained power by understanding the sympathies between different objects (walnut was linked to the brain, because it looked like a brain).

magicians, alchemists, and their worldviews

hermes trismegistus: after the fall of constantinople, there was an exodus of scholars from the byzantine empire. in the 1460s, the 'Corpus Hermeticium' (book) was brought to the Medici family in florence. it was translated, and revered; the book was thought to have been written by an ancient egyptian magician. in reality, the book was written by some dude in the early middle ages; hermes never existed. he claimed that all physical

creation was shaped by astrological forces. the power of the stars/planets came from god — however, human worldly desires corrupt us from the astrological influence. by purifying oneself, a human could become a magician with great power.

paracelsus: 1492-1524. named himself 'paracelsus' to make himself sound more authoritative. wandering renaissance magician inspired by hermes trismegistus. wandering mainly because he kept getting kicked out of towns after being called a fraud. he believed that the world wasn't a 'solved problem'; he had to learn and discover the hidden forces behind nature. he believed in three primordial elements, *tria prima*: sulphur, mercury, and salt.

- salt: unburnability, unreactivity. corresponds to our body and 'base' thoughts.
- sulphur: combustion, fire, heat. corresponds to the soul and emotions.
- mercury: metallicism. corresponds to the spirit (intellect, thoughts, etc).

as per paracelsus, the three elements don't show up neatly in nature. it's the job of the alchemist to purify the world and the self.

this was a sharp break from previous views of medicine, which were chiefly *galenic* (followed the teachings of an ancient named galen). 4 humors.

andreas libavius: 1555-1617 and **jean baptiste van helmont**. other alchemists.

samuel hartlib: 1600-1662. a merchant, part of a very intellectual social club known as the 'hartlib circle'. alchemist, tried to make alchemy mainstream, but went about it in a different way. believed alchemy was a universal truth; it promoted the unity of all things and all people (as opposed to the previous views, which thought the truths of alchemy were held as secrets, and could only be known to certain classes of people. the circle included and influenced some royal society members, who borrowed the 'universality' of his scientific views.

william gilbert: 1544-1603. tried to understand the behavior of the compass, publishing a treatise that claimed the earth was a giant magnet. wrote a treatise about static electricity, magnetism, and the compass. precursor to today's scientists, but was in many ways the last magician. believed the earth was alive, and magnetism was one of its hidden 'sympathies' that influenced the soul of the earth. followed paracelsus, tried to learn from everyday knowledge.

magic: tldr

differed from aristotelianism in that the world wasn't treated as 'solved' anymore. looked at the world around them to discover secrets, not just for the hell of it, but to make tangible improvements to their lives.

questions	aristotle	paracelsus/magicians
nature of world?	mechanisms known	full of secrets
why study world?	to categorize	to discover
why knowledge?	for the sake of it	for practical reasons
source of knowledge?	the ancients	observation, revelation

francis bacon: a new way

1561-1626, lord chancellor of england. born into aristocracy, studied at cambridge. good connections, but couldn't get any career advancement under queen elizabeth; after king james took the throne, he moved up the ladder all the way to lord chancellor of england (the highest legal position). due to political enemies, was removed from office in 1621, charged with corruption, and rumored to be a pedophile. nontheless, created the *baconian method*, influencing scientific development and making it mainstream.

societal advancements in europe

the spanish had, by the mid-to-late 1500s, amassed a large naval presence; the rest of the europeans were late to the international colonization mindset. the english noticed this, and decided to catch up (spanish tried to invade europe with the spanish armada; while they were defeated by a storm, the english realized they were in an

arms race). francis drake circumnavigated the globe, 1585, walter raleigh colonized virginia, setting up the first permanent colony in the US.

this caused an intellectual cultural shift as well. focus towards practical discovery; just as the material globe was being explored, scholars should strive to discover new things.

the spanish and portugese were some of the first ones to this new thought process. the spanish government set out a systematic effort to create, collect, and update maps of the new world, keeping these maps in secret vaults to protect them from the english.

