Vesalius College
Brussels

NSC-202E

History and Philosophy of Science

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Lecture Notes by Koen Lefever

NSC-202E: History and Philosophy of Science – Lecture notes

A. Origins of Science from Ancient Times to the Middle Ages

Science tries to answer questions on how things work and why they are the way they are. This it has in common with religion. Technology is the application of science to change the world, in the same way that ritual and magic can be seen as applications of religion. In the earliest times, these distinctions were not existing.

When mankind stopped its nomadic life style, started to live in settlements and started to do agriculture, this also lead to new organizations and structures and to take longer periods of time into perspective (not just finding food for today, but sowing food for next year, storing it in the mean time, predicting the weather and floods...) Around 7000 BCE, mankind started to domesticate maize. In prehistoric times (that is, before the invention of written language), astronomy had already started (e.g. Stonehenge). There was not yet a difference between astronomy and astrology.

A.1. Mesopotamia: Sumer & Babylon

In the Near East, the first civilizations started. Around 3500 BCE, numerical data out of observations started to be recorded. The Plimpton 322 clay tablet contained "Pythagorean triplets" such as (3,4,5) and (5,12,13), but the theorem of Pythagoras was not yet proven in its general form. Babylonians created the Venus tablet of Ammisaduqa in the 17th century BCE, which contains observations of when Venus would rise and set; around 1200 BCE they started to create star catalogs. They created lists of the length of daylight, the appearance and disappearance of moon and planets and they also recorded eclipses of the sun and moon.

During the second millennium BCE, they started to write medical handbooks, such as the "Diagnostic Handbook" by Esagil-kin-apli. These text were not yet scientific, they contained exorcism and magic.

A.2. Egypt

Geometry was important, because the Egyptians needed to record the ownership of the fertile lands on the banks of the Nile, which would flood annually.

The first medical text which was void of magical thinking, was the Edwin Smith Papyrus around 1500 BCE (ascribed to Imhotep, who lived around 2650-2600 BCE and who was also the architect of the Pyramid of Djoser).
19th dynasty (1300-1100 BCE): medical insurance, pension, sick leave

A.3. Presocratic Greece

City of Miletus, 6th & 5th century BC: the Ionians had contact with other cultures: question of identity, of unity in religion and morals ⟶ start of science and philosophy.

- Thales of Miletus, 640-546 BCE:
  - land floats on water, turbulence in the water causes earth quakes – before earth quakes were attributed to the anger of the god Poseidon
  - Predicted sun eclipse of May 28^{th} 585 BCE
- Anaximander of Miletus 610–546 BCE: map of the world
- Anaximedes of Miletus, 585-528 BCE
- Hecataeus of Miletus and Xenophanes of Colophon opposed sophists, relativism:
  - Alètheia: that which is not concealed, truth
  - Theoria: seeing
  - Historia: research
  - Cosmos: beautiful ornament (root of the word "cosmetics")
- Hecataues of Miletus & Herodotus of Halicarnassus (5th century): history

Move from poetic texts to prose.

Pythagoras of Samos:

- Earth is spherical
- Harmony of the spheres, harmony in music
- incommensurability of the number two (square root of two is an irrational number)
- Theorem of Pythagoras: $c^2 = a^2 + b^2$ where c is the length of the long side of a rectangular triangle & a and b are the lengths of the sides next to the 90° angle.

Leucippus (5th century BCE) & Democritos: atomism

Hippocrates of Kos: medicine

A.4. Socrates, Plato & Aristotle

Socrates reacted against the relativism of the sophists.

