ROMANTIC AGE

Astronomy, Biology, Earth sciences

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The 19th century, the Romantic era.

Why romantic? Borrowed from the arts and music, but influenced also the approach to nature and its studies: emphasizing descriptive biology and classification of animals and plants.

ASTRONOMY
and
EARTH SCIENCES

EARTH SCIENCES

AGE OF THE UNIVERSE AND OF EARTH

How can we measure the age of the universe? The size of the universe? The size and distances of stars?
How can we estimate the age of earth?
How were the various chemical elements created?

Characteristic of the 19th century is the transition from geology of stone collecting and sorting, to attempts on modeling the mechanisms shaping the earth crust. The release from religious constraints provided space for testing new theories based on fossils, distributions of rock and soil types, earthquakes, volcanic eruptions, soil erosion and sediment, glaciers and their traces, sea floors, earth core etc.

Before the 19th century, a reminder:

1650 James Ussher, **1581-1656,** an Irish archbishop, claim earth was created 4000 BC, before the first day of creation.
1715 Edmond Halley, 1656-1742, Calculated an estimation of earth age from seawater salinity. He assumed the ancient see contained sweet water, and salinity rose due to earth erosion.
1785 Dr. James Parkinson, 1755-1824, a surgeon (who identified what was later called "Parkinson disease") and a geologist, one of the founders of the geological society and a supporter of "catastrophism". Saved the nature museum in Leicester square from bankruptcy of his owner, **Sir Ashton Lever**. Published "Organic remains of a former world", illustrated with reconstructions of skeletons based on excavated fossils.
1795 **James Hutton, 1726-1797.** published two volumes of theories about earth. The principle of uniformitarianism claim that processes that slowly shape earth have acted uniformly for long time. This principle overlooks catastrophic events. Clams club: why marine fossils are found on mountains? Nepotists: due to rise and drop of see levels. Platonists: due to volcanoes and earthquakes.
Hutton estimated the temperature at earth core, and proposed plate tectonics.
1802 John Playfair 1748-1819. The mathematician, who simplified Hutton's models.

From the beginning of the 19th century:

1807 The geological society is founded.
1830-3 Charles Lyell, 1797-1895. A son of moss expert, and a student of **William Buckland's 1784-1856**. Published "Principles of Geology": Catastrophism versus uniformitarianism – volcanic eruptions or erosion. The church supports catastrophism (Noah's flood…)
1841 Charles Lyell in a popular lecture travel in America.
1839 Roderick Murchison 1792-1871. Published "The Silurian System" based on diversification of fishes he found in fossils in Wales (Silurian is named after a Celtic tribe of that area). Field trips of "Stone cracking" to explore fossils. Ordering of prehistoric periods by sedimentation layers: deeper layers belong to older times.
Reverend Adam Sedgwick 1785-1873. Claimed that Cambrionic layers are not Silurian, as Murchison believed. Controversy is due to mixture of layers at different sites.

The time order of prehistoric periods at 1879 was as follows:

This is just temporal order, without absolute times. Determining the age of earth and layers is based on assumptions that came out to be sometimes erroneous.

Devonian
Cambrian
Ordovician
Silurian
Jurassic (Jura mountains French-Swiss border)
Permian (Ural mountains in Russia)
Cretaceous (limestone in Latin)
Pleistocene
Pliocene
Oligocene

Last 65 million years (added by Lyell)

Pleistocene (most recent), Pliocene (more recent) Oligocene (but little recent)

In America the systems are different: Precambrian, Paleozoic, Mesozoic & Cenozoic

Obviously there is no clear correspondence of layers across the ocean.

George Poulett Scrope 1797-1876

1825 Concluded that volcano eruptions at the recorded rates can explain spread of lava over earth.

Hermann von Helmholtz 1821-1894

1854 Calculated heat decay in the universe based on thermodynamic considerations.

William Thomson (Kelvin) 1824-1907

1862 Deduced the maximal age of the sun based on its heat radiation. From Fourier's equation for heat radiation from a sphere calculated that earth solidified from molten lava 20-400 million years ago.

Julius Robert Mayer 1814-1878

1845 Suggested that the sun accumulated its energy from colliding asteroids.

Jean Louis Rodolphe Agassiz 1807–1873 Swiss-American

1840 Agassiz proposed theory of the ice age. Documented rocks by age. All species existed since the creation of the universe. Darwin read his book.

Joseph Louis Gay-Lussac and Jean Baptiste Biot

1804 Launched high in a Hydrogen balloon, and rebutted decrease in gravity with height.

AGE OF THE UNIVERSE

Lamarck, Cuvier and Lyell estimated the age of earth from animal fossils, deposited sediment layer, and lava rocks.

Till the end of the 19th century, geological estimates of minimal age of earth was much higher than the age of the sun, estimated by physicists based on the sources of energy they recognized. Only the discovery of the conversion of mass to energy in relativity theory solved the dilemma.

Radioactive methods improved the estimates for earth age, that was significantly older than the biblical 6000 years, period that by reliable archeological documentation showed no evolutionary changes of humans.

The age of earth and Darwin's evolution theory exposed scientific findings to the rage of the religious establishment. Years after the bitter opposition to Copernicus and Galileo, the struggle between science and the church burst again due to the biological and geological new findings.

Charles Darwin 1809-1882

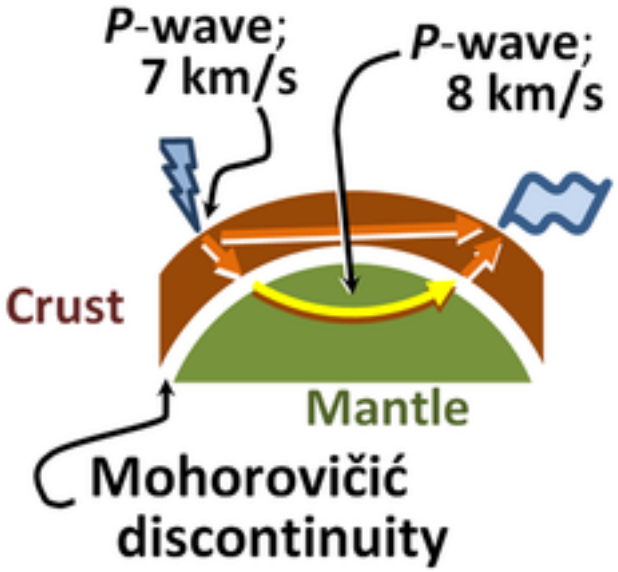
1859 Darwin estimated that geological processes that created parts of England lasted 300,000 years.

R.D.Oldham 1858-1936

1906 Shock waves from earthquakes are reflected back earth surface from the core.

Andrija Mohorovičić 1857-1936

1909 **Mohorovičić** discontinuity, or Moho, is a boundary Layer between earth crust and the mantel, that due to density jump reflects sound waves.



Alfred R. Wallace 1823-1913

1881 Proposed that the beginning of the Cambrian period was 28 million years ago.

William Huggins 1824-1910

1863 Measured spectra from stars, and demonstrated that they contain gases similar to the sun.

Osmond Fisher 1817-1914

1850 Proposed that earth core is liquid

1895 Isolated Helium whose absorption spectral lines exist in the sun. Helium is named after the Greek sun god Helios.

William Thomson (Lord Kelvin). 1824-1907

Estimated age of earth as 98-400 million years, and wondered what is the source of sun energy that provide so long burning times.

Georges Luis Leclerc, Comte de Buffon

1770 Measured the rise of temperature in deep coal mines. Based on the rate of cooling of spheres he estimated the age of earth as 75,000-168,000 years.

George Johnstone Stoney 1826-1911

1898 Showed that earth atmosphere may exist only if the speed of air molecules does not allow them to escape gravity.

Ernest Rutherford 1871-1937+ Frederick Soddy 1877-1956

1901-3 Proposed that the heat in earth core is generated by radioactivity. Since Uranium decays into Lead, it provides an age clock for Uranium oars that is 700 million years.

DINOSAURS

1787 Dinosaur bones were found in Woodbury Creek, and Mammoth skeletons in Wistar's city and Kentucky.

George Cuvier 1769-1832

1795 Reconstructed dinosaur skeleton from bones he received from America.
1796 Theory of extinction – a global catastrophe with religious background (Noah's flood).
Jefferson refused to accept these arguments.

William Smith 1769-1839

1769 Supervised the dinosaur reconstruction. Documented aging of rocks based on fossils.
1815 Published survey map of England, and concluded that god extinct his creations repeatedly.

Meriwether Lewis 1774-1809 & William Clark 1770-1838

1806 Expedition to the inner America found dinosaur bones in Montana .

Gideon Algernon Mantell 1790-1852

1822 A country doctor in Sussex found a huge tooth, and later many fossils. Start a museum in his house.
1823 **Mary Aning**, a country girl in south England, assembled a large collection of fossils and dinosaur bones that were displayed in exhibitions as revealing discoveries.
1824 **William Buckland** a theologian who discovered foot steps of ancient creatures.

Richard Owen 1804-1892

1841 Name the dinosaurs, taking credit from Mantell. Established the natural history museum as popular institute beyond its academic significance.

Edward Drinker Cope 1840-1897 & Othniel Charles Marsh 1831-1899

1868-1897 Discovered and classified a large number of dinosaurs.

This historical outline demonstrates the significance of the explorations and findings of fossils, from primitive marine creatures and up to the dinosaurs, as a vivid evidence for the age of earth and its geological and biological evolution.

The large abundance of primitive marine fossils provide a comparative time-marks for layers of sediments around the world.
The discovery of dinosaurs in all the continents indicate on the continuous connection between them in the dinosaur age, and the world-wide catastrophe that cause their extinction.

ASTRONOMY

The astronomers in the 19th century studied the planets at the far edge of our solar system, comets and asteroids, and studied the composition of suns.

The comprehension that earth is not so unique, but one of the planets around the sun, and there are many other suns in the universe we call stars with motion so slow in the time scale of an astronomer that it is undetectable.

Telescopes with bigger mirrors and lower optical aberrations that allowed to see more stars, obviously the field of view is a smaller part of the sky. The use of photographic plates with telescopes that “track” the motion of the sky (rather compensate the rotation of earth). These generated detailed maps of the sky, including faint star clouds and nebulae undetectable by eye, eased hours of tedious visual inspection and discovery of the far planets, and mainly provided exact measurements of slow changes in long time scales.

With the “inspecting astronomers” a new clan of “mathematical astronomers” emerged. Historical documentation of the orbit of Uranus made it clear to William Herschel that it is a planet (completed his orbit in 81 years). But careful follow up of the orbit displayed 2 minute arc deviation from Kepler-Newton laws, which lead to conclude that Uranus orbit is diverted by gravitational attraction to another planet. The position of this attractor was mathematically calculated, and the focused inspection of the predicted position indeed discovered Neptune. Despite its huge size, its far distance would have made this discovery equivalent to finding a needle in a haystack…

The new technologies brought the findings of the asteroid Ceres, Juno and Vesta (first annotated as planets), by the end of century 1000 asteroids were localized.

Newton was first to disperse white light into its color components using a prism. At the beginning of the century spectroscopy of sunlight revealed black lines, but it took half a century to develop high resolution spectrometers and relate the spectral lines to chemical composition of atoms. Despite the claim of the French philosopher Comte at the beginning of the century that we shall never be able to discover the content of star due to their distance, astronomical spectroscopy provided a method to determine the chemical composition of stars. The spectrum also provided means to estimate stars temperature, and later their speed.

Venus transitions over the sun (couples of dates 1761,1769 and repeated 1874, 1882) made it possible to triangulate our distance to the sun (see 18th century). The partial success of Captain Cook voyage to Tahiti motivated Airy to send delegations again around the world.

Towards the end of the century Astronomical societies are established, star maps are distributed, and cooperation between astronomers all around the world enriched the field. The understanding that our universe spans space much beyond the milky way becomes accepted based on measurements of star speeds and triangulation from parallax of star positions between summer and winter.

ASTROIDS

Giuseppe Piazzl 1746-1826

1801 Piazzi discovered a planetoid – a small planet.

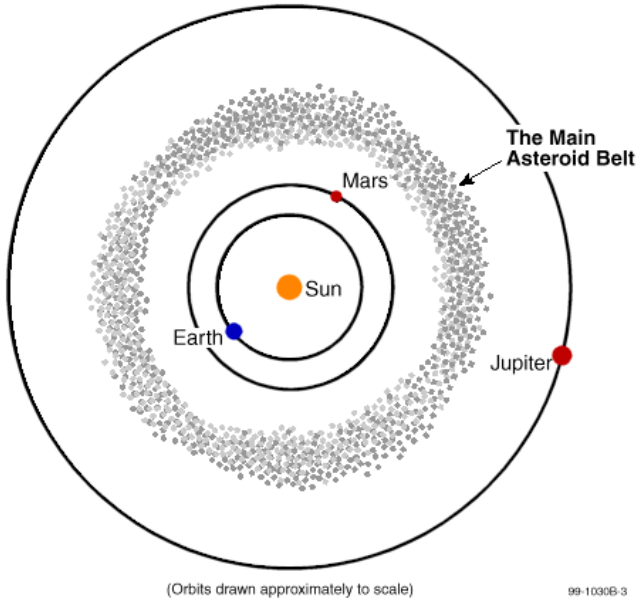
Heinrich Wilhelm Matthias Olbers 1758-1840

1802 Olbers discovered another planetoid in an orbit close to the first, and deduced that both are remains of an exploded star.

1803 Piazzi name Ceres and Pallas. **Herschel** called them asteroids – star like.

Karl Ludwig Harding 1765-1834

1804 Harding discovered another asteroid, Juno.
1807 Olbers discovered the asteroid Vesta.
These findings supported Bode-Titus law,
see following.
By 1900 1000 asteroids were identified,
By 2000 26,000 asteroids were detected.
They are probably a mass that did not coalesce into a planet, or the remains of a star explosion.



COMETS & METEORS

M. Pons

1818 From Marseilles. Discovered a comet he identified by his tail.

Johann Franz Encke 1791-1865

1822 Calculated that Pons comet will return every 3 years and 16b weeks, which was confirmed. Today we identified 680 comets, with tail length varying between 7 million km up to 150 sun diameters.

Wilhelm von Biela, 1782-1856

1826 The Austrian astronomer discovered a comet that earth orbit crossed his tail at 1872 and displayed a marvelous meteorite showers stream fall down.

Jöns Jacob Berzelius 1779-1848

1834 The great chemist reports organic materials (humic acid) in meteorites he called ”carbonaceous chondrites“

Jacques Babinet 1794-1872

1857 Estimated that the tail of a comet is so diluted that if earth crosses it will not be detected.

Hubert Anson Newton (of Yale U.) 1830-1896

1864 Proposed that meteorite showers, usually between August and November, are connected to comets disintegration.

NEPTUNE

Johann Daniel Titius 1729-1796 & Johann Elert Bode 1947-1826.

Proposed that the radii of planet orbits follow a powers of 2 law: $a = 0.4 + 0.3 \times 2^m$

The idea of harmonic relations between the axis of planet orbits was Kepler's, continuing the classical tradition starting at Pythagoras, who searched harmonious numbers guiding natural dimensions (like in music)

Jean Élix Benjamin Valz, Friedrich Bernhard Gottfried Nicolai & Niccolo Cacciatore

1835Independently proposed existence of a planet beyond Uranus that account for unexplained orbit of Halley's comet and Uranus itself.

Urbain Le Verrier & John Couch Adams

1846 Both independently in France and England studied Uranus orbit and concluded that there is a planet in an orbit with longer radius and they estimated its orbit and position.