bacon and the new culture

enjoyed the new focus on practical knowledge. as an example, he listed gave three baconian inventions that gave countries enormous practical advantages over others: the cannon (created military advantage), the compass (eased navigation, opened up the world), and the printing press (allowed for the creation of books, which had previously been rare commodities). they arose by chance, by individual genius; bacon wanted to make a system of learning where these technologies could be systematically expored.

ran into problem: aristotelianism was inherently useless in that regard. it was designed only to explain the existing, not expore the new. aristotle's basic logical syllogism goes as follows:

1. all reptiles have no hair.
2. snakes are reptiles.
3. snakes have no hair.

this *starts* with a general rule; it's an deductive process that takes rules as a given. to discover new rules and new ways of thought, we have to invert the syllogism, in an *in*ductive form of knowledge seeking, going from particular instances to general phenomena. he published all these thoughts in a book called *the new organon* in 1620 (an *organon* is an instrument of thought, like a system of logic). in the baconian system:

1. individual instances of a phenomenon are observed.
2. certain facts are generalized into 'first vintages'. false facts and vintages are culled as counterexamples are found.
3. long-lived vintages are adopted as axioms (although they are mainly referred to as theories now).

bacon believed that all generalizations are implicitly inductive; he sought to formalize this induction in experimental methods. he warned of several pitfalls:

1. idol the tribe: flaws intrinsic to the tribe of man — our senses, fallible memory, etc.
2. idol of the cave: personal fallibilities — individual preference, the environment in which we were raised, education, etc. for example, our political views are shaped by our experiences growing up.
3. idol of the marketplace: language limits our worldview; before we have a word or new notation for something, we have a tendency to be locked in to our old worldview (eg. spacetime).
4. idol of the theatre: dogmas, entrenched systems of beliefs.

any person, no matter how intelligent or wise, is always vulnerable to these idols. if we make the search for knowledge a collective effort, then we can guard each other from these idols. different biases will balance out, and people can watch each other. imagined an institute of knowledge, *salomon's house*, where the 'gatherers' gathered knowledge, passed it onto the 'combiners', who pushed their trends up to the 'interpreters', who would produce practical inventions. he was skeptical of math; in his opinion, it dealt with generalities as opposed to working with the world.

in practice, however, collecting large amounts of data didn't tend to magically give you any conclusions, and the ones you drew were arbitrary at best. because of this, bacon's work was forgotten relatively quickly, remaining niche.

civil war

the 1660s were a tumultuous period in england, marred by a civil war.

beginnings of the war: in 1640, king charles convened parliament so they could raise funds. parliament immediately ruled that king charles had no authority to dissolve the parliament session, beginning the 'long parliament', where the parliament stayed in session for 10 years. the parliament went to war with the king, and other political, religious, military, and socioeconomic groups decided to take advantage of the instability and joined the battle.

in 1649, king charles was captured and beheaded by parliament. they voted oliver cromwell as a military dictator, giving him enough power to crush the other rebelling factions and bring stability back to england.

the royal society

in the midst of these unstable times, a group of men started gathering in london. they didn't discuss anything political (very cognizant of the divisive effect politics were having on their society), instead only talking about the study of nature. they met in gresham college.

some notable scientists included:

- **robert boyle**: created mechanical devices, measured air pressure and temperature. realized the inverse correlation between gas pressure and volume, which is today called boyle's law.
- **robert hooke**: created a microscope, first saw the enormous diversity of microscopic life, discovered cells. published *micrographia*, a treatise.

most of their observations weren't systemic; recorded anomalies like two-headed calves, but didn't really do much with that information. even robert boyle, a very systematic person, didn't make concrete judgements; while he said the air could be *modelled* as a collection of discrete springs, he didn't try to generalize his results. overly fearful of generating dogmatism; aristotle's thought had suppressed progress, and political/religious dogmas were behind the civil war. this led to conflict with a new scientist, **isaac newton**.

newton split light into a color spectrum, and demonstrated how each color couldn't be split up further. however, he believed he had found *the mechanism* behind light; the royal society reluctantly admitted him, but thought his offhand proclamations of absolute truth and dogma were irrational and dangerous (the fact that newton was an ass to people with competing theories didn't help). they feared he would become an absolutist like thomas hobbes.