Plato:

- The universal is in the world of “ideas” (forms, prototypes), the world we experience exists of particular things which “participate” to ideas. For example: a “horse” participates to the idea of “horsehood”
- The universal is first, it causes the particular things. We can experience particular things by our senses, we can know the universal by reasoning (maths, philosophy). This is called “idealism”, “realism” or “platonism”. By contrast, for Aristotle there are first the particular things to which we give a common name.
- The first idea is the cause of all other ideas and also of the world we experience through our senses. This is the idea of the “Good”, which is also the Perfect, the Beautiful, the True, the Just... In this idea, there is no difference between morals, esthetics and epistemology (theory of knowledge)

Aristotle of Stageira (384-322 BCE):

- Physics: general principles of change: All nature sciences, including philosophy of mind and body, sensory experiences, biology...: living versus inanimate, terrestrial versus celestial
    - Change from the potential to the actual. For example: an acorn has the potential to become an oak.
    - Teleology: towards a goal (cf. Final cause)
    - Four causes:
        - material cause
        - formal cause: arrangement of matter
        - efficient cause (what we would call “cause” today)
        - final cause: purpose
    - natural motion: everything moves towards a natural place
        - earth is the heaviest element, it moves towards the center.
        - The other elements are water, air, fire and aether, they got pushed away from the center by the earth.
        - In the terrestrial world, movement is by straight lines; in the celestial world, movement is by circles
        - There exists no vacuum
    - Logic: Aristotelian logic or term logic:
        - Term = part of speech which represents something. A term is not true or false. Examples: “man”, “mortal” are terms
        - propositions are sentences which contain 2 terms, the predicate and the subject. For example: “All men are mortal”, “men” is the subject, “mortal” is the predicate. Propositions can be “universal” or “particular” and “affirmative” or “negative”:

Name	Universal or particular	Affirmative or negative	Example
A	U	A	All men are mortal
I	P	A	Some men are philosophers
E	U	N	No men are mortal
O	P	N	Some men are not philosophers

  - Syllogisms have 3 terms: 2 premisses and 1 conclusion. They are being remembered by "mnemonics", for example "bArbArA" for 2 "A" premisses and an "A" conclusion (see table above).
- Scientific method: aims at the universal
- The universal in the particular is the "essence"
    - Difference with Plato: the universal is a "prototype" for the particular.
  - Both inductive and deductive reasoning
  - "All science (dianoia) is either practical (ethics, politics), poetical (arts) or theoretical (physics, maths, metaphysics)"
  - The qualitative is more important than the quantitative

Euclid of Alexandria (circa 300 BCE):

- The Elements: axiomatic method: starting from a few axioms (or postulates) and definitions, the rest of mathematical knowledge is proven in theorems.

Archimedes of Syracuse (287-212 BCE)

Astronomy:

- Aristarchus of Samos (310-230 BCE): Heliocentric model
- Hiparcos (190-120 BCE): star catalog, magnitudes of stars
- Claudius Ptolemy (90-168): Geocentric model, planets move on circles in circles
- Antikythera mechanism circa 87 BCE:
  - analog computer to calculate astronomical positions (Video)

Hero of Alexandria (10-70):

- robot exhibition, first vending machine

A lot of Greek knowledge was lost due to several fires in the Great Library of Alexandria, and also due to the conversion from papyrus to parchment. Many texts have however been saved in Latin and Arabic translations.

A.5. Science in China

- Astronomical observations since 2137BCE: sun eclipse
- 500 BCE: Warring states period: times of great turmoil
  - invention of the crossbow
  - "100 schools of thought"
    - "Schools of names": development of logic and of scientific method
      - method = "fa"
    - "Legalistic school" was more important than "school of names"
      - law = "fa"
  - "Book of silk", 400BCE: list of 29 comets
- Han Dynasty (206BCE-200AD)
  - 200BCE: Great Wall, against Mongol invasions
  - Zhang Heng (78-139): astronomer, mathematician, inventor, geographer, cartographer, artist, poet, statesman, and literary scholar
    - inventor of seismometer
    - water powered armillary sphere
    - Star catalog with 2500 stars
  - 185: observation of supernova SN185
  - Ma Jung (200-265):
    - silk loom
    - chain pump
    - mechanical puppet theater
    - south pointing chariot, this compass did not use a magnet, but it used differential gears to match the turning of the chariot.
- Song Dynasty, 960-1279: period of stability, meritocracy, banknotes (1023)
  - Shen Kuo: "Dream pool essays" (1088)
    - dry dock
    - magnetic compass
    - geomorphology: erosion and uplift/deposition of silt
  - Su Song: clock tower with escapement mechanism (video).
  - Archeology
  - Yang Hui (1238-1298) mathematician: "The men of old changed the name of their method from problem to problem, so that as no specific explanation was given, there is no way of telling their theoretical origin or basis" - call for scientific method
- Mongols, Kublai Khan, 13th century: banknotes, siege warfare
  - William of Rubruck (Willem van Ruysbroeck, 1220–1293) was ambassador to the Mongols, friend of Roger Bacon.
  - Marco Polo (1254–1324)
- Four Great Inventions:
  - compass (2nd century): originally used for geomancy (feng shui), later for navigation (11th century)
  - gunpowder (around 300)
  - paper (2nd century)
  - printing (7th century)