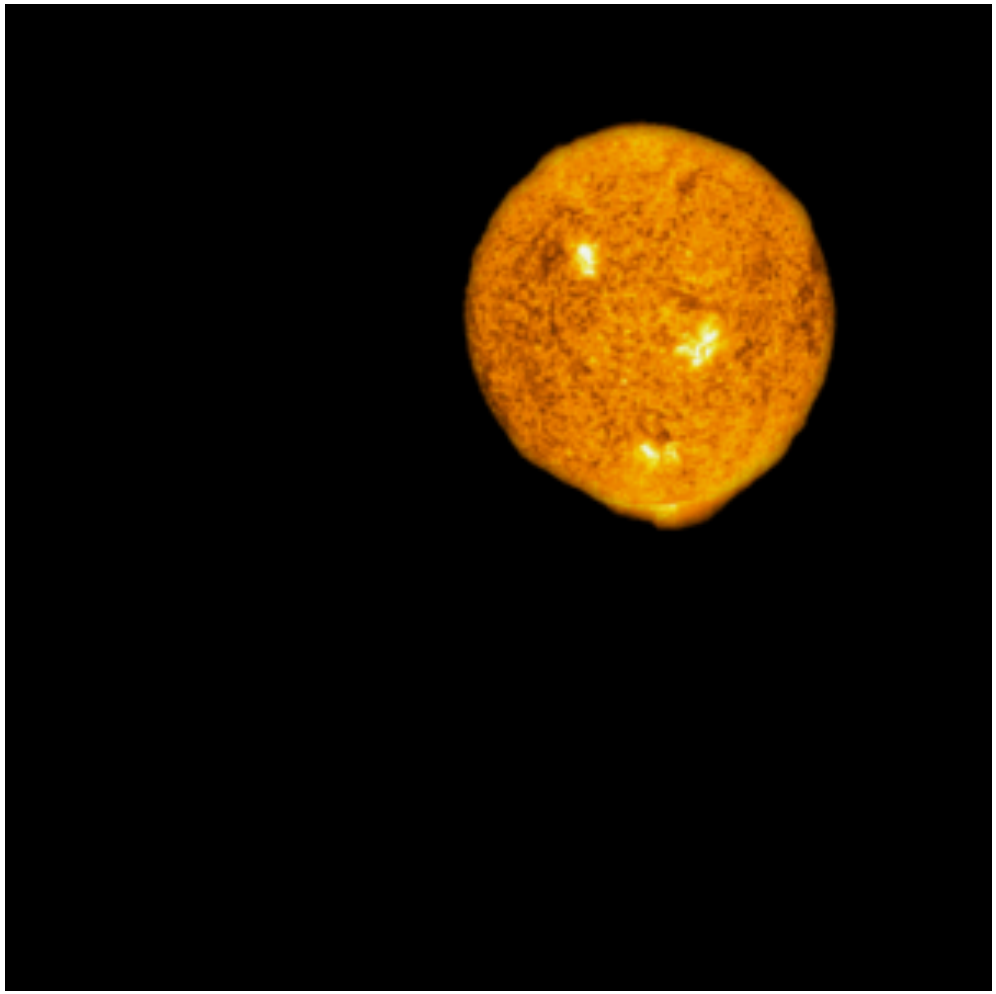
Johann Gottfried Galle & **Heinrich Louis d'Arrest**

1846 Neptune was indeed found as predicted from the displacement it inflicts on Uranus. However, Titus-Bode law was broken for the Neptune case…

Heinrich Wilhelm Olbres (1758-1840) Germany

1826 Olbres paradox The dark night sky are incompatible with an infinite universe with uniform density of suns.

The argument is simple: the light reaching us from a distance R decay as $1/R^2$ but the number of sun sources, assuming constant density of suns, increase proportional to R^2. Therefore the total light reaching us from a shell at distance R is a constant, and integrated over R to infinity yields infinite light flux, see the simulated movie.



THE COMPOSITION OF STARS

William Hyde Wollaston 1766-1828

1802 Discovered dark lines in the spectrum of sun light.

Joseph Fraunhofer 1787–1826

1814 Inspected the “absorption lines” using a long spectroscope with high resolution power, and found that they overlap the “emission lines” in gas flames, and they vary with the burning materials.

Robert Wilhelm Bunsen, 1811–99 & Gustav Robert Kirchhoff, 1824–87

1859 Developed a spectroscope with slit input, prism and lenses, with capability of comparing one spectrum above the other. Further on the prism was replaced by a diffraction grating that provided higher resolution and better light collection efficiency. These experiments demonstrated that the elements are common to earth and other stars, and started chemistry in space.

William Huggins 1824-1910

1866 Spectroscopy of a nova.

Giovanni Virginio Schiaparelli 1835-1910

1866 Proposed that meteors are fragments of comets.

HELIUM

Pierre Jules Janssen, 1824–1907 & Norman Lockyer, 1836–1920

1868 During sun eclipse they discovered (independently in France and Britain) a yellow spectral line of an unknown material. due to its source from the sun they named it after the Greek titan of the sun “helium”.

Georges Rayet, Captain C. T. Haig, Norman R. Pogson, & Lieutenant John Herschel also detected the yellow Helium spectral line.

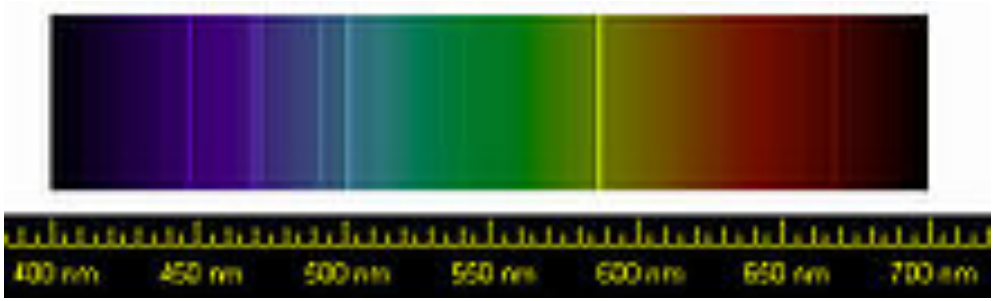
1881 Luigi Palmiery Detected Helium in the eruption of the Vesuvius.

William Ramsay 1852-1916 & Osmond Fisher 1817-1914

Per Teodor Cleve 1840-1905 & Nils Abraham Langlet 1868-1936

1895 Helium was isolated from the uranium oar Clevite in Norway. Its emission spectrum was identical to the absorption dark lines from the sun.

The spectrum of Helium with the strong yellow line



THE SUN

In the following years spectra of 36 known metals such as Iron, Magnesium, Calcium, Chromium, Copper, Zinc, Nickel, Barium, Sodium etc. were all detected from sunlight. Moreover, it is possible to resolve elements in sun spectra at different depths below the surface (photosphere, chromosphere) and during sun eclipses acquire spectra from the corona (mainly Hydrogen).

Spectra from other stars showed similar consistency to our sun.

Sun diameter is 109 times bigger than earth, its density ¼ of the earth density, its mass is 332,000 time bigger than earth. Lord Kelvin estimated that the heat irradiated from the sun equals burning of 13,500 tons of coal per hour.

Richard Carrington 1826-1875 & Richard Hodgson 1826-1875

1860 Both detected ejected flares from the sun corona, and 18 hours later magnetic storms and sparks discharging from telegraph wires.

Samuel Schwabe 1789-1875

1851 Published his finding on 11 years periodicity of sun spots.

Thomas Chrowder Chamberlain 1843-1928

1899Studies behavior of materials at extreme conditions, such as inside the sun, and assumed they can absorb energies much larger than normal conditions. This may explain why geological estimated of “energy decay” conclude that earth is much older than the sun.

Friedrich Wilhelm Bessel 1784 - 1846

1838 Measured the parallax to star Cygni 61. The triangulation base is the diameter of earth orbit around the sun (measured at two positions half a year apart). The distance he found is 11 light years. 1km = 1.05702341×10^{-13} light years

Orbit diameter=149.60×10^{6} km=$149.60\times10^{6}\times1.05702341\times10^{-13}=1.58\times10^{-5}$ light years

Thus the triangle base is about a one millionth of its height, demanding accuracy of angle difference between the two positions of a fraction of an arc seconds: 0.1”

Charles Messier 1730-1817

Detects diffused clusters of stars.

William Huggins 1824-1910

1866Observed gaseous clusters, Nebulae. From displacements of spectral lines he calculated their velocities with respect to us, finding tens of km/sec, yet their position changes are undetectable during our life span.

Henry Draper (New York) 1837-1882

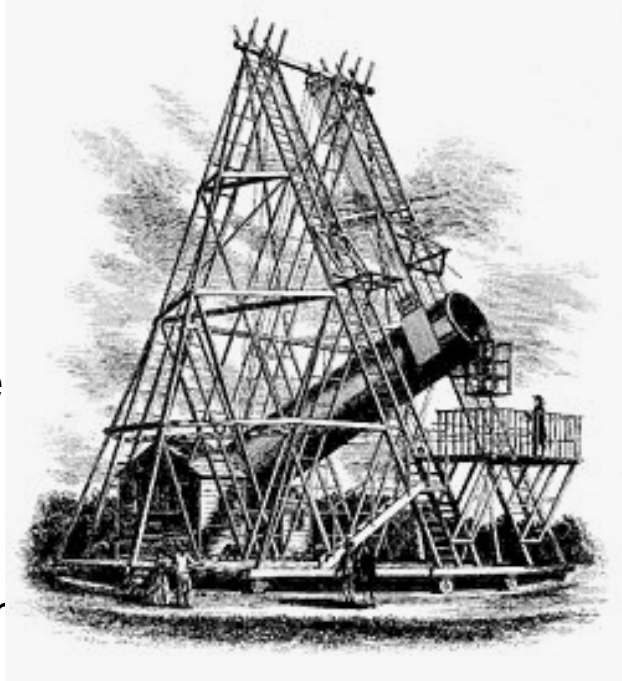
1880 Took photographs of tens of Nebulae.

Sir William Herschel 1738 –1822

1800 Discovered infrared radiation: While dispersing light by a prism to measure the temperature rise as a function of color, he realized that the highest rise happened "beyond" the red. By microscope inspections he found that corals are not plants – because they do not have cell walls.

Herschel was born in Hannover, where he played (like his father) in a military band. He studied music, and conducted a successful ensemble. He moved to London with his sister, Caroline (Hannover was a part of Britain), and became famous as the best telescope builder. His first astronomical work was measurements of the height of mountains on the moon from the length of the shadows and the direction of the sun. He catalogued double stars, and in 1781 he discovered Uranus, which made him famous and gave him the position of the Royal Astronomer with salary that provided a full time devotion to astronomy. He discovered new moon of Saturn, built some 400 telescopes, the largest had 126 cm Diameter reflector and 12 m focal Length (see picture).

Most of the visual inspections were carried by his sister, using smaller and more convenient telescopes. He edited a catalogue of Nebulae, understood that the milky way is a disk of stars, and coined the name "Asteroid". His son John followed him



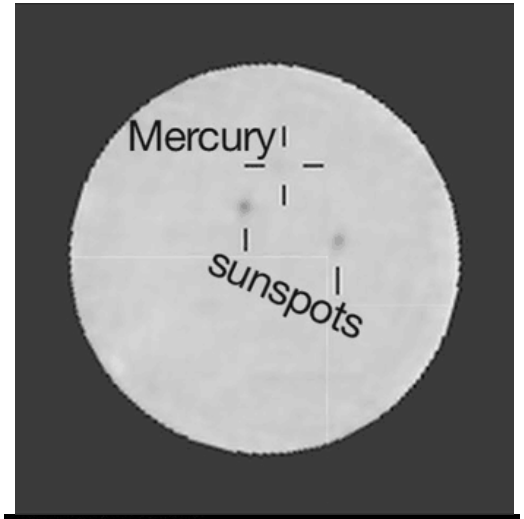
TELESCOPES

Astronomy before Galileo relied on bare eye observations. A tube with angular scales was used to measure star position, registered relative to other star pivots. With the development of lens polishing, two lens telescopes became common, but the breakthrough occurred with the building of telescopes with a reflecting parabolic concave mirror (Newtonian telescopes, although he was not the first to build them). The main advantage was the improved light collection, allowing to see fainter stars. The reflecting telescopes also had better resolution (due to the larger entrance aperture, the absence of chromatic aberration, and the techniques to polish mirrors with reduce spherical aberration, e.g. knife-edge method). The application of photographic plates (pioneered by Janssen) further improved detection of faint stars, but long exposures required development of mechanical tracking systems. Documented sky maps offered for next generations references for measuring very slow motions of stars.

Interestingly, advances in astronomy and telescopes served physicists to advance wave theory of light, diffraction, and the theoretical limitations in resolving power which was reached after optics became practically geometrical aberration-free. For example, the visual star size was soon realized not to reflects its true angular size.

The development of larger telescopes revealed the moons of Jupiter (Barnard). Neptune (Lassell 1846), Mars (Asaph-Hall), the meteorite structure of Saturn rings (Keley 1896), double stars (Burnham) and the spiral structure of galaxies. Nevertheless, the weight and glass-reflector distortions, atmospheric effects, and light background from air pollution constrained telescope performance in resolution (spacial and and spectral). Solution came up at the beginning of the 20th century, with telescopes on high mountains far from cities. Bernhard Schmidt implemented his optical design

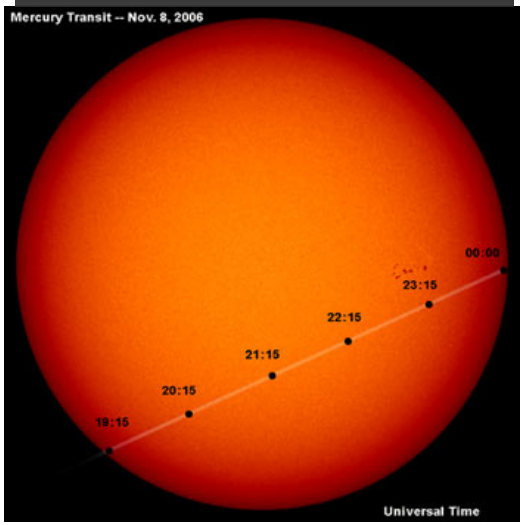
design (Schmidt telescope) at 1930 in the Palomar mountain observatory, providing larger field of view with lower distortions away from the optical axis. Radio telescopes imaged the sky from a totally new perspective. Towards the end of the 20th century electronic CCD imagers (first developed for the astronomers), adaptive optics to compensate atmospheric thermal perturbations, and space telescopes positioned in satellites supply today sky images from the far infra-red till ultra-violet, light wavelength that are absorbed by the atmosphere.



A (wrong) theory proposing dependence of gravity field on body velocity encouraged **Maxwell & Lorentz** to develop Electromagnetic field theory (where charges inflict velocity-dependent forces). **William Thomson** tried to explain the precession of Mercury perihelion (closest point in orbit to the sun).

Urbain Le Verrier 1811-1877

1855 – Documented 35/60 degrees per 100 years of precession In Mercury‘s perihelion from its time of crossing the sun, and attributed it to gravitation to an unknown planet in inner orbit. The planet was never found. The true explanation was only Provided by the general relativity in 1917.
Reports about migrating spots on the surface of the sun were found as artifacts.