thomas hobbes

thomas hobbes (1669) was a philosopher who took the opposite route to the royal society. where the royal society looked at the civil war and pinned the blame on too much dogma, hobbes believed strife was because of too much freedom for dissent. he idealized euclidean geometry as presenting absolute truths, and carried this absolutist world view to the political scheme. believed there should only be one truth, and discussion & dissent were the causes of conflict. he believed in the *leviathan*: once the ruler of a land took something to be true, the law should be the will of the people. dissent is by his definition as impossible as the dissent of the human body from the will of the human mind. science should go from absolute certainities, instead of from the RS's observational method. was actually friends with bacon, the funder of the royal society; the 'enemy at home'.

rené descartes

another enemy of the royal society. grew up in a jesuit school, learned aristotle and mathematics. part of the intellectual elite in paris and holland.

read from other scientist/philosphers such as **isaac beckman**: corpuscular theory of physics; all phenomena stem from the movement of tiny 'corpuscules' (eg. color is corpuscules of different shapes hitting the retina). he described the world entirely mechanically and geometrically. descartes looked at beckman's work, but thought there was no certainty in knowing if his was the 'correct' explanation.

he took another page out of the book of **sextus empiricus** (160-210 c.e.), one of the first documented 'skeptics'. he believed that we don't really know *anything*; our senses are fallible, as is our reasoning. descartes integrated this into his rules of reasoning, with which he tried to reach the truth:

- never accept anything as true absent evidence of its truth.
- divide each difficult concept into as many parts as possible.

- reason from simple parts into complex parts.
- be sure to never leave anything out of your reasoning process.

this process is known as 'cartesian doubt'; *extreme* doubt. maybe you're in a dream. maybe you're not? who knows? descartes believed the only thing we could know for sure our own existence. he digs himself out of this hole using god. descartes knows he is imperfect, because he doubts. this implies the idea of perfection, which couldn't have been thought of by him (because he is imperfect). something 'more perfect' than him couldn't originate inside him, so there must be an absolutely perfect object outside the self. that must be god. the conception of a perfect being assures god's existence, and a perfect god cannot be a deceiver because deceit is a flaw. therefor our clear and distinct ideas must be true, as god guarantees their truth. falsity must then arise from ideas that are obscured by our own imperfection. we can avoid falsity by starting on ideas that to us are clear and distinct to us (such as basic geometrical axioms, etc), and deriving things above. in this way, he favored a deductive approach; experiment was only a means to find out which truth was the 'correct' one.

this was formalized in descartes' physics. as per him, matter is extension in space, space is matter (we know matter exists bc otherwise god would be a deceiver). matter is endowed by god with a fixed amount of motion.

here's a brief comparison that might prove helpful.

Bacon	Descartes
senses	reason
empiricism	rationalism
not-math	math
collective research	individual reasoning
pluralism	dogmatism (one truth)

tycho brahe

1546-1601. born into the highest nobility. kidnapped and raised (parents seemed fine with it), by his uncle. very loud, fought in duels and got nose cut off. wore a gold and silver prosthetic nose. didn't want to deal with nobility, wanted to make astronomy respectable.

in 1572, a star went supernova and formed the crab nebula. it was briefly the brightest object in the sky (below the moon). because the heavens were perfect, people were convinced it was a meteorological phenomenon (in the upper atmosphere). he waited one day for the earth to rotate, then noted the lack of parallax, concluding the light was indeed in the heavens. coincidentally, halley's comet passed the earth. he *did* find parallax, but it was smaller than that of the moon, meaning that the comet was farther than the moon but closer than the stars. used the fame from these two discoveries to approach the king, somehow persuaded him to give him an island to build an observatory on. tycho moved to hven, this island, and constructed 2 complexes: uraniborg and stjernborg. build a giant underground laboratory with an enormous building sized *quadrant* (projected a telescope onto a giant compass) for calculating exact positions of celestial objects.