A.6. Science in India

- Indus Valley Civilization:
  - standardization of weights and measures
  - 3000 BCE: sewers, irrigation
  - 2500 BCE: furnace for creating ceramic objects, cartography, animal-drawn plough
  - 2400 BCE: dock at Lothal
- Baudgayana, 8th century BCE: pythagorean triplets, square root of 2
- Sushruta, 6th century BCE: cataract surgery
- Pāṇini, 5th century BCE: grammar, phonetics, morphology of words
- First century BCE: atomism: atoms are point sized (not extended in space) and durationless (not extended in time)
- Pingala: combinatorial maths: Pascal's triangle, binomial coefficient, binary numbers
- Aryabhata, 5th century: trigonometry: sine, versine
- Bhaskara II (1150): idea of perpetuum mobile, calculus (Rolle's theorem)
- Brahmagupta of Multan (598-668): number zero, decimal numbers
- Madhar (8th century): innoculation against smallpox
- Madhaua of Kerala (1340-1425): mathematical analysis, infinite series for pi

A.7. Arabic science

- Arabic translations from lost Greek texts
- Arabic numerals: decimal number system brought from India to The West
- Alhazen (965-1040)
  - contributions to the principles of optics, physics, astronomy, mathematics, ophthalmology, philosophy, visual perception
  - commentaries on Aristotle, Ptolemy and Euclid
  - scientific method: experimentation ("i'tibar") and controlled testing

A.8. Late Middle Ages:

- Roger Bacon, “doctor mirabilis” (= “wonderful teacher”) (1214-1294)
    - Franciscan monk, studied in Oxfort, lectured in Paris
    - inspired by
        - Aristotle
        - Indian science via Arabs (Alhazen)
        - Chinese Science via William of Rubruck (including gunpowder)
        - Robert Grosseteste: “Method of verification”
    - empirical method
    - “experimental knowledge”, even if this was still “scholastic”: talk about experiments, but Roger Bacon's experiments were mostly “book knowledge”

- William of Ockham 1288–1348
    - Occam's Razor: “Frustra fit per plura quod potest fieri per pauciora” (It is futile to do with more things that which can be done with fewer): chose theories which as few hypotheses as possible
    - Nominalism: universals don't really exist, it are only names for groups of things
        - against Plato's Forms/Ideas
        - more radical than Aristotle, who acknowledged essence in the particular things

End of Middle ages:

- Printing press by Johannes Gutenberg, 1436
- Fall of Constantinople (Eastern Roman Empire), 1453

B. The “Scientific Revolution” 1543-1750

The term “Scientific revolution” for the period starting in 1543 was coined by Alexander Koyré in 1939.
1750-1850: First Industrial Revolution.

B.1. 1543 - two important books at the start of the Scientific Revolution:

- Nicolaus Copernicus: “De Revolutionibus Orbium Coelestium” ('On revolutions of heavenly spheres)
  - Heliocentrism:
    - no single center of all celestial spheres: moon circles around earth, earth circles around the sun.
    - the center of the earth is no longer the center of the universe, that place gets taken by the sun (which is “near the center of the universe”)
    - more accurate estimate/calculation of distances between earth/sun/moon
    - The Earth is in motion
    - The motion of the sun we see is caused by the motion of the earth around its axis
    - retrograde movement of planets are caused by motion of the earth and the planets in different orbits around the sun.

- Andreas Vesalius (Andries Van Wesel, 1514-1564): De humani corporis fabrica (On the Structure of the Human Body)
  - ...
  - Against humorism as described by Galen of Pergamon (129-200)
  - ...