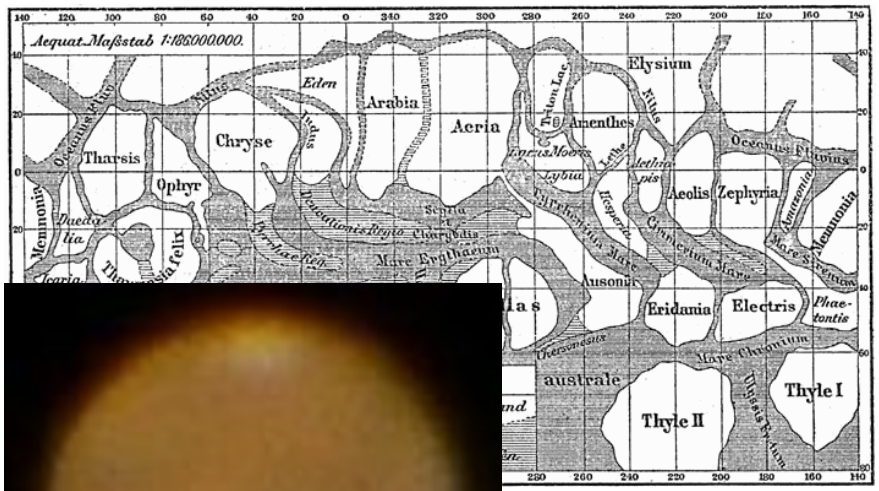


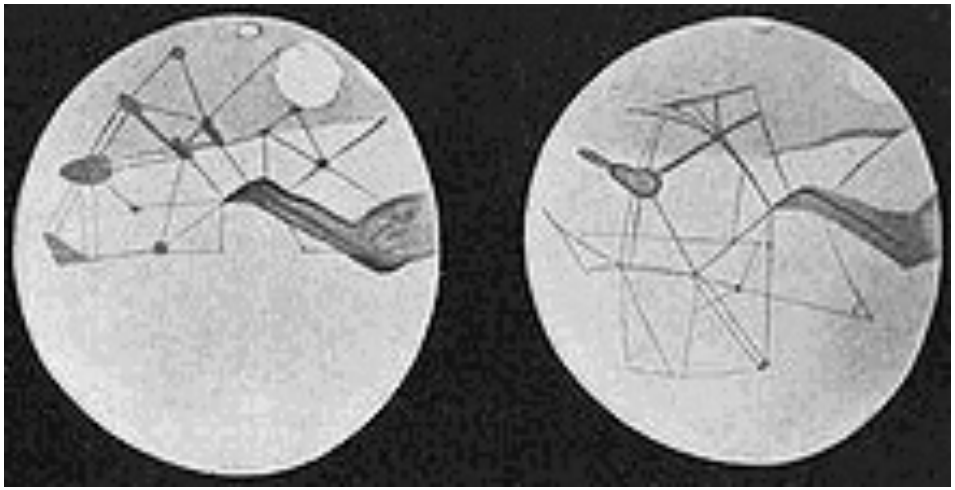
Simon Newcomb 1835-1909

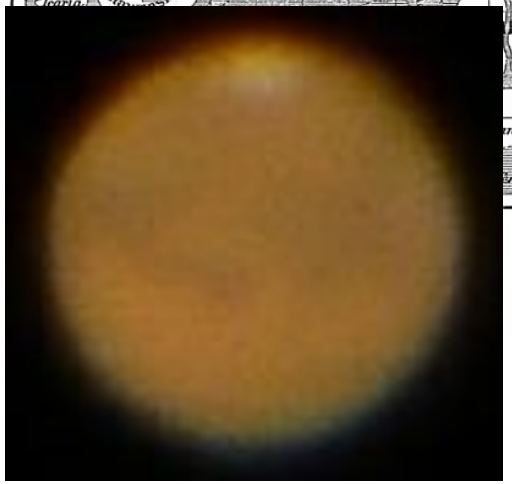
1882 Measured 43 arc seconds per 100 years of Mercury precession.

Giovanni Schiaparelli 1835-1910

1877 Described a detailed map of channels on the Mars as seen when Mars and the sun were at opposite directions with respect to earth. These findings were also seen by Percival Lowell, yet his straight lines did not overlap the drawings of the channels… The reports were enthusiastically accepted by scientists and the public alike, maybe due to the vivid discussions whether life exist on other planets, or the constructions of the Suez and Panama channels. The differences were even used as evidence for active construction of new channels by the Mars people…







Drawing of the Mars channels as visually observed by telescopes. Long and tedious inspection through telescopes must have caused visual illusions.

A photograph of Mars showing faint intensity variations.

SUPERNOVA

Ernst Hartwig 1851-1923

1885 Observed an explosion (Nova) in Andromeda nebula, and measured its maximal intensity before it decayed. Find out the intensity is equal to that of the whole galaxy.

As noted above, there are historical records of supernova:

1054 explosion of a supernova in Cancer constellation, observed even at daylight during 23 day in the Chinese Sung national observatory at K'ai-feng.

1604 Galileo measured location and distance of supernova, indicating it is far beyond the moon, and not an atmospheric event.

SUMMARY:

During the 19th century the far past of earth and the long distance to stars were obstacles to accepted geological and astronomical models. Classification of geological layers and of fossils found in them suggest earth age much older than set by theological beliefs. Technologic developments in telescope Optics and in spectroscopy provide methods to measure the element contents of far suns. Newton's laws implemented in calculation of planet orbits, comets and asteroids not only confirm their global validity but also predict new stellar bodies in order to explain small deviations.

BIOLOGY

Today it is difficult to imagine the level of biological knowledge (or rather the ignorance) at the beginning of the 19th century. Despite many millennia of selective agricultural practice of selected perfection of, for example, wheat and farm animals, the scientific basis for heredity and its rules were fuzzy.

At the 18th century, development in microscopy and chemistry provided technologies to isolate biological materials, and even localize biomolecules and structures in tissue and inside cells. Medicine is gradually detached from magic spell and superstition, and adopt scientific methodologies.

the 19th century contributed the basis of modern biology and medicine:

- Cell theory, cell proliferation in mitosis, intracellular organelles (nucleus, mitochondria, Golgi).
- Evolution and heredity of properties.
- Fertilization and embryology – stem cells.
- Neurobiology – structure of nerve cells, the brain and its parts, electric activity of nerves, sensing (hearing, vision).
- Photosynthesis in plants and metabolism in animals.
- Microbiology – bacteria, yeast, viruses, infectious diseases, vaccination and hygiene.
- The biochemistry of molecules of life - proteins and enzymes, fatty acids, carbohydrates, sugars, nucleic acids.
- The role of inorganic salts in life-preserving solutions (saline) and in nerves.
- Prostatic groups – Hemoglobin, chlorophyll – and connection to vitamins.
- Disinfecting materials, drugs and poisons. Antibodies, anesthetic and synthesis of organic chemicals.
- Psychology and mental diseases.

The following (long) list of biologists, chemists and physicians with a (brief summary of their contributions aim to outline the progress in biological thinking and the development of theories.

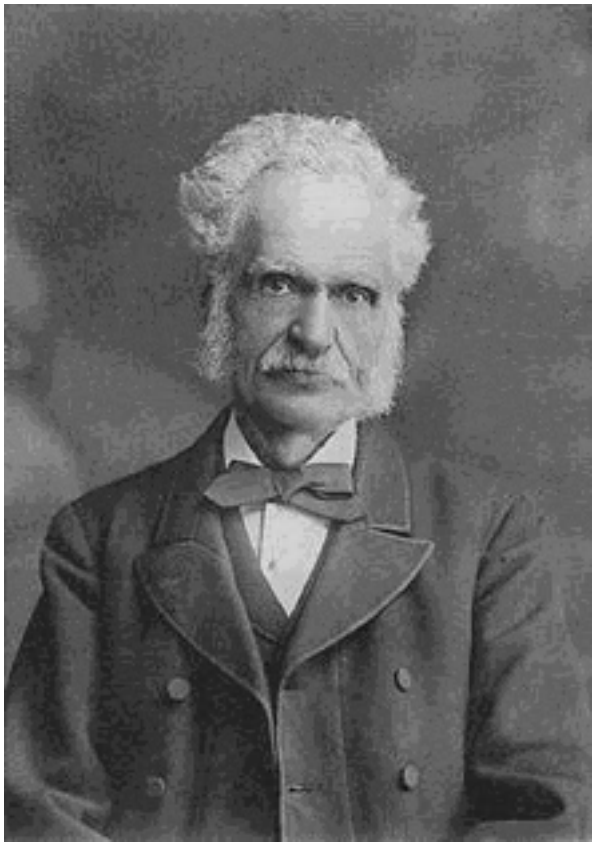
Maybe, unlike physics, biological complexity and the diversity of life forms made experimental studies difficult and conclusions indecisive and fuzzy. Previous bias was therefore an important force motive in the building of biological models and theories, and made new ideas (such as Darwin's) hard to penetrate the main stream science.

Nevertheless, ingenuity of devoted scientists, tedious work of experimentalists (from zoologist and botanist classifications, through microscopic characterization of cells and their content, to chemical characterization of life materials) in combination with philosophical rationing and logical argumentation, all brought biology to a point ready for the 20th century molecular biology breakthrough.

The following presentation may be more beneficial for people that studies biology and have lose background in medicine. I hope that the interested "ignorant" reader would nevertheless be able to follow.

Henry Walter Bates 1825 -1892 English Naturalist.

1848 Participated in a delegation to the Amazonas rain forest with **Alfred Russel Wallace,** and returned with a collection of 15,000 insects, mostly unknown in the western world. A part of the collection was lost when the transporting ship burnt. Bates discovered butterflies with bad taste as a protective mechanism, that indicated to him as a proof to natural selection in evolution.

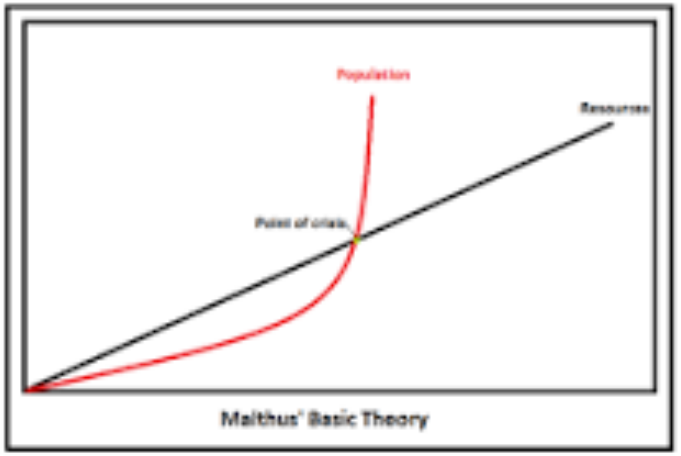


Thomas Malthus 1766-1834

1798 Discussed population growth and food production rates. Mlthus law: population growth is geometrical but food production grow linearly, which will not meet demand and bring starvation.

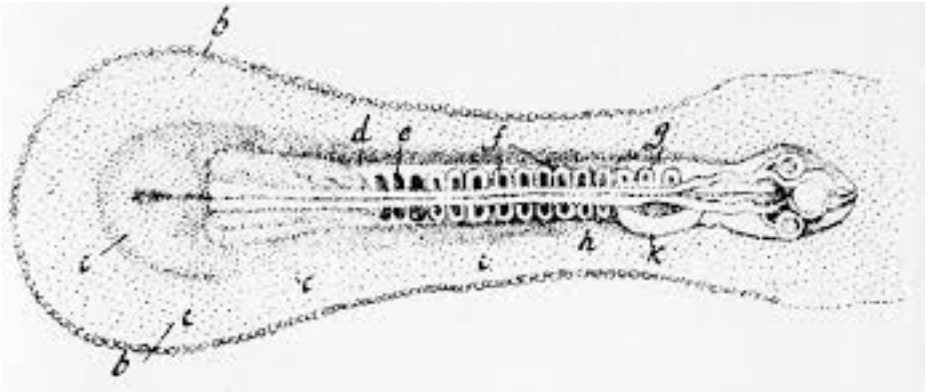
Malthus had great influence on economists. The “green revolution” demonstrated a potential to produce more food, but the progress in medicine predicted population explosion, that brought the “crisis point” closer.

Today we know that the curves for amounts of food and population growth are hard to extrapolate (due to plagues, wars, and even number of children restrictions in Chine). Yet, Malthus law is still at the heart of economical discussion. The importance of predictive models was recently brought forward in the Corona virus epidemic, for the preparation of hospital beds and the design of strategies for imposing and relaxing home siege and social proximity regulations aiming at maximizing herd immunity without overloading the medical system.



Kaspar Friedrich Wolff 1733-1794

1767 Claimed that chick embryonic tissues are not proliferating from existing tissues, but are developed from "nothing".



Lazzaro Spallanzani 1729-1799

1768 Proved that spontaneous life cannot develop in rich media if it was heated to destroy existing organisms, and kept sterile in sealed bottles.
He also demonstrated that fertilization in mammals require both egg and sperm.

Joseph Priestley 1733-1804

1771 Showed that plants expel gas consumed by animals and in flame. Discovery of Oxygen and Carbon dioxide.

Henri Dutrochet 1776–1847 & **François Raspail 1794–1878**

The Cell – the basic unit of life. Wrongly described creation of new cells INSIDE existing cells.

Barthelemy Dumortier 1797–1878

1832 Observed cell division in plants.
Probably preceded **Hugo von Mohl 1805–1872** who coined the name "Protoplasm".

Franz Bauer 1758-1840 Czech

1802 Described cell nucleus. The name was coined by Brown (Brownian motion) at 1831.

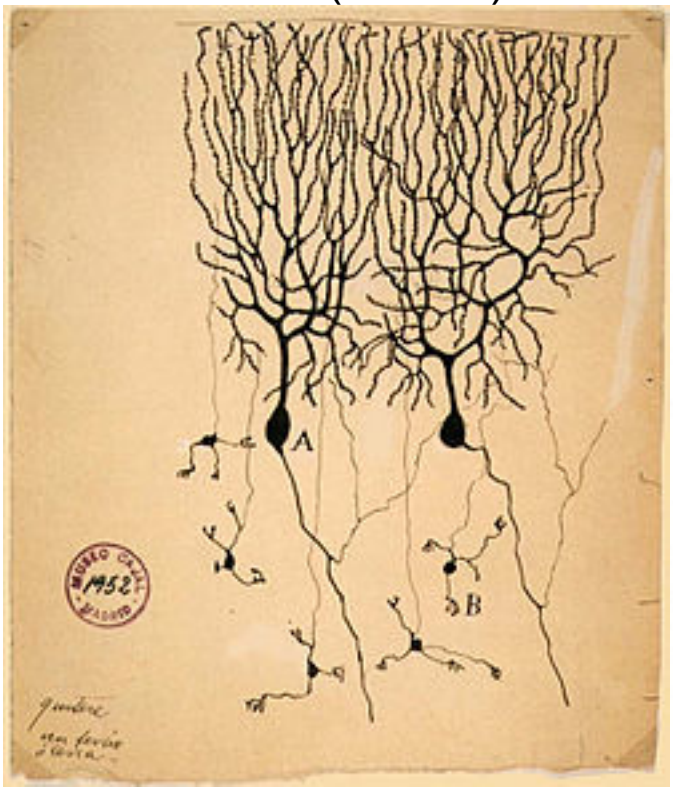
Jan Purkyňe 1787–1869 or **Purkinje**

Cells build plants and animals.

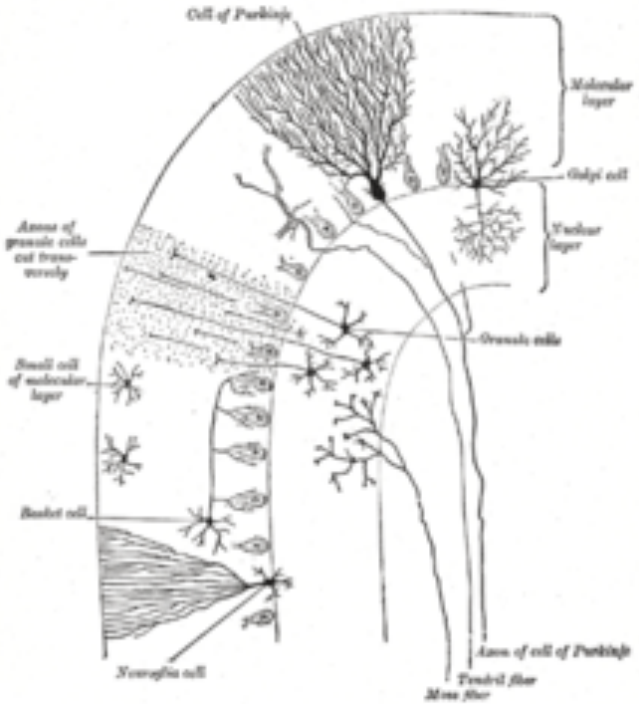
1832 Nerve cells have axons and dendrites.

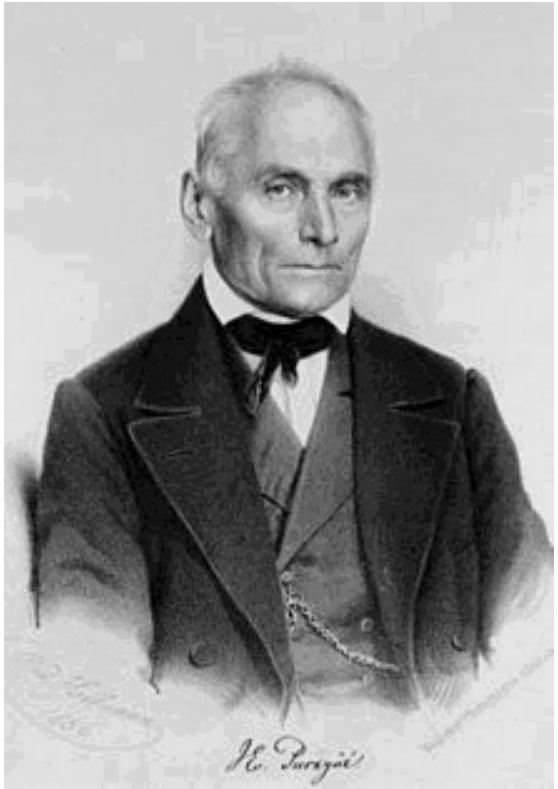
Coin the name “Protoplasm” with **Mohl**, defined as the content of cells.