he began to doubt the copernican system when his telescope failed to observe any parallax when observing the stars (he didn't realize how *immensely* far away the stars were). this prompted him to create the *tychotic system*, in which the sun and moon orbited the earth, and all other planets orbited the sun. this was pretty much the same as the copernican system, but had fixed stars (and now that the sun was in the middle, he could reconcile astronomy with religion). over time, he developed enemies, so went on to serve an emperor of the holy roman empire (a clear step up). he lived the party life, decided to keep drinking instead of going to the bathroom, got an urinary tract infection, then died. what a way to go.

johannes kepler

imperial astronomer for holy roman emperor rudolph II. turbulent years for the holy roman empire.

more of a theoretical astronomer than tycho brahe (who was very much a baconian). believed there was a mathematical basis for reality — god created the world according to mathematical principles. believed the order of the planets was determined by nested platonic solids (if you nested the platonic solids, the planets orbited

each other at precisely the ratios of the inscribed circles). this turned out, purely coincidentally, to be *nearly* true (at least as far as their instruments then could detect).

tried to calculate the orbit of mars. this turned out to be difficult.

1. the planets sweep out equal area in equal time
2. $$P^2 = kA^3$$

   P = period, A is the length of the semimajor axis of the orbit of a planet. published it in *harmonicus mundi* (harmony of the world). believed the universe was music that was only in harmony when created by god.

galileo

born in pisa. not really famous for one particular invention, most famous for his clash with the church, became a scientific martyr.

professor of mathematics, taught in pisa and then padua. taught aristotelianism as per the university curriculum, but began to despise it in his free time. looked towards archimedes for inspiration, began to see the universe as something that could be modelled by mathematical laws. believed mathematics was necessary in order to understand the world (upending math as the 'base' science it was under aristotelianism).

used water clocks to measure the speed of falling objects, and realized the quadratic relation about the speed of falling bodies. didn't want to teach, so tried to get the favor of a king and become a royal astronomer (with much more pay, and much fewer duties). heard about a magical tube that made far things appear close by. reverse engineered and created his own telescope, immediately turned the telescope upward. he presented himself as the columbus of the heavens, marketing this exporation towards royals.

he saw the moon, noticed the mountains, and used geometry to calculate the size of the impact craters there. he looked at the sun and discovered sunspots. he looked at the milky way, and saw billions of stars. he finally looked at jupiter, and discovered 4 of jupiter's moons. now that he finally has some creations, he can quit his job at the university and live under prince medici.

in 1616, cardinal bellarmine, a high church official, warned galileo about the political dangers behind supporting the copernican model. as per the literal view of biblical scripture, the sun moved around the earth; if there was *proof*, the church would probably reinterpret scripture, but only the church got to make that decision.

galileo responded with the doctrine of two books: scripture and nature cannot conflict because they both come from god. if they appear to, we should trust nature; scripture is metaphorical, nature is very much not.

bellarmine shot back: while galileo's argument in theology is logical he doesn't have the authority to make these decisions or arguments (only the church high-fathers can reinterpret scripture). in 1616, he bans copernicus' book *De Revolutionibus*, and galileo is let off — he is not branded a heretic, but is given a a very stern warning about adhering to copernicanism. for a while, galileo listens; he moves on to other topics such as atoms, etc.

7 years later, in 1623, a new pope (urban viii) is elected. he is a friend (some would say fan) of galileo's, and grants him many favors. now that galileo has more favor with the church, he asks his friend whether he can resume work. he receives a noncommital answer, and publishes 'a dialogue on the two chief world systems', a direct book on copernicanism, in 1631. he presents it as a dialogue between three people; 'simplicio', the figure advocating for the older view of the heavens, is repeatedly presented as an idiot throughout the book. in the final paragraph of the book, he adds a disclaimer: ~'while reason tells us the copernican system is true, only god knows the answer). it's appended to appease the church, but was obviously meant to be discarded from the text. in addition, simplicio delivered this final line; the church (correctly) saw this as an aggressive jab at their view of life.