B.2. Francis_bacon (1561-1626)

- 1620: "Novum Organum Scientiarum" ("New instrument of science")
  - Title refers to "Organon" of Aristotle (logic)
  - Book I: about "idols of the mind" (false images, cognitive bias)
    - Idola Tribus: idols of the tribe: tendency to perceive more order and regularity in systems than truly exists, common to a race or nation
    - Idola specus: idols of the cave (or idols of the den): personal weaknesses due to personality, peculiar to personal likes/dislikes
    - Idola Fori: idols of the marketplace, confusion in the use of language (difference between jargon and common language)
    - Idola Theatri: idols of the theatre, following academic dogma, abuse of authority
  - Book II:
    - 4 causes (material, formal, efficient & final) redefined: the final cause is not the most important anymore, the "formal" cause becomes more important:
      - Form = idea = law of nature
      - Inductive reasoning:
        - Fact ⟶ axiom ⟶ physical law
        - 3 tables:
          - Table of essence and presence
            - example: "heat" is present in fire, sun, boiling water
          - Table of Absence in proximity
            - example: "heat" is absent in ice
          - Table of degrees
            - example: water can become ice or steam, change in heat
          - From the tables we get the "first vintage" = starting point. Scientific discovery is slow, over several generations.

B.3. René Descartes (1596-1650)

- Cartesian coordinates: it becomes possible to translate between algebra and geometry
- 1637: "Discours de la méthode pour bien conduire sa raison et chercher la vétité dans les sciences" ("Method to correctly guide reason and to search for scientific truth)
  - Rejects any appeal to "ends" (final cause) and Aristotelian logic
  - fundamental set of principles by metaphysical doubt: methodological scepticism
  - doubt/thought exists: "cogito ergo sum", "I think, therefor I am"
  - What form?
    - Senses are unreliable, thinking comes from essences
    - deduction ⟶ rationalism
    - perception: external to the senses ⟶ so there is something external: world, God
  - Dualism: body like a machine (extension, motion, follows laws of nature) versus

mind/soul (nonmaterial). Both are connected by the pineal gland (part of brain of which we now know that it produces melatonin = hormone which regulates sleep/waking)

B.4. William Gilberd 1544-1603

- Also written as William Gilbert; physician to Queen Elizabeth I and King James (V)I
- Rejected Aristotelian physics (it is the Earth which is rotating around its axis, not the sun and stars around the Earth) and scholastic method.
- 1600: "De Magnete, Magnetisque Corporibus et de Magno Magnete Tellure" ("On Magnets, Magnetic Bodies and the Great Magnet Earth)
  - Created a model of the Earth in lodestone: terrella ("Little Earth", video) to do experiments.
  - Postulated that the Earth has an iron core which caused the magnetic field, rejected the theories that compasses point to the Polar Star or to a magnetic island near the north pole
- Introduced word "electricus", meaning "like amber" (amber is "elektron" in Greek, "formed by the sun")
  - study of static electricity
  - Created first electroscope (instrument to detect electric charge): the versorium
  - electricity and magnetism are different forces (later: electromagnetism with Hans Christian Oersted & James Clerk Maxwell)
  - From this, Sir Thomas Browne introduced in 1646 the word "electricity"
- Created a map of the moon, thought that light spots were water and dark spots were land.

B.5. Galileo Galilei

- improved the refracting telescope, invented the military compass and a thermometer
- observed the phases of Venus
- Observed the four largest moons of Jupiter: Io, Europa, Ganymede and Callisto ("Galilean moons")
- The Milky Way consists of many stars which are invisible to the naked eye
- The speed of falling bodies is independent from their weight
  - against Aristotelian physics, where the falling speed was thought to be dependent of the weight (Earth is in the middle of the universe because it is the heaviest element)
- 1632 "Dialogue Concerning the Two Chief World Systems" defended heliocentrism and seemed to attack pope Urban VIII (the voice of Aristotelian physics was named "Simplicio" in the dialogs, some people thought that "Simplicio" was Urban VIII), which draw the attention of the Inquisition, sentenced to home arrest
  - Was rehabilitated in 1992 by pope John-Paul II
- Galilean principle of (mechanical) relativism: if the Earth is moving around the sun, why don't we feel it? We only feel acceleration, deceleration and change in direction, but since the orbit of the Earth is so large we can locally/momentarily consider it as being a uniform movement.