Nerve cells with axons (top)
and dendrites (bottom)



Purkinje cells in the cerebellum





Theodor Schwann 1810-1882

1836 Extracted Pepsin from guts – the first enzyme used in digestion.
1837 Showed that heated air prevents gangrene.

Matthias Jacob Schleiden 1804-1881

1838 Proposed that all PLANTS are built from cells, and noted the importance of the nucleus.
1839 Adds that also all animals are built from cells that contain all nuclei: the elementary unit of life.

Konstantin Sigizmundovich Kirchhof 1764-1833

1815 Reported that Gluten from wheat can supply the body with Dextrin and Sugar.

Pierre-Joseph Pelletier 1788-1842 & **Joseph Bienaimé Caventou 1788-1842**

1817 Isolated Chlorophyll (see following), and later Quinine, Caffeine and Strychnine

Christian Friedrich Nasse 1778-1851

1820 Formulated “Nasse’s law”: Hemophilia is a male alone symptom, but inherited by healthy women.

Jean Louis Prevost 1790-1850 & **Jean Baptiste Dumas 1800-1884**

1824 The sperm is not a parasite, but a necessary fertilization factor.

Karl Ernst von Baer 1792-1876

1826 Demonstrated that female eggs are generated in the Ovaries, which ended 200 years of search.

1827 Became a pioneer in embryology by phrasing a few laws:

- Gross formations in the embryo are developed before the adult tissues.
- The specific tissue are segmented from the gross ones, and are specific for the adult.

William Prout 1785-1850

1827 Classified biomolecules, carbohydrates, proteins and lipids. (Nucleic acids are still missing).

Albert von Kölliker 1817-1905

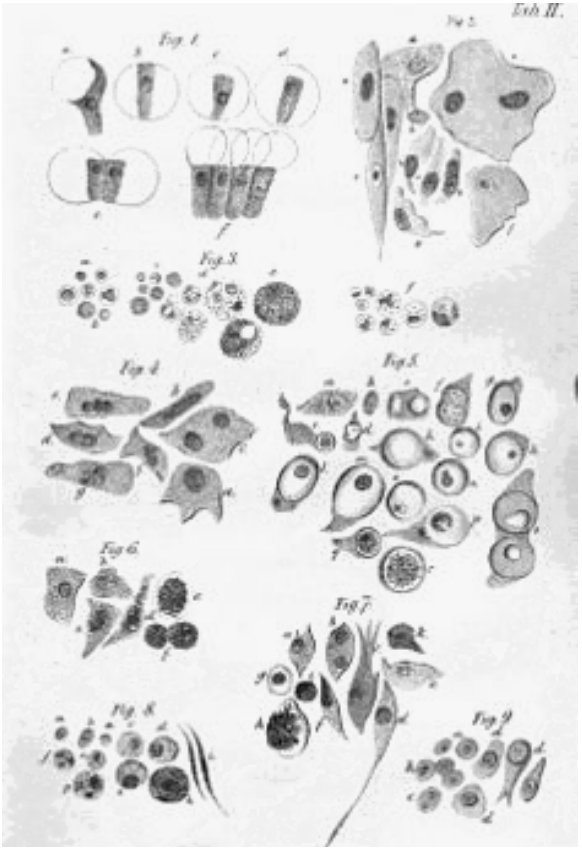
1857 described mitochondria in muscle cells.

Robert Remark 1815-1865

1852 New cells divide from old, not “crystallized” inside an existing cell as Schlieden proposed.

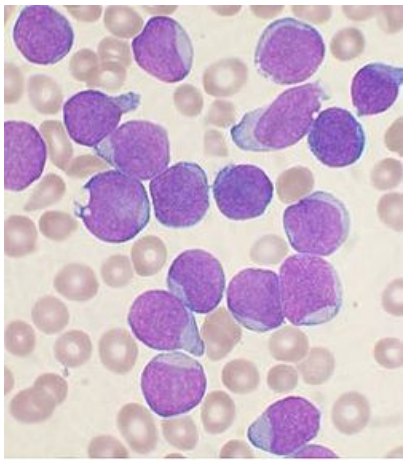
Rudolf Virchow 1821-1902

1858 – “Omnis cellula e cellula” Cell are created from cells. The Phrase was coined by François-Vincent Raspail and was popularized By Virchow. Cells divide: Did not credit **Remark**, but advanced Accepting of **Schleiden-Schwann** cell theory.



Virchow resisted **Darwin’s** evolution, and that Neanderthal man as an ancestor of humans. He ridiculed skull dimensions as criteria for race, and assembled data that denied changes between Arians and Jews. He dismissed the link between bacteria and diseases of **Pasteur** and **Koch**: **“**Diseases are due to dysfunctional cells, and bacteria accumulate in such cells but are not the cause of diseases”.

Leukemia – blood cancer



TIMELINE of cell theory

1665 Robert Hooke – Using a compound microscope he described cork cell walls
1680 Anton van Leuwenhoek – Using a single lens microscope he observed bacteria and cells.
1768 Lazzaro Spallanzani – Proved that sterile rich medium does not have proliferating bacteria spontaneously.
1827 Robert Brawn – Described the cell nucleus.
1838 Mathias Schleiden - Described plant cells.
1839 Theodor Schwann – Animals are also built from cells.
1855 Louis Pasteur – Bacteria cause diseases. Negated spontaneous life creation.
1857 Albert von Kölliker – Described mitochondria in muscle cells. 1817-1905
1882 Robert Koch – Related tuberculosis with bacterial infection.
1885 Rudolph Virchow – Cells divide from cells.
1898 Camilo Golgi - Stain “Golgi apparatus” in cells.

Albert von Kölliker 1817-1905

Developed methods for tissue sections and histological staining. Discovered mitochondria in muscles.

Martin Barry 1802-1855

1843 Reported merging of sperms and egg of rabbits (published as a short paper in the Royal Society Journal)

Christian Leopold von Buch 1774-1853

1825 Proposed that varieties can diverge into species within generations.

Louis Pierre Vieillot 1748– 1830

Implemented Linnaeus classification methods to central America birds. Studies types and colors of feathers.

Robert Grant 1793-1874, August Schweigger 1783-1821, & Friedrich Tiedemann 1781-1861

1826 Supported a common origin to plants and animals.

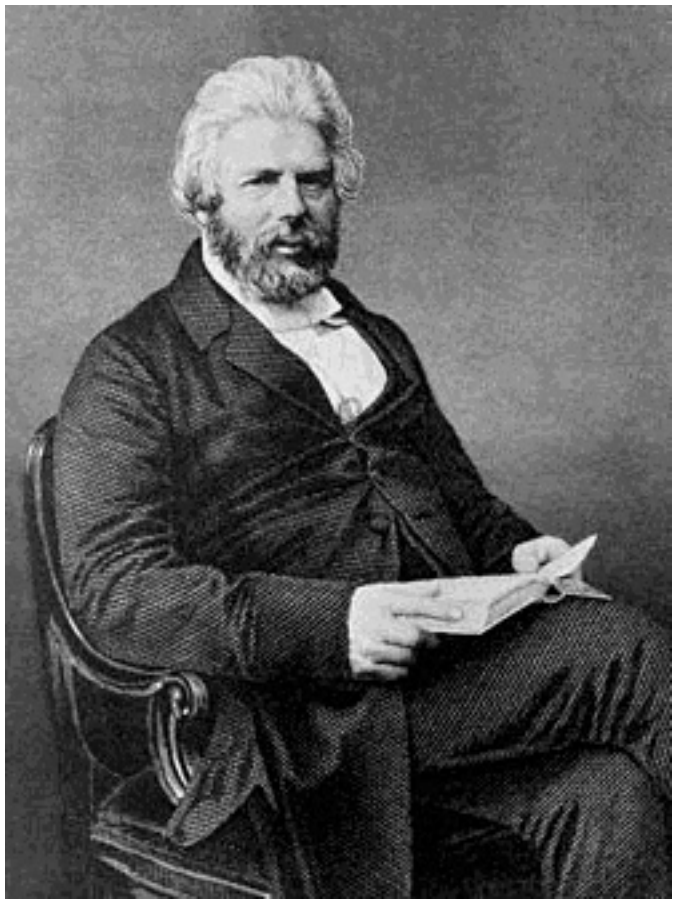
Friedrich August Kekulé von Stradonitz 1829-1896

1858 Proposed that carbon atoms form chain molecules.

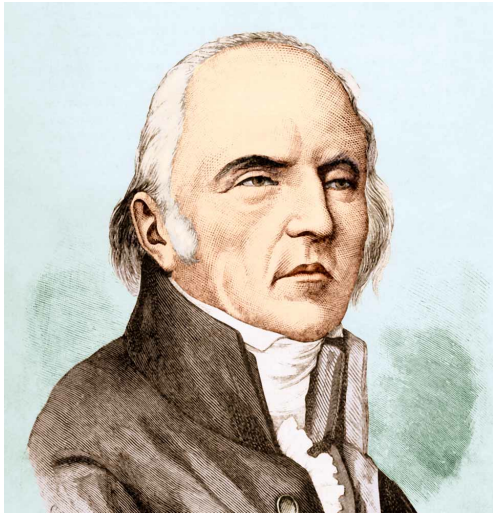
1865 Proposed the ring structure of Benzene.

Robert Chambers 1802-1871 Scott

Studies geology and then evolution of life.
1844 Thoughts fall within the realm of natural laws.
Developed after Baer's principle a theory of Lamarckian evolution influenced by Auguste Comte's positivism (science is experiments and research).
Published without authorship, due to fear of the church.



Jean-Baptiste Pierre Antoine de Monet, Chevalier de Lamarck
Jean-Baptiste Lamarck 1744-1829



Lamarck was first to propose gradual evolution of life. Believed In “soft” heredity of acquired characteristics.
He came from a military family, but was wounded and moved into Biology.
1778 Worked in the “King’s gardens” that are today “Gardin de Plantes”, the national natural history museum. Edited a book about the French flowers.
1801 Studies zoology of invertebrates, and extended Linnaeus classification method.
1809 Based on fossil studies, and differently from Buffon who suggested gradual changes of life, he proposed evolution of life forms that adapt to nature, and heredity of these acquired traits which result in diversity. He first believed in a linear progress, but from the classification of life forms he moved to support evolutionary tree, that start at spontaneous generation of simple life forms (such as bacteria). Based on heredity of acquired “habits” (or behavior) due to environmental adaptation, he proposed nurturing of preferred traits by selective breading. Examples were development of limbs due to frequent use.
The basic assumption of heritage of acquired properties was wrong, but his biological knowledge was much broader than Darwin’s, and his theories found support on life species and classes, including mutations in humans that showed adaptation to environmental conditions. Moreover, “epigenetics” is a modern field that demonstrated molecular mechanisms that provide ways to pass on changes, for example in genetic expression controls, to next generations.

Gottfried Reinhold Treviranus & **Karl Friedrich Burdach**

1802 Coined the name „BIOLOGY“ as a branch of science, including zoology, botany and mineralogy, replacing “Natural history”.

Georges Cuvier 1832 -1769 French

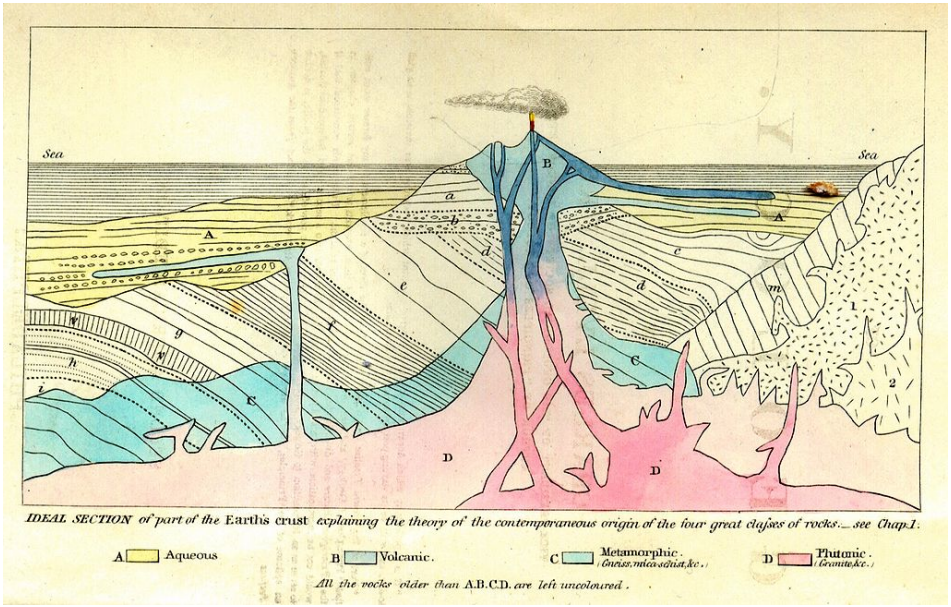
The father of paleontology.

1812 Fossils are layered chronologically in sediment soils: Fish, Amphibians, reptiles, mammals. He opposed Lamarck’s gradual evolution, and supported Catastrophism that extinct some kind of species and created new kinds.

Charles Lyell 1797-1875 Scott

A lawyer and geologist. His theories and later support he paved the road to Darwin.

1829 Denied catastrophism, and supported Uniformism (first proposed by **James Hutton 1726-179**): earth and life on it developed in a continuous process. Claimed that the present rate of changes teach about the past with same change rates. This theory opposed the religious and scientific theory based on Noah's flood. The bible set earth age as 6000, but failed to account for the creation of river valleys by the slow erosion by water and glaciers. On the other hand, inverted sediment layers, volcanic eruptions and earthquakes were all incompatible with uniformism, and supported catastrophism. Lyell's geological manuscript, so popular that four editions were published, expanded to six volumes, and presented a complete theory and classified geological layers according to the fossils found in them. Lyell discussed Lamarck's ideas critically, but opposed evolution theory. Only following the publication of Darwin "The Origin of Species" he became an enthusiastic Darwin supporter, and promoted his lectures and publications.



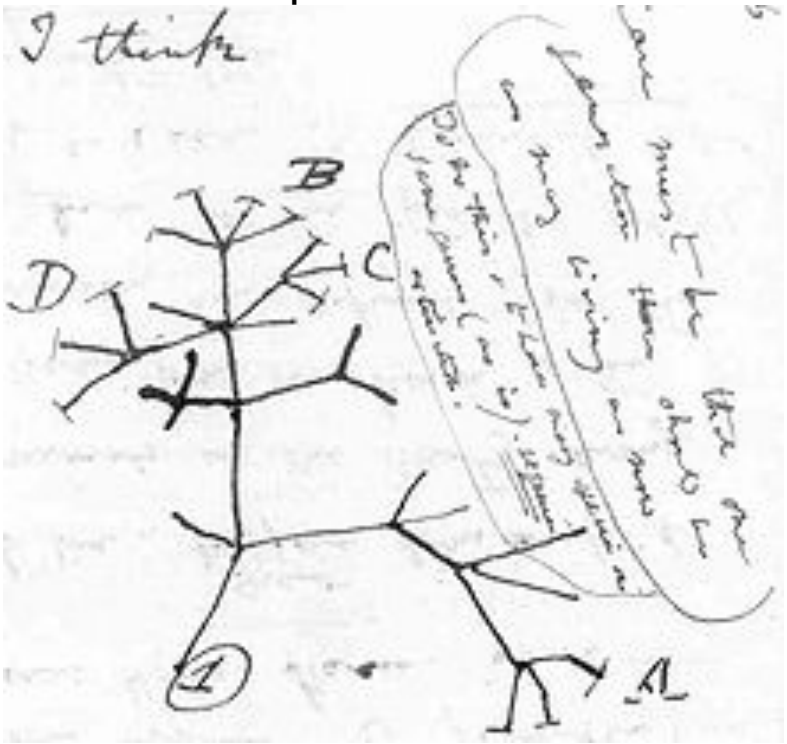
Charles R. Darwin 1809-1888 & **Alfred Wallace 1823-1913**

1884 Darwin wrote but did not publish "`The Origin of Species".

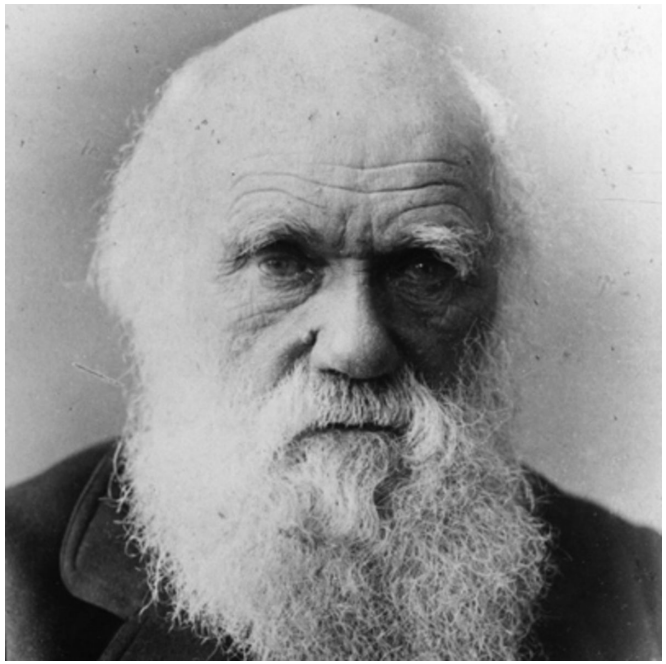
1858 Darwin and Wallace, who developed the idea of "natural selection" independently, publish the manuscript due to Lyell's encouragement at **1859**. They believed that every small change that was beneficial to life was preserved by heredity. The initial term was "descent through modification" and only in later editions Darwin coined the term "evolution". Darwin believed that inherited characteristics are average of parents characters.