the pope was offended by simplicio, and saw the stated incompatibility of science and religion as a direct personal jab. the political climate didn't help, 1631 was in the middle of the 30 years war between the catholic emperor and the protestant princes. the pope previously tolerated more radical views because he didn't want to be seen as too associated with the emperor. in 1631, the king of sweden invaded the catholic bavaria, and the pope suddenly had a lot less confidence in his military authority. when conservative cardinals confronted the pope and pressured him into taking a harder stance on heretics, the pope unhappily agreed. while the *dialogues* had already been approved by censors, the church claimed false pretenses and summoned galileo to rome to be interrogated. he

was tried for violating cardinal bellarmine's 1616 instructions. he was branded a heretic, and lived the rest of his life in house arrest.

why did the galileo affair become so famous? galileo became a martyr for new factions that (while not necessarily *openly*) started to view any religion as a tool that was used to suppress politically inconvenient knowledge and keep power. galileo wouldn't have sided with any of these people; he himself was a lifelong catholic, but then again — the convenient thing about martyrs is that they aren't really around to disagree with you.

christiaan huygens

studied optics and mechanics, discovered the rings of saturn.

newton

1642 born to farmers. extremely religious. read scripture and the history of christianity, believed that both catholic and protestant churches were heretical and didn't understand the real nature of god. to become a fellow at cambridge, had to be ordained as an Anglican, and refused to do so. very 'strong willed' (read: flexy), put his name everywhere.

1660 became a student at cambridge. curriculum was aristotelian, but there was academic freedom outside the curriculum. interested in newer philosophy, took advantage of this interest after university went on break due to a cholera epidemic. 1665-1666, had his *anni miriablis* (miracle years), creating:

1. the method of fluxions and fluents (the calculus).
2. the composition of light, used the results to build the first reflective telescope (immune to most chromatic aberrations).
3. centripetal force formula, mv^2/r.
4. gravitational inverse square law. now that he knew the centripetal force, he could calculate the force on the moon, using this to derive the constant of gravity (using the gravity on the earth's surface). doesn't publish this yet.

the royal society sent edmund halley to meet with newton. in discussion, newton proved all three of kepler's laws, the inverse square law, and much of calculus. kepler, excited, asked him to publish the results; after 2 years of work, the royal society printed newton's *principia mathematicia*. he does all of the above, the demonstrates the three laws of motion.

1. inertia
2. f=ma
3. equal and opposite reaction

using this and the inverse square law, he successfully created the modern model of the solar system (later to be confirmed after the advent of space probes). this blew the minds of people who could actually understand the text; it unified most of physics and astronomy into a single useful theory. newtonian universe:

- geometrical space, infinite and defined by coordinates.
- infinite, not just boundless (as descartes said).
- space is prior to matter, and is independent of it. space can exist without matter (unlike descartes, vaccums could exist in newton's world). TODO there was more bhai

combined baconianism (focus only on observations) and cartesianism (focus only on math reason) into newton's scientific method. take laws from nature, use math to extend them and use them to predict other phenomena.

system depends on principle of gravitation. newton wasn't able to explain why gravity occured; in a way, it seemed like a magical force (descartes followers used this to diss newton's theories as a paracelsan step backwards). newton didn't hypothesize as to why it worked (privately believed universal attraction was the will of god), which he and the church liked; it seemed as 'proof' of god's existence. In addition, he realized tidal locking and orbital decay meant that a stable solar system required god's periodic active intervention. we now know that the solar system is stable thanks to laplace.

the anglican church loved this view; they didn't want the new revolutionary 'god is everywhere' god, and they wanted an active god that would answer prayers (both leading to more followers). this was newton's primary

benefit; he presented a logical god that supported class distinctions while also intervening for everyone (god is a king, we're anglican and we have kings whoo).

science in the mid-17th century

several factions. the **cartesians**, followers of descartes and his imperial view of the one true truth.

- matter is extension in space
- everything is matter in motion
- only mechanical interactions exist, no action at a distance
- world is geometrical, can be described with math
- experiments are used to choose between different explanations.

the **baconians** followed bacon, and adhered to his doctrine of uncertainty and results.

- systematic and institutionalized knowledge, eg the royal society.
- very wary of certainty; viewed it as a slippery slope towards eliminating dissenters.