B.6. Johannes Kepler 1571-1630

- Raised by his mother Katharina Guldenman, who was a herbalist, his father was a mercenary who left the family when Johannes Kepler was 5 years old
  - saw the Great Comet of 1577 and the lunar eclipse of 1580 as a kid
- Went to Prague from 1600 until 1612 where he was the assistant of Tycho Brahe and inherited Brahe's observational data
  - Tycho Brahe 1546-1601 saw the supernova of 1572, published "De Nova Stella" in 1573
    - blow to Aristotelian physics, according to which there was no change in the celestial sphere
- Improved Galileo's refracting telescope
- Made money as an astrologer, casting horoscopes
- Mysterium Cosmographicum: defending Copernicus, tried to show God's geometrical plan of the universe
- Astronomiae pars Optica: study of optics, parallax, structure of the eye
- Saw supernova of 1604, a.k.a. Kepler's Star
- 1609 "Astronomia Nova" (The New Astronomy): first two laws of planetary motion
  - orbits of planets are ellipses with the sun in one of the two focal points
  - a line joining a planet and the sun sweeps out equal ares during equal intervals of time
- 1619 "Harmonices Mundi" (Harmonies of the world): Third law of planetary motion: square of orbital period of a planet is directly proportional to the cube of semi-major axis of its orbit
- The laws of Kepler describe the motion of planets: kinematics
  - the cause of this motion (forces) are studied in dynamics (Newton's laws)
  - Kepler himself (mistakenly) thought that planetary magnetism as discovered by Gilberd could be the cause of the planetary orbits.
- Wrote the "first" Science Fiction story: Somnium (online book)
  - story about the travel to the moon by the son of a witch and an unknown father
  - description of the sky as seen from the moon (the Earth is only visible from one side of the moon)
  - the traveler to the moon uses opium to survive the vacuum
  - as a result of the publication of Somnium, a witchcraft trial was started against Kepler's mother

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B. The "Scientific Revolution" 1543-1750 (continued)

B.7. Isaac Newton and Gottfried Leibniz

While Kepler's kinematics described the motions of the planets, the dynamics of Newton described the cause of these motions: forces.

Newton's laws of motion (1687) are:

1. If an object is at rest of moving uniformly in a straight line, it will remain at rest or moving uniformly if there are no forces applied to it.
2. The acceleration of an object with mass m on which a force F is applied is **a=F/m**.
   - The mass is how much an object resists a change in acceleration: the higher the mass is, the bigger the force F must be to obtain the same acceleration. For example: it takes more force to accelerate (or decelerate) a truck than a bicycle.
   - This law is usually written in the form **F=m•a** (the dot = multiplication), but the above notation stresses that the force is the cause of the acceleration.
   - The force and the acceleration are vectors (=arrow with length and direction), the mass is a scalar (= just a number).
3. Action = reaction

The unit of force is the "newton": 1 newton = 1 kg•m/s^2 = the force to accelerate a mass of 1kg by 1m/s^2 (i.e. going from 1m/s to 2m/s in 1 second)

Together with Newton's law of universal gravitation (1687), which states that every mass in the universe attracts any other mass in the universe with a force which is directly proportional to product of their masses and inversely proportional to the square of the distance between them, these laws of motion explain the laws of Kepler.

Leibniz did not start from forces, but from the vis viva ("living force") **m•v²**. Nowadays, we call **m•v²** the "kinetic energy". Leibniz developed the differential calculus independently from Newton.

Newton's and Leibniz' physics and the classical physics which came out of those are completely deterministic: if we know all positions and velocities (velocity is a vector expressing the speed (scalar) and direction) of objects, all active forces and all energies, then we can calculate all positions in past and future.

To calculate these forces, both Leibniz and Newton developed differential calculus.