The idea developed far from home, during Darwin's trip on the Beagle to Galapagos and Wallace trip in the Malay archipelago.

1859 The implication of Darwin's evolution that "apes are our ancestors" ignited aggressive public debates.



A page from Darwin's notebook from his trip on the Beagle.



1831<u>The voyage of the beagle to Galapagos</u>

The observations during this voyage that brought Darwin to the ideas of <u>Natural Selection</u>, <u>Survival of the fittest</u> and <u>Divergence</u> are:

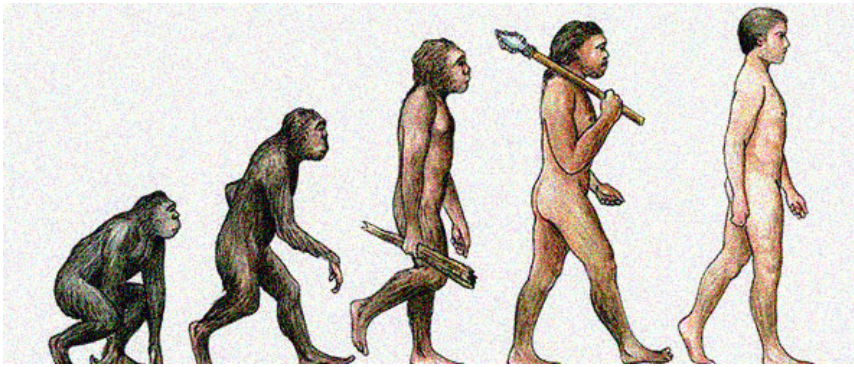
1. Ground finch beaks adaptation to the kind of food on the island they inhabited.
2. The variety of Rhea in south Argentina.
3. Skeleton bones of vertebrates similar to present days vertebrates.

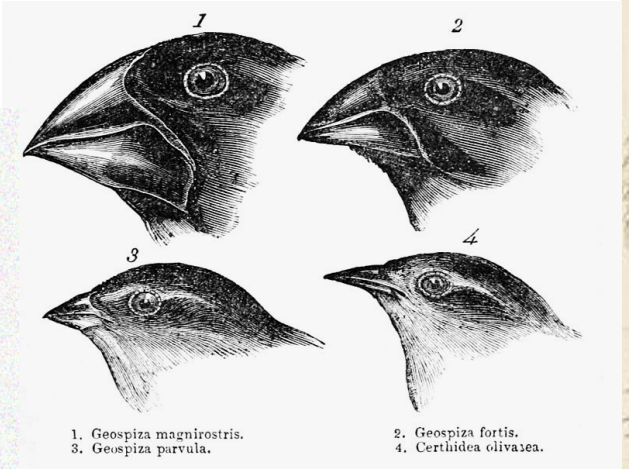
Darwin developed his ideas at 1844, but did not publish them until he saw the book "Vestiges of the Natural History of Creation" by **Robert Chymbers 1802-1871**. The book deals in a simple way with the idea of evolution, but Darwin worried that the show will be stolen from him… He also read **Alfred Wallace** independent version about evolution, and decided to submit with Wallace an announcement at the "Linnaean society" in London, and finished writing and published "The Origin of Species". Lyell, whose book on Geology Darwin read on his Beagle trip, supported him enthusiastically.

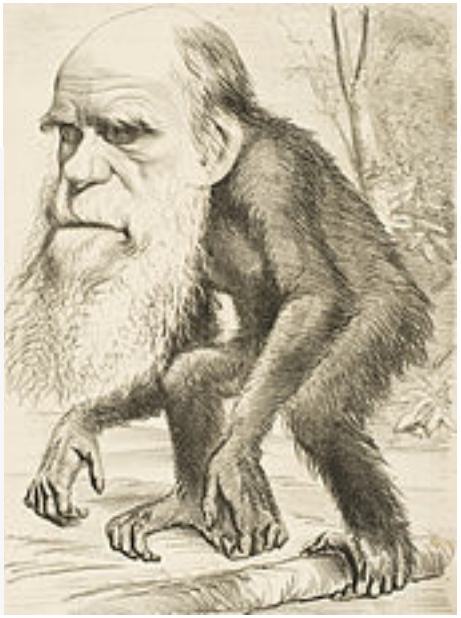
18 years later Darwin published "The origin of Man", that shook the Puritan Victorian religious establishment.

As late as 1925 a teacher in Tennessee that taught the evolution theory was sued in a court:

"The monkey case"

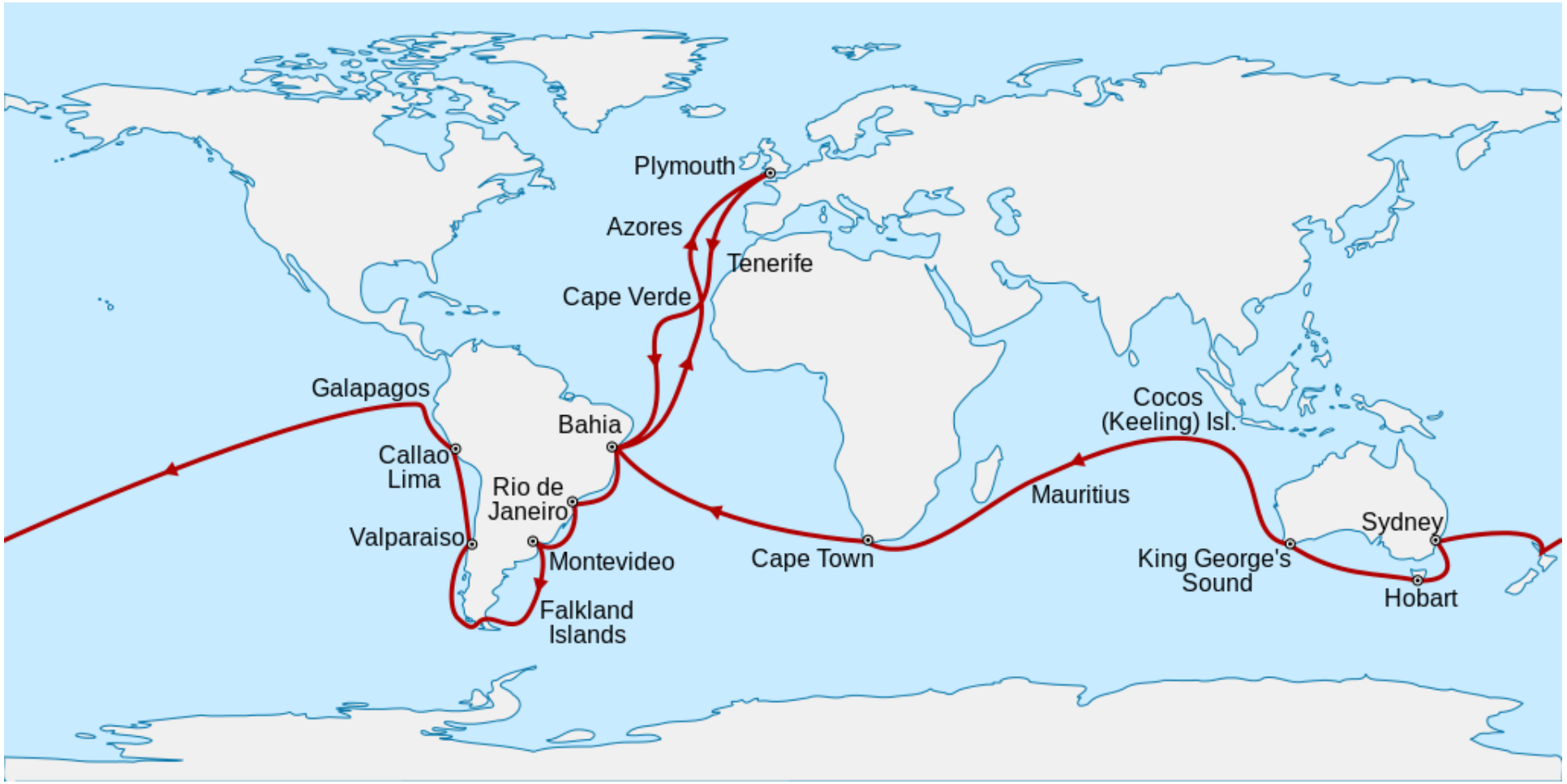






The voyage of the Beagle 1831-1836

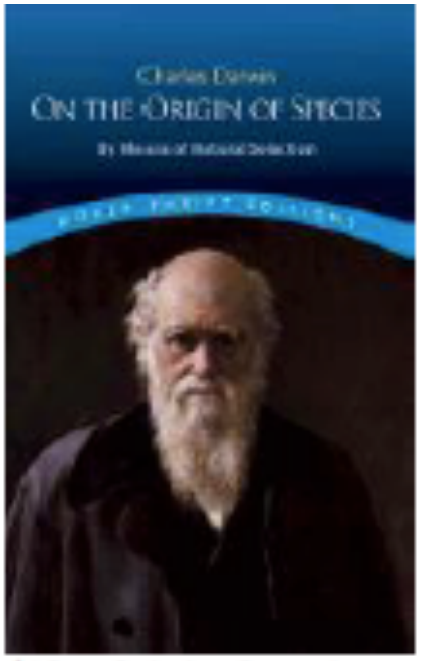
Darwin was a young medical doctor who did not get a job, and was hired as a ship doctor. The trip around the world west-wise left Plymouth to cape Verde, crossed the Atlantic to south America, around Patagonia back north to Galapagos, crossed the Pacific and south of Australia and Tasmania, Tahiti, New Zeeland, and Cape of good hope St. Helena and Mauritius and Azores.



1859 Darwin claim that all life originate from a common ancestor, and diversification of species come from natural selection of variants best fitted to their environment – similar to the induced selection of farm plants and animals.

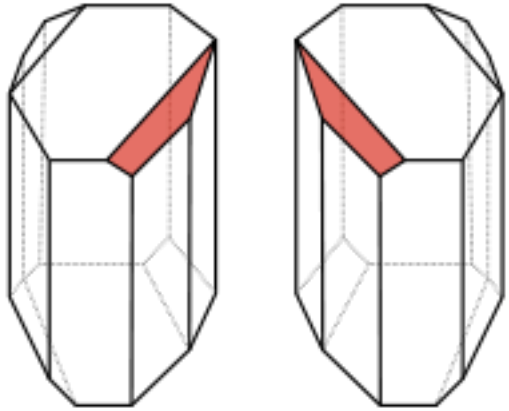
The term “mutation” was distorted due to Linnaeus’ sorting in species and classes. Therefore anatomist such as Ernst Heinrich Haeckel studies relations between animal species. Darwin, who was an expert Geologist (and secretary of the Geological Society 1838-1841) presented proofs from fossils that life forms developed gradually.

1876 **Wallace** published his contribution to the theory of evolution: “The geographical distribution of animal”



Darwin’s book
“The Origin of Species”
A best seller till today

Louis Pasteur 1822 -1895



1848 Tartaric acid has two crustal structures – Enantiomers: Levo & Dextro. The start of Stereochemistry.

1849 Aerobic and Un-aerobic (no Oxygen) metabolism.

1855 Microorganisms create fermentation (sugars to alcohol by yeast.

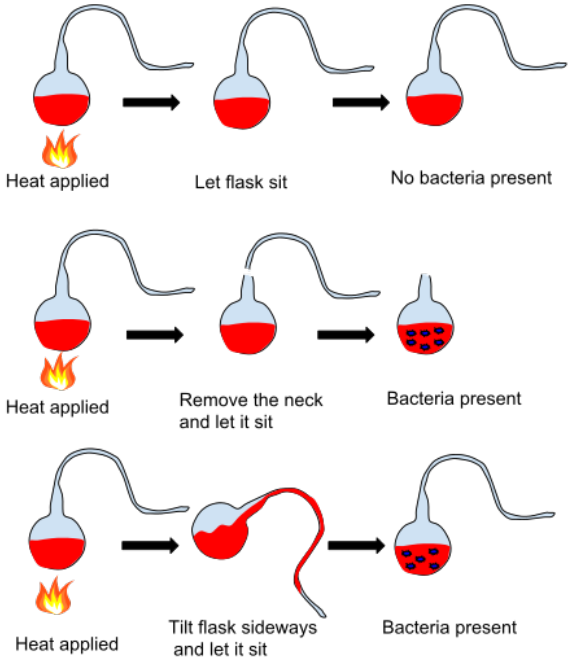
1857 Demonstrate that sour milk (lactic acid formation) is caused by bacteria

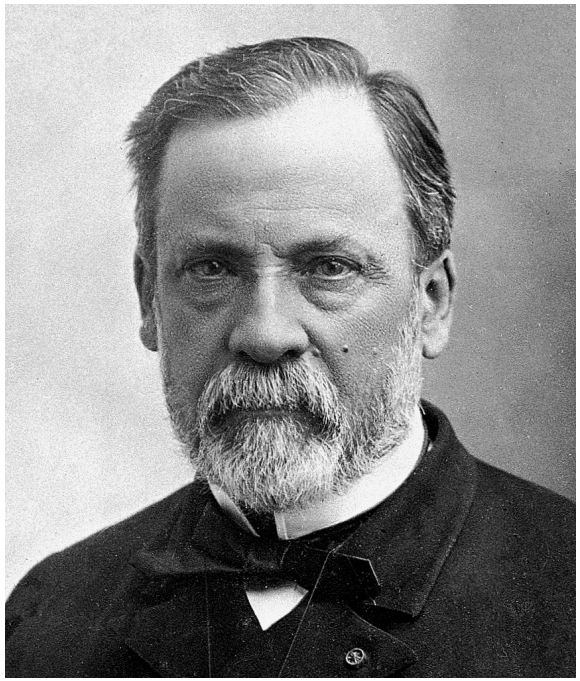
1862 Pasteurization – by Pasteur and **Claude Bernard.**

1864 Demonstrate that rich medium that was boiled and covered by a filter stay clear of organism. Disproved (again) spontaneous life generation.

Sterilization extinct silk warm disease.

Demonstrated vaccination by dead bacteria.





1862 Pasteur published the germ theory: Proliferation of pathogenic microorganisms in human body are the cause of diseases. Immunity can be acquired by cultures of weakened viruses (Vaccines, named after **Edward Jenner 1749-1823** cows viruses that vaccinated against smallpox).

Pasteur believed in vitalism: The word “life” is a replacement to chemical information, therefore fermentation is a physiological process linked to the life cycle of budding yeast, and cannot be explained by chemistry.

1885 Rabies vaccine.

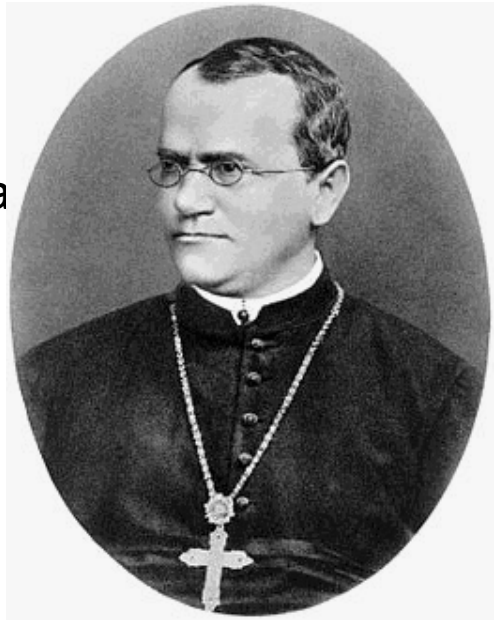
1887 Institut Pasteur in Paris was founded.

After Pasteur’s note books was published by his children, at his request, he was accused of forging results. His conclusions however were proved over the years and his excluded outliers were justified as polluted incidences, and are in fact common practice in modern statistical analysis.

Friedrich Miescher 1844-1895, John Goss 1800-1880, **Alexander Seton 1769-1850** & **Thomas Andrew Knight 1759-1838**

1822-1824 All, independently, study heredity of recessive genes in pees by hybridization experiments, but fail to accumulate data for several generations. 30-40 more years passed before Mendel's work was publicized.

Gregor Johan Mendel 1822 – 1884



1859 Mendel published heredity rules of garden peas from his Plant Hybridization experiments. Mendel did first experiments on mice and other plants, but settled on peas due to several advanta

- The reproductive organs are concealed by leaves, preventing foreign fertilization thus growing pure species in nature, yet allow artificial insemination by simple experimental procedures.
- Availability of simple to identify properties.
- Low cost.
- Short generation cycle.
- Small growing area, adaptable for the convent yard.

Mendel applied experimental methods that guaranteed his success: Detailed planning, isolation of variables, collection of large data sets, and careful statistical analysis.
The 7 properties Mendel recorded are: Color of the flower (Purple / white), Position of the flower (top of the stem / along the side of the stem), pea pod color (yellow / green), pea pod texture (smooth / rough), pod color (green / yellow), pod shape (flat / inflated), pea plant height (short / long).
Mendel's contribution is the basis of modern genetics, but was not recognized at his time, since the belief that properties of siblings are average of parents properties. The lack of recognition in his work saddened Mendel deeply.

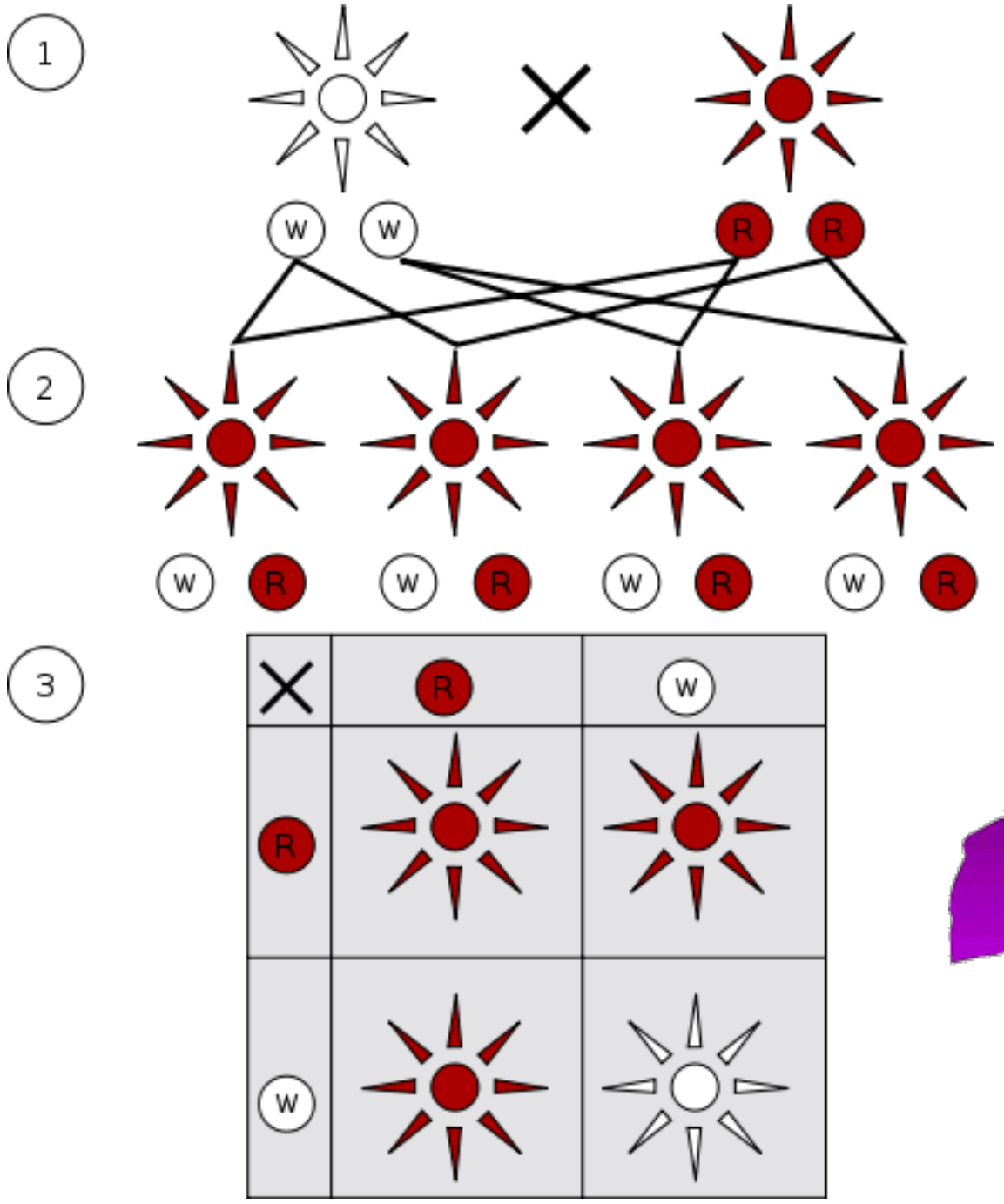
His work was only rediscovered at 1900, and his experiments were reproduced by
Hugo Marie de Vries 1848-1935, Carl Erich Correns 1864-1933
& Erich von Tschermak von Seysegegg 1871-1962

Mendel's rules of heredity

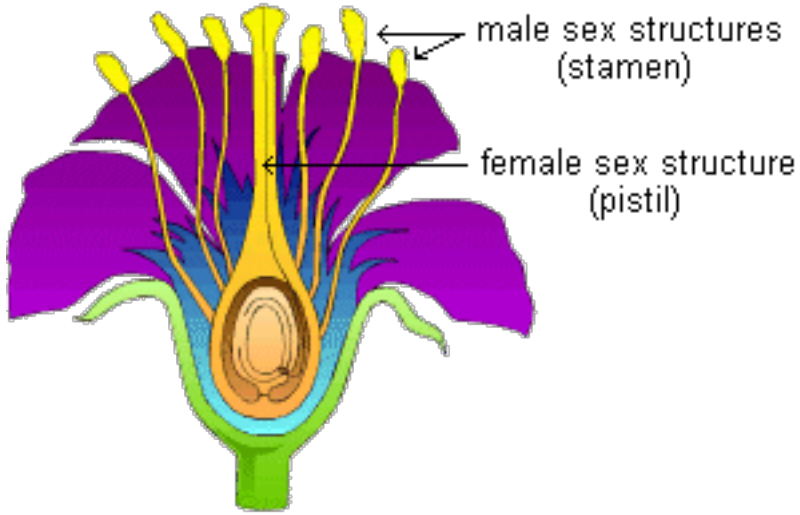
1. Segregation principle: Every organism contain two factors (genes) for every property, that split making sperms and ovule. When they unite in fertilization the progeny acquires these dominant or recessive properties. The properties are independent on the environment, and only determined by the parents.

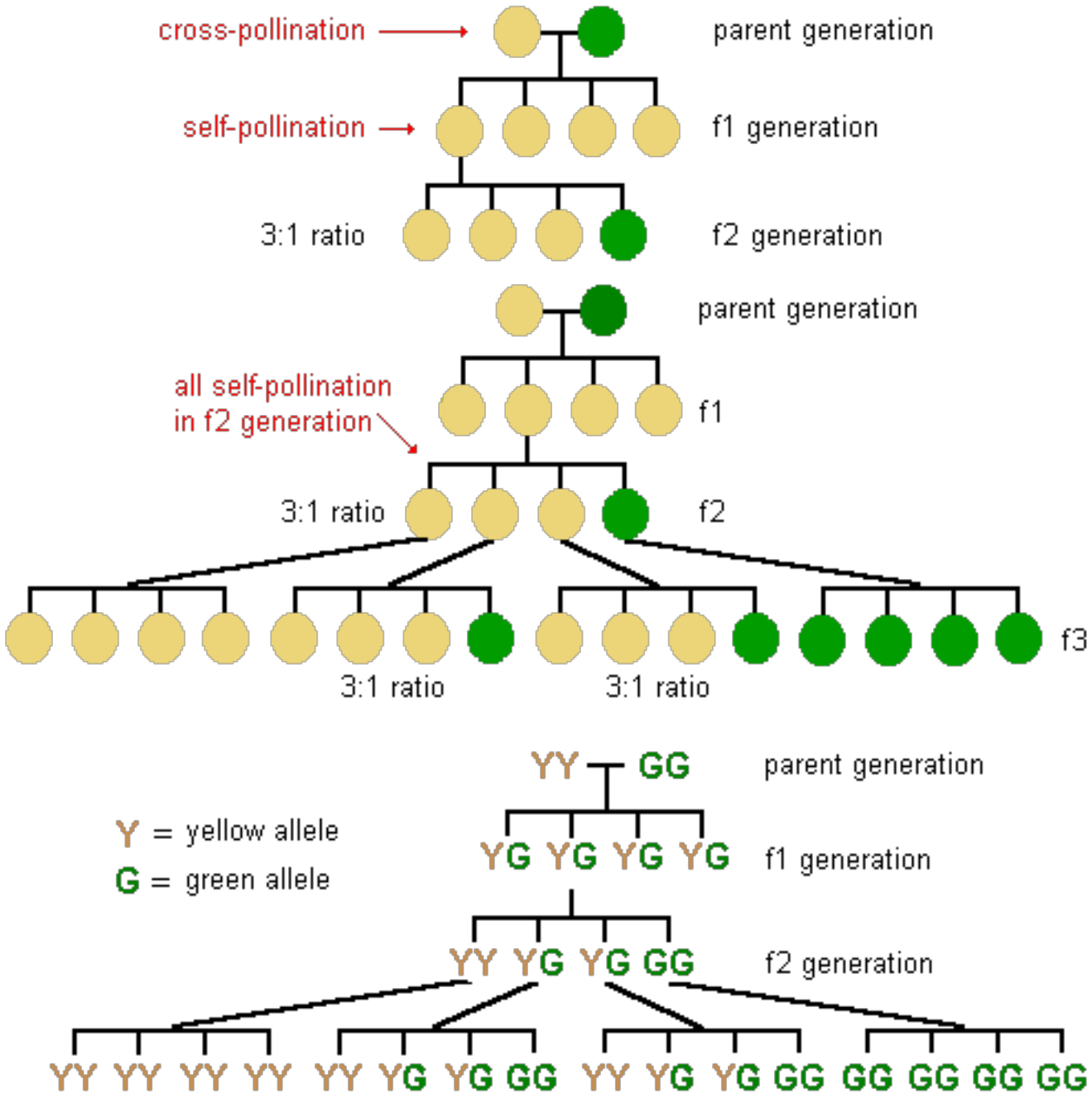
2. Independent assortment: of the genes into the sperm or ovule. Every progeny hires a random mix of factors that determine his own properties.

3. Dominance principle: in heterozygote a dominant factor will "conceal" the recessive factor, but can be rediscovered in a homozygote with two recessive factors at the third generation.



Dominant and recessive phenotypes. (1) Parental generation. (2) F1 generation. (3) F2 generation.

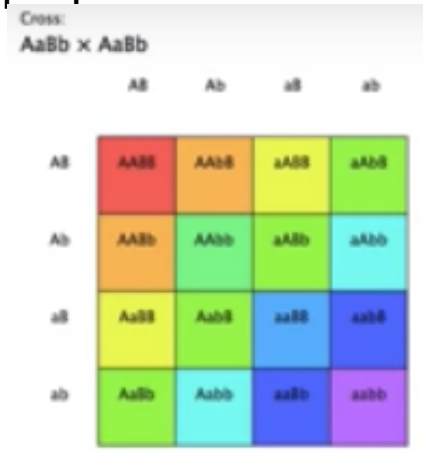


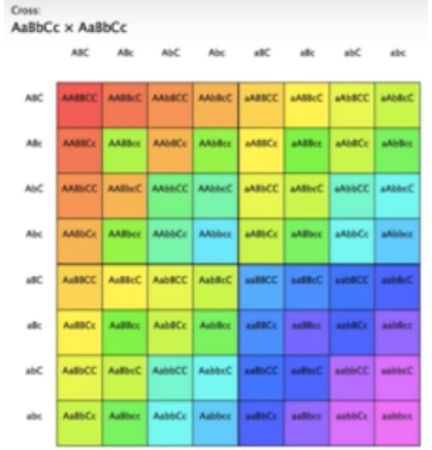

cross-pollination
parent generation
self-pollination
f1 generation
3:1 ratio
f2 generation
parent generation
all self-pollination
in f2 generation
f1
3:1 ratio
f2
f3
3:1 ratio
3:1 ratio
Y = yellow allele
G = green allele
YY GG
parent generation
YG YG YG YG
f1 generation
YY YG YG GG
f2 generation
YY YY YY YY YY YG YG GG YY YG YG GG GG GG GG GG

Mendelean genetics have modern "corrections":

The laws of heredity are more complex than Mendel concluded:

1. Distribution of hereditary properties is random only if the genes are residing on different chromosomes. The correlation between inherited genes on the same chromosome fall with distance along the chromosome.
2. Beyond recessive and dominant heritage there are properties that average on the two genes, and there are "mosaic" properties (such as black and white feathers).
3. There are special laws for sex chromosome, determination of progeny sex, and sex-related properties.
4. Plants have more than two gene copies, and most properties are determined by several genes: Genotype-phenotype relations are complex.
5. Lethal property of one gene (e.g. Tay-Sachs, Sickle-cell anemia, Cystic phibrosis) has effect on gene distribution in populations, but disappear very slowly. Most diseases are poly-genetic, with direct effect on progeny genes. Environments effect gene distributions in populations, but do not determine hereditary genes.
6. Punnet square calculation: give the distribution of first generation phenotypes for several dominant or averaged properties for homozygote or heterozygote parents, for mono- duo- or hybrid pairing.





1869 Nucleic acids were isolated from cell nuclei.
1871 Nuclei were extracted from puss in bandages of war injured soldiers using pepsin .

Jacobus van 't Hoff and **Joseph-Achille Le Bel**

1874Stereo-chemistry: three-dimensional presentation of organic compounds, and proposal of the tetragonal structure of carbon.

Oskar Hertwig 1849-1922 & **Hermann Fol 1845-1892**

1876 Independently described experiments in sea urchin of sperm penetrating the egg, and nuclei merging.

Wilhelm Kühne 1837–1900

1878 Coined the term “Enzyme”.

Walther Flemming 1843-1905, **Eduard Strasburger 1844-1912** & **Edouard van Beneden 1846-1910**

1880-1890 Describe chromosome segregation during cell division.
1879 Fleming counted chromosomes during mitosis.

Emil Fischer 1852-1919

1884 Started his work analyzing structure and consistency of sugars.
1884 Proposed the structure of purines. He synthesized them at **1898**.

Richard Altmann 1852-1900

1889 Purification of DNA (was found later contaminated with proteins).

Hugo de Vries 1848-1935

1871 Described cell membrane permeability to Ammonia and Glycerol.

1889Proposed that hereditary properties are linked with particles he called pan genes.