- derivatives and anti-derivatives (integrals).
- led to an infamous priority controversy.

C. The story of light

Robert Hook in the 1660s and Christiaan Huygens in 1678 thought that light was a wave.

Pierre Gassendi (published posthumously in the 1660s) and Isaac Newton in 1675 thought that light was made of particles.

Around 1800, the double slit experiment by Thomas Young proved that light indeed was a wave.

The photo-electric effect (Heinrich Hertz 1887, Albert Einstein) proved that light was indeed made out of particles.

Because of the dual wave-particle nature of light, we now call light a "wavicle". In quantum physics, we discovered that all matter is made out of wavicles.

In 1676, Ole Rømer measured the speed of light. The speed of light is constant in a given medium: it is fastest in vacuum, slower in air and still slower in water or glass. The fraction of the speed of light in several media is the refraction index of light between these media.

The speed of light in vacuum is defined as being exactly 299,792,458 m/s. The constant speed of light led to the special relativity theory around 1900.

Movies:

– A video to demonstrate the concept of interference of waves: http://www.youtube.com/watch?v=pjDscZ0pFEc
– A video to explain the double slit experiment, which proves that light is a wave: http://www.youtube.com/watch?v=Ia5IsjVE-EM
– A video to explain the photoelectric effect, which proves that light consists of particles (photons): http://www.youtube.com/watch?v=jAt4Liq3bgc

D. Logic from Leibniz to Gödel

Leibniz tried to develop a language (calculus ratiocinator) in which errors would be syntactical errors. This was the first attempt at creating a “symbolic logic” in the modern sense.

George Boole and Auguste De Morgan discovered that logic operators such as “AND”, “OR” and “NOT” behave like algebraic operations.

A	B	A AND B	A OR B
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	1
		A x B	A + B

A	NOT A
0	1
1	0
	1 - A

Gotlob Frege tried to reduce all of mathematics to logic.

Bertrand Russel found a paradox in Frege's system: is the set of all sets which are not a member of itself, a member of itself? If it is, it isn't. If it isn't, it is. Together with Whitehead, Russel tried to get rid of paradoxes in maths.

Around 1900, David Hilbert started a program to prove that mathematics is complete (all true theorems can be proven) and consistent (there are no paradoxes in maths). This had to be proven by mathematical means, so the proof would be “meta-mathematics”.

In 1929, Kurt Gödel proved that first order predicate logic was both complete and consistent. However, first order logic is not strong enough to formalize all of mathematics. In 1931, Kurt Gödel proved that mathematics is complete or consistent, but cannot be both at the same time.

Alan Turing proved with the “halting problem” that we in general cannot know if a problem is just unsolved or if it is unsolvable.General Relativity Theory (GRT)

E. Relativity theory: the last great classical theory

General Relativity Theory (GRT)

Out of the constant speed of light and out of the Michelson-Morley experiment, the Special Relativity Theory (SRT) concludes that time and space are relative, meaning that the same distance looks longer to somebody who stands still than to somebody who moves. Also, time goes faster for an observer at rest than to an observer who is moving fast.

The General Relativity Theory (GRT) is about mass: closer to a large mass, time goes slower.

F. Thermodynamics and quantum physics: the new physics

In both Thermodynamics and quantum physics, probabilities and statistics start to play an important role.

In thermodynamics, a lot of particles are considered. Since it is not possible to follow each particle which is for example moving in a gas, we use a statistical approach.

The second law of thermodynamics, which says that entropy (an measure of disorder) is increasing. It is another way to say that energy which is converted into heat cannot be converted completely into useful forms of energy. This is one of the very few laws in nature which are not symmetric in time: time goes forward, it never goes backwards. This also makes a perpetuum mobile impossible.

In quantum mechanics, we consider all matter as wavicles. The wave part expresses a probability.

G. Evolution, abiogenesis and Life

Charles Bonnet used the word "evolution" in it's present meaning of "growth or progressive development" for the first time in 1762.

Jean-Baptiste Lamarck: evolution by inheriting traits acquired by the parent. This theory is not correct.

Charles Darwin: evolution by random changes, some of these changes give better chances at survival and procreation.