Hans Driesch 1867-1941

1892 Separated two daughter cells after first division of fertilized sea urchin egg, and showed that every cell developed into a complete embryo. He thus rebutted the theory of pre-existing miniscule embryo with all adult limbs ("homunculus" for man), and proved that every cell contain the information for building the adult life – "totipotent".

Eduard Buchner 1860-1917

1897 Started his experiments to ferment sugar with yeast extracts without live cells.

Anselme Payen 1795-1871 & Jean-François Persoz 1805-1868

1833 Isolated the first enzyme – diastase, from barley malt, and conclude about the central role of enzymes in biology.

Julius von Mayer 1814-1878

1842 Connected metabolism heat and work based on blood measurements when he was a ship doctor. Calculated the mechanical equivalent of heat.

Carl Wilhelm von Nägeli 1817-1891

1842 Chromosome structure.

Naegeli & Carl Edward Cramer 1831-1901

1855 Plant cell membrane is a necessary barrier to maintain osmotic pressure.

Ernest Overton 1865-1933

1895-99 Proposed the following assumptions:

- Lipid membranes enclose plant cells.
- Separation of lipids from water is the basis of anesthesia (using alcohol).
- Cell external Sodium ions exchange with internal Potassium ions.
- There is an active transport across membranes that require energy.

CHLOROPHYL

Joseph Pelletier 1788-1842

1817 Through extraction in mild solvents he isolated Chlorophyll and other biological materials from plants. Together with **Bienaimé Caventou** they also isolated Caffeine, Strychnine, Colchicine, Quinine & Veratrine.

Chlorophyll, the green compound in plant leaves, was first considered a single molecule, but at **1864 Stokes** showed that it is a mixture. When dried leaves were crushed, dissolved in Ethanol and the Ethanol evaporated, Chlorophyll crystals grew, but when the dried leaves were dissolved in Acetone or Ether after solvent evaporation amorphous precipitate was left.

Richard Martin Willstatter 1872-1942 *et al*

1912 Showed that Chlorophyll contain two molecules: a & b. Nobel in Chemistry 1915. The separation was achieved when leave powder was dissolved in Kerosene and mixed in Methanol-water. Chlorophyll-b (deep green) partitioned into the methanol, and Chlorophyll-a (blue-black) remained in the Kerosene. Natural Chlorophyll contained 3 times more a than b. Chlorophyll-*a* ($C_{55}H_{72}MgN_4O_5$, mol. wt.: 893.49)

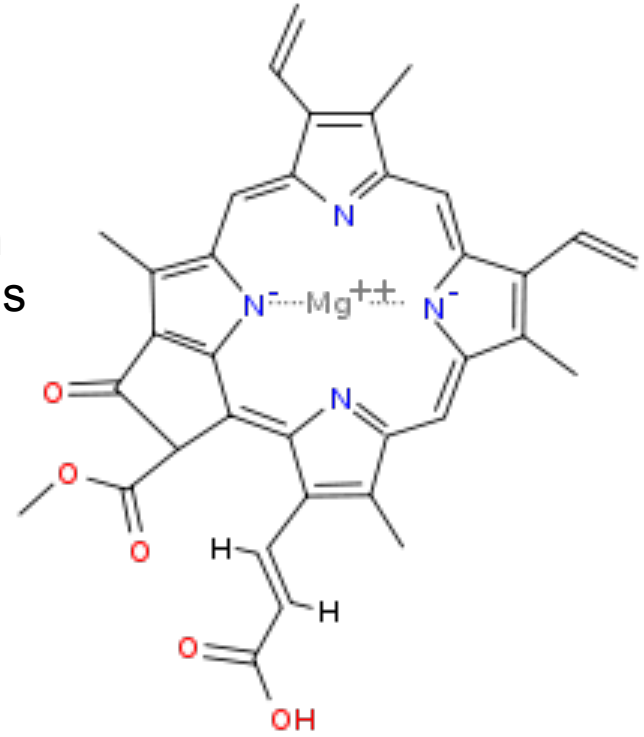
Chlorophyll-*b* ($C_{55}H_{70}MgN_4O_6$, mol. wt.: 906.51)

Chlorophyll absorbs strongly red light (therefore the green color). The absorbed light energy convert CO_2 and water into Oxygen and Hydrocarbons: PHOTOSYNTHESIS.

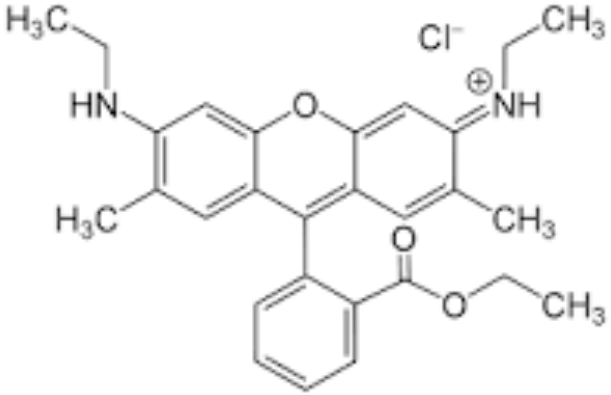
$$\text{photons} + CO_2 + H_2O \rightarrow (CH_2O)_n + O_2$$

Today we know that two absorbed photons convert electron from water to CO_2. (Oxidation-reduction reaction).

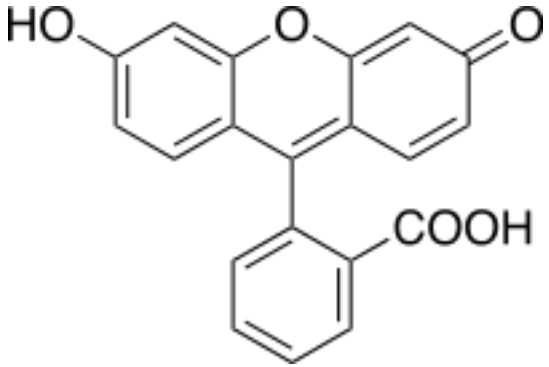
Chlorophyll contain Magnesium at the center of its Carbon ring structure with alternating double-and-single bonds. This Creates a cloud of electrons “floating” over the molecule. The larger the cloud is, the lower is its energy (more red).



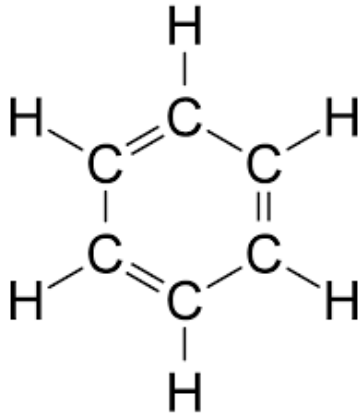
Rhodamine
Absorbs Yellow



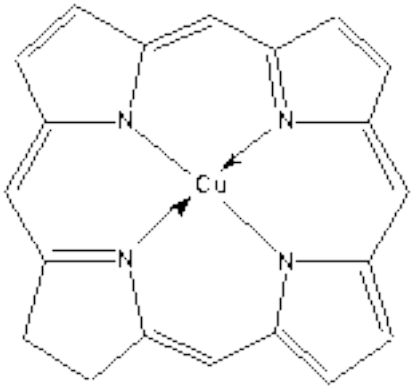
Fluorescein
Absorbs Green



Benzen
Absorbs deep blue



PORPHYRIN



The Porphyrin ring is a basic structure to many modifications applied in the animal and plant life forms. It cannot be synthesized by animals, and is obtained from food and vitamins. The variations are at the periphery and the metals bound at the center.

Chlorophyll has Magnesium at its center, that binds an electron, and has green color.

Hemoglobin & Myoglobin contain Iron at its center, binds Oxygen, and is red.

Vitamin B12 has Cobalt bind metabolites and is red.

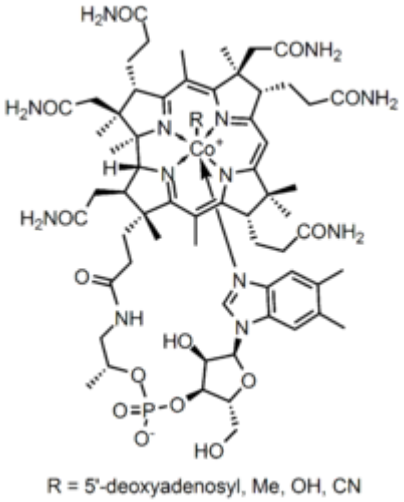
Methyl coenzyme M reductase MCR contain Nickel

Cytochrom P450 contain Iron and transfers electrons. It is Brown when oxidized and Orange-Pink when reduced.

Phthalocyanine does not have a metal, and its color is blue.

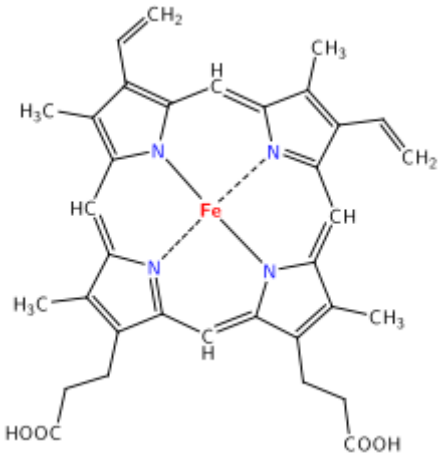
Lead toxicity is due to its replacement of the Iron in Hemoglobin, and interfering with Oxygen binding in the blood.

B12

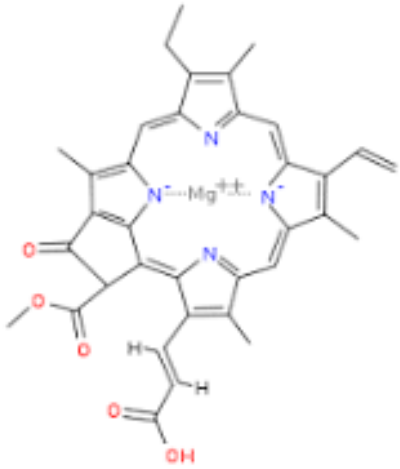


R = 5'-deoxyadenosyl, Me, OH, CN

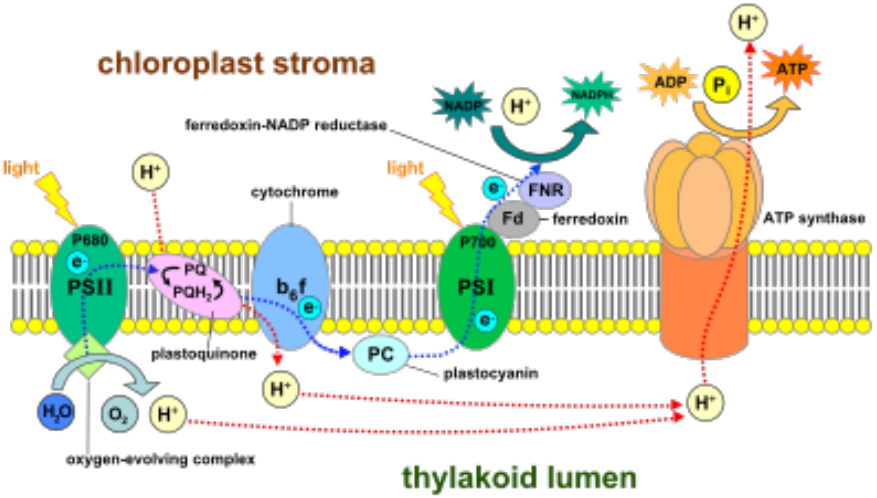
Heme

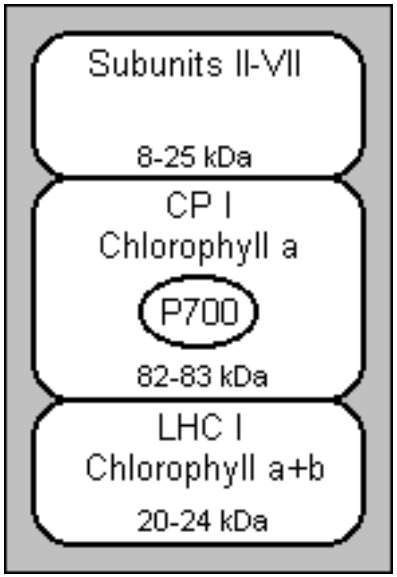


Chlorophyll



PHOTOSYSTEM I (PS1)

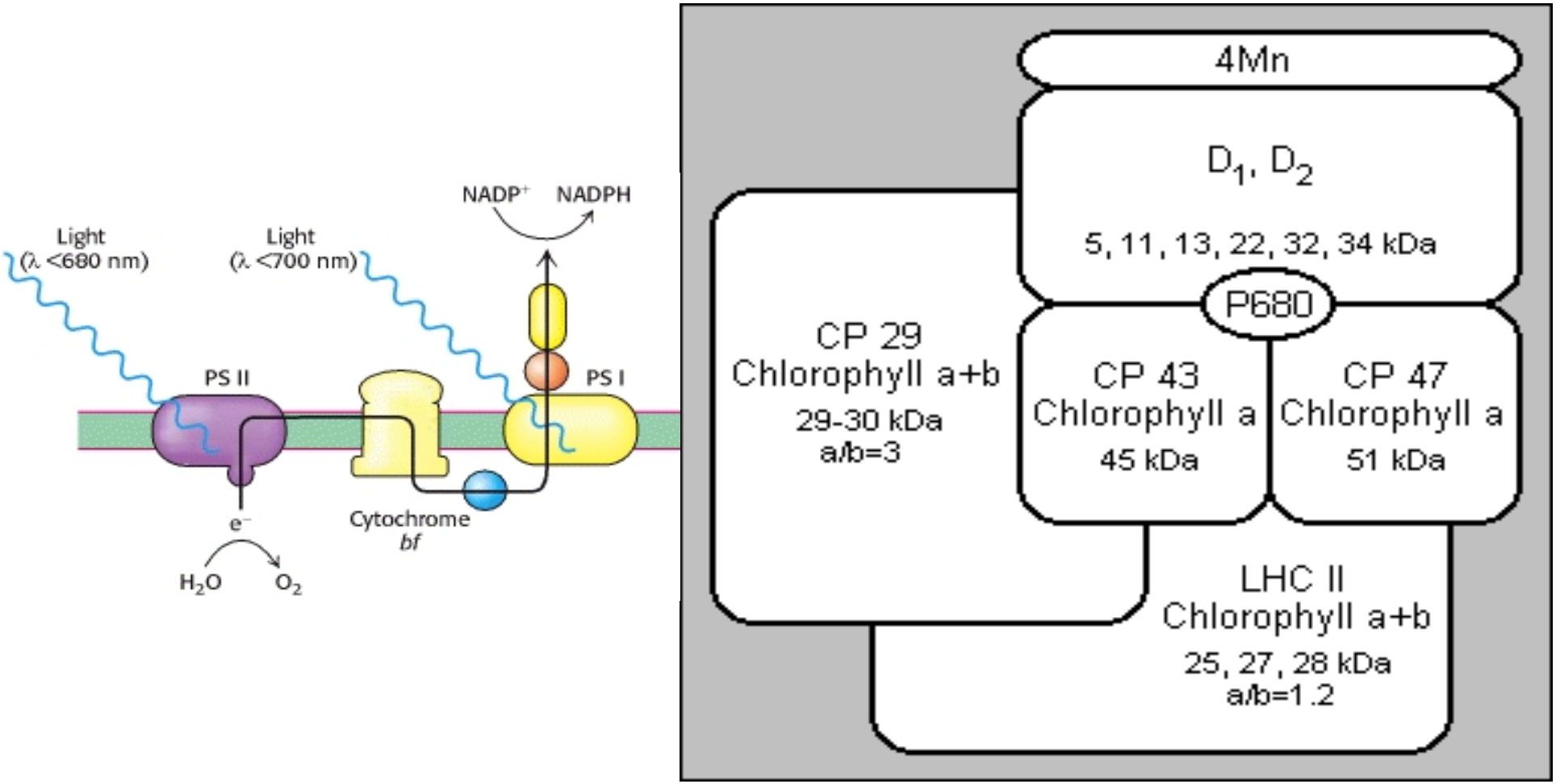




The scheme shows the complexes that can be isolated from thylakoid membranes of chloroplasts, the organelle carrying photosynthesis in plant leaves. **Mild dissolving** isolates the whole complex called PS1-110 containing two sub-complexes of Chlorophyll *a*+*b* light-harvesting + Chlorophyll-protein: reaction center chlorophyll-*a* . The first "antenna" chlorophyll collects light and transfers the energy of the excited states "downhill" to the second Chlorophyll, the "reaction center" that converts the excited energy into electrons. PS1-110 also contain a few small proteins. Dissolving in mild detergents (LiDS or SDS-PAGE) that replace the membrane lipids and enclose individual complexes in soap vesicles. Separation by electrophoresis in Polyacrylamide gel yield the P700 complex of the reaction centers, with two coupled Chlorophyll molecules (their π orbitals are in resonance).