Gregor Mendel: two laws of inheritance.

Watson & Crick: discovery of DNA as carrier of heritable traits.

Abiogenesis is the study of the origin of life. Some, including Crick, think that life on earth comes from space, the theory which says that space is full of life is called panspermia. However, the theory which says that (our) life originates on Earth, is more accepted. The Miller-Urey experiment might explain how this could have gone.

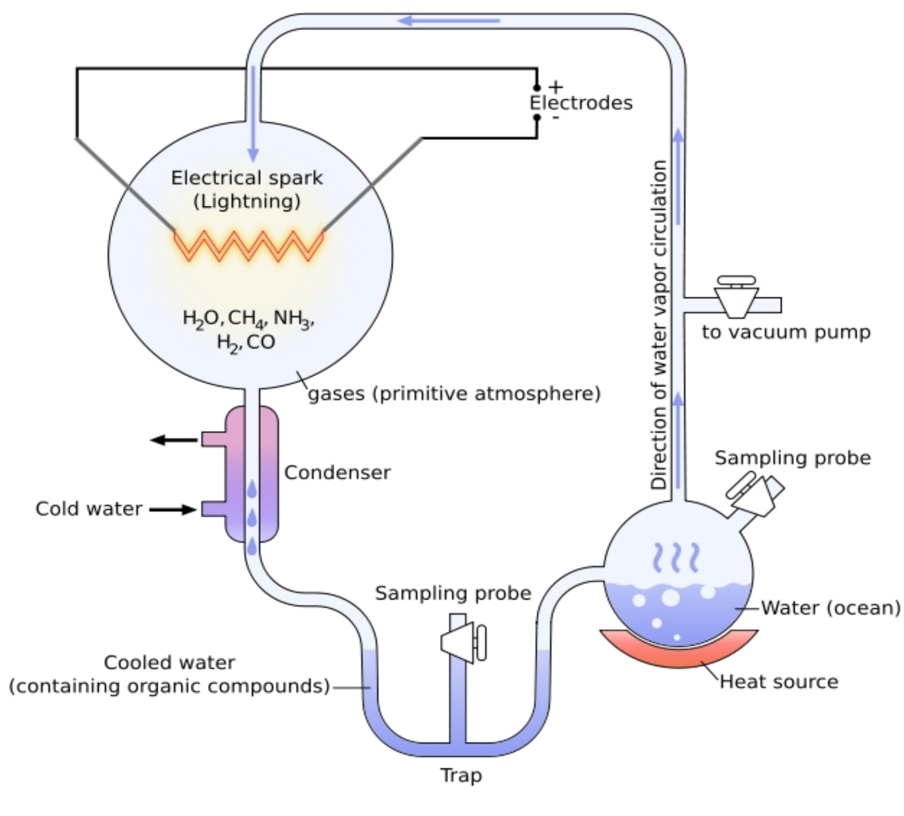

Diagram from Wikipedia: Miller-Urey Experiment

H. The end of certainty

The controversial movie “Dangerous Knowledge” (link to movie) by David Malone (2007, BBC4) discusses 4 important figures:

- Georg Cantor, mathematician, developed the mathematics of transfinite numbers (numbers bigger than infinity) en tried to prove and disprove the continuum hypothesis.
- Ludwig Boltzmann, physicist, developed most of thermodynamics, and introduced probabilities and statistics into physics.
- Kurt Gödel, mathematician, proved that mathematical axiomatic systems are either incomplete or inconsistent.
- Alan Turing, mathematician and computer pioneer, showed with the halting problem that it cannot be predicted if a proposition will be decidable or not.

While the movie is heavily criticized for suggesting that certain knowledge can lead to insanity or suicide, it somehow expresses the desperation that lived in the parts of the scientific community about the loss of certainty in sciences.

I. In search of “scientific method”

In the early 20th century, philosophers tried to build a scientific method out of logic:

Naive verification: The Wiener Kreis had a positivist approach of science.

Popper proposed falsification as a scientific method.

Later, historians & sociologists of science started to study how scientists actually work: Thomas Kuhn, Bruno Latour, Paul Feyerabend.