PHOTOSYSTEM II (PS2)

Is more complex than PS1 and contain Chlorophyll with 680nm absorption band (as compared to the 700nm absorption of PS1). The two systems cooperate to convert light to sufficient energy needed to create NADPH.



Marie François Xavier Bichat 1771-1802

1880 First book in a series about pathology of tissues

Nicholas-Theodore de Saussure 1767-1845

1804 Described mechanisms of photosynthesis.

Friedrich Sertürner 1783-1841

1805 Purification of Morphine from Poppy plants.

Alexander von Humboldt 1769-1859

1805 From carefully studying plants in their habitat in South America he discovered that species and classes did not originate from the same site.

Ludolf Christian Treviranus 1779-1864

1805 Sperm in mammals is analogous to pollen in plants.

Louis Nicolas Vauquelin 1763-1829 & **Pierre Jean Robiquet 1780-1840**

1806 Isolated the first Amino Acid from Asparagus: Asparagine.

William Hyde Wollaston 1766-1828

1810 Isolated the second Amino Acid from bile stones: Cysteine.

Christian Heinrich Pander 1794-1865

1817 Described three germ layers in chick embryos.

Étienne Geoffrey Saint-Hilaire 1772-1844

1818 Suggested „ homologous“ limbs from a common evolutionary origin, such as wings and arms.

1825 Coined the term “homology”. As Lamarck’s colleague he collected many cases of body parts that evolved to better fit the environment. He tried to combine continuous evolution (found in fossils and life species), with discontinuous appearance of new species and higher life categories, by proposing a rare creation of monstrous life forms that thrive in proper environmental conditions.

William Charles Wells 1757-1817

1812 Phrases the principle of natural selection in human populations. Example: Africans are selected for immunity to local diseases.

Christian Leopold von Buch 1774-1853

1825 Concluded from geology and fossils that varieties can be segmented into species through generations.

Karl Ernst Ritter von Baer 1792-1876

1828 Based on observations of embryos of different life species he concluded that all embryos start with three germ layers, and that all embryonic development has a homogeneous start and heterogeneous segmentation in stages similar to all embryos, and are different than the adult life forms.

Friedrich Wöhler 1800-1882

1828 Synthesized Urea by heating Ammonium Cyanide.
This was the first lab preparation of organic compound from inorganic components. It gave a final death strike to “vitalism”, and started Organic Chemistry”.

Pierre Jean Robiquet 1880-1940

1830 Hydrolytic splitting of the Glycosides Amygdalin to sugars.

Giovanni Battista Amici 1786-1863

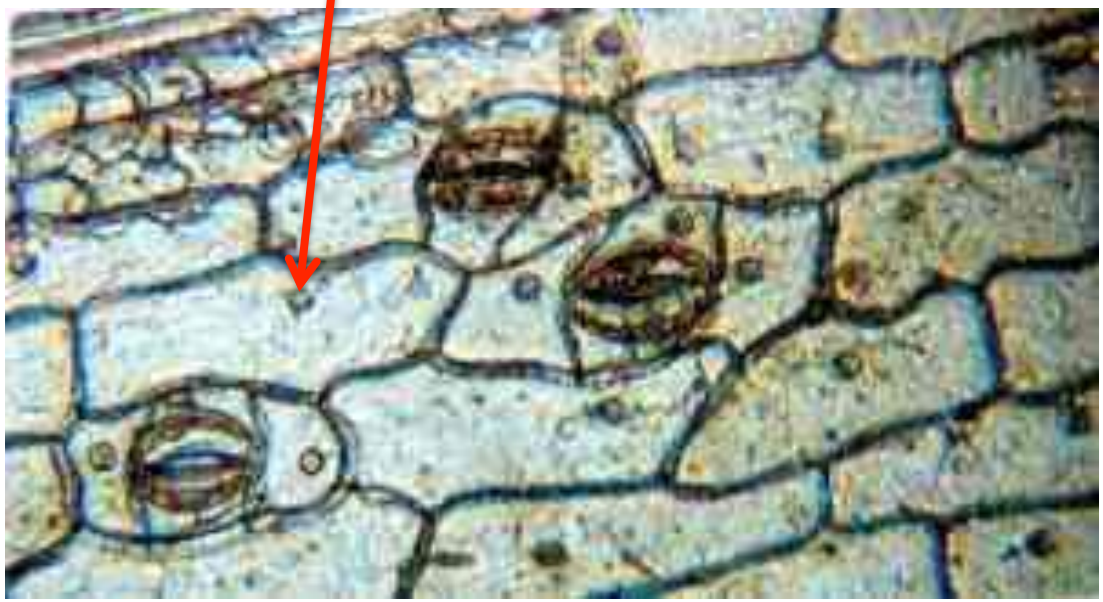
1830 Followed the growth of pollen spikes towards the flower ovary.

Robert Brown 1773-1858

1831 Discovered cell nucleus while inspecting orchids microscopically.

Brown also reported "Brownian motion" of pollens.

Orchid epidermis cells and stomata with a nucleus in each cell.



Brown's microscope

Anselm Payen 1795-1871 & Jean-François Persoz 1808-1868

1834 Isolated diastase from barley and predicted the importance of of enzymes in biology.

Theodor Schwann 1810 –1882

1836 Reported about Pepsin activity and properties.
Was mainly famous for “cell theory”: all plants and living are Built from cells.

Heinrich Gustav Magnus 1802-1870

1837 Found the CO_2 released from the lungs is brought there by the blood, and that arteries contain more Oxygen and less CO_2 than in veins.

René Dutrochet 1776-1847

1837 Found that Chlorophyll is essential for photosynthesis. Studied Osmosis.

Hugo von Mohl 1805-1872

1837 Described Chloroplasts in plant cells. Coined the term „protoplasm“.

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Theodor Schwann 1810-1882, Charles Cagniard de la Tour 1777-1859, & Friedrich Traugott Kützing 1807-1893

1837-8 Studied in parallel yeast, reported that they are live organisms responsible for fermentation. Raised the debate weather fermentation is a chemical or vital process.

Carlo Matteucci 1811-1868

1838 Measured electric currents in muscles with a galvanometer.

Gerardus Johannes Mulder 1802-1880

1838 Publicized Berzelius term “protein”

Richard Owen 1804-1892

1839 Distinguished between “homologous” and “Analogous”: Birds and bat wings are analogous: skeletal bones and muscles are similar. But feathers are different than the membranes between bats fingers. Supported fixed species, opposed species evolution. Coined the name “Dinosauria”.
1851 Copley Medal.

Aleksander Piotr Mohl 1899-1954

1839 Describe the creation of a separating cell wall between dividing cells: “mitosis”.
1870-8 Realize that cell mitosis is common to plants and animals – strengthen the cell theory.

Johann Schoenlein 1793-1864

1839 During microscopic studies he discovered human parasite: Trichophyton schoenleinii that cause Ringworm Tinea in skull hair.

Christian Friedrich Schoenbein 1799-1868

1839 Discovered Ozone O_3 during water electrolysis experiments.
He is also known for inventing the fuel cell: conversion of a chemical in oxidation reaction to electricity.

T. L. Hünefel

1840 Observed crystals in blood.

Friedrich Gustav Jacob Henle 1809-1885

1840 First modern description of the germ theory of diseases.

Albrecht von Kölliker 1817-1905

1841 Showed that sperms are sex cells that are continuously generated in the testicles.

Johann Japetus Steenstrup 1813-1897

1842 Described conversion from sexual fertilization to asexual fertilization in plants and animals.
In Jellyfish there is sexual proliferation that generates a polyp (or hydroid) stage proliferating asexually.
Ferns form sporophytes that generate spores that grow gametophytes that proliferate sexually.

Justus von Liebig 1803-1873

1843 Assumed that organic acids (such as Malic, Tartaric, Oxalic) are intermediate products in a metabolic chain of synthesizing carbohydrates in plants.

Karl Friedrich Wilhelm Ludwig 1816-1895

1844 Showed that waste products are filtered in the Malpighian corpuscle in the kidneys, and then concentrated in tubules and extruded from the body.

Johann Dzierzon 1811-1906

1845 Reported that bee males are developing from unfertilized eggs, but bees workers and queens come from fertilized eggs.

Karl Bogislaus Reichert 1811-1883

1847 Discovered under the microscope blood with tetrahedral crystals, an important stage in purification to demonstrate that they contain proteins.

Carl Georg Lucas Christian Bergmann 1814-1865

1847 Noted that same species of hot blooded animals growing in cold climate grow bigger than in heat, and explain that surface to body mass ratio reduces heat loss in cold environment. “Bergmann’s rule”.

August Alfonse Derbés 1818-1894

1847 Observed Vitellin Membrane formation immediately following sperm penetration during fertilization of the egg.

Emil Du Bois-Reymond 1818-1896

1848 Demonstrated propagation of a negative charged wave in nerves, and proposed is is a result of a structural change.

Franz Unger 1800-1870

1852 Theory about common origin of all plants.

Georges Newport 1803-1854

1852 Followed sperm penetration into Frog egg membrane.

Ludwik Karol Teichmann 1823-1895

1853 Discovered the Oxygen-carrying molecule in the blood, that contain Iron and is not a protein. He calls it „Heme“.

Rudolph Virchow 1821-1902

1854 Publicized the idea that disease mechanisms should be understood through chemical mechanisms in the cell.

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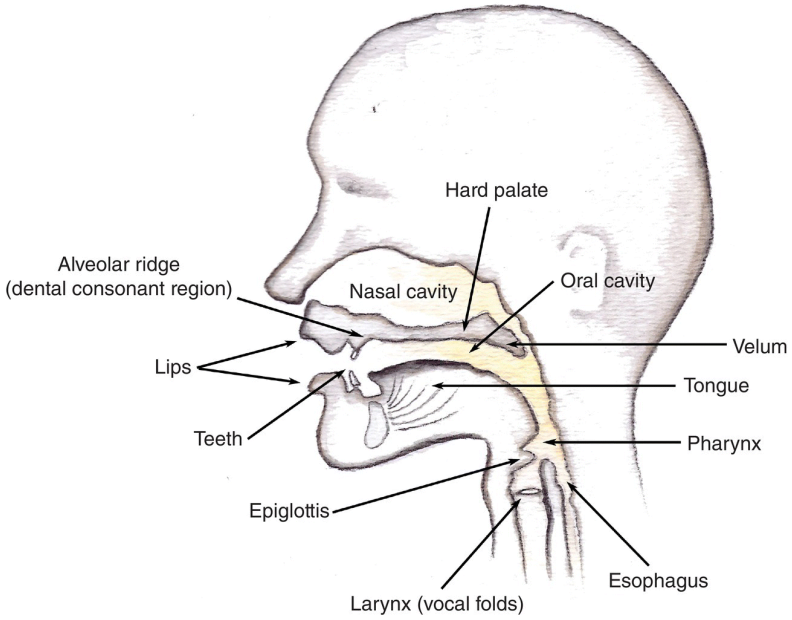
Claude Bernard 1813-1878

1848 Discovered the glycolytic function of the liver in degradation of polysaccharides to glucose by hydrolysis.

Max Müller 1823-1900

1848 Stressed the importance of the tongue in the development of speech. Super laryngeal vocal tract.



Franz von Leydig 1821-1908

1850 Discovered the interstitial cells in the connective tissue of the testes.

Hermann Ludwig Ferdinand von Helmholtz 1821-1894

1847 The brain controls motion in sleep, thus creates a feeling of images. Perception is unconditional deduction.

1852 Measured speed of propagation of nerve pulses in frogs sciatic nerve (from spine to leg).

1867 Explained adaptation of eye lens to near and far sight.

1868 Proposed resonance model in hearing, between a fiber in the drum membrane and the cochlea.

Allvar Gullstrand 1862-1930

Studied the optics of the eye, Nobel 1911.

Jean Baptiste Boussingnault 1801-1887

1850 Demonstrated that plants require only Nitrogen from soil, and fix carbon from air.

Ignaz Semmelweis 1818-1865

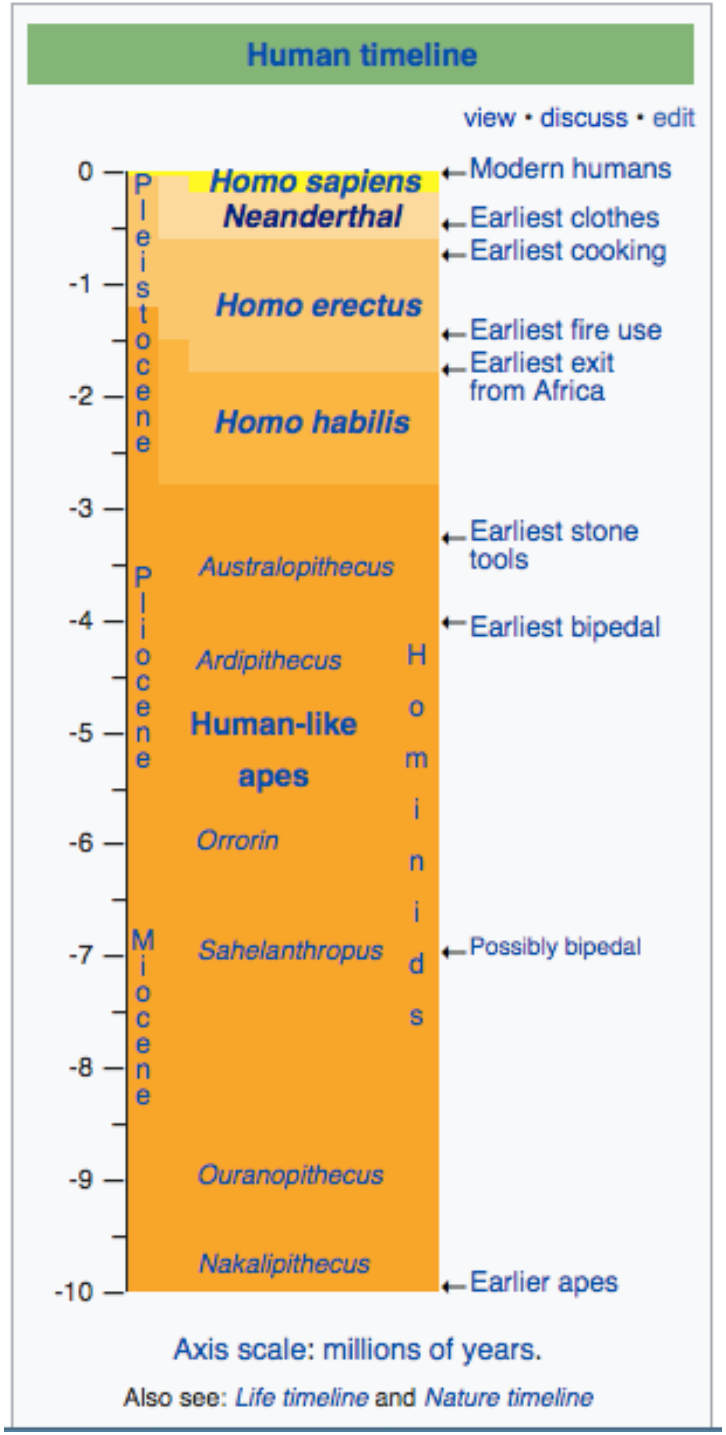
1850 Recognized the importance of washing hands to prevent infection spreading of flue among treated children.

Alfred Russel Wallace 1823-1913

1855“Sarawak Law“: “Every species has come into existence coincident both in space and time with closely allied species.” species found in fossils are in proximity of originated species. This is the conclusion of a voyage in the Malay Archipelagos separating with deep ocean between Celebes and Borneo, with two different fauna and flora (life and plant worlds). His voyage books were published before Darwin’s.

Claude Bernard 1813-1878

1855 Believed that internal environment of the body is preserved by secretion from all tissues. **1865** Diseases are extreme cases of normal [processes.
1857 Demonstrated generation of glycogen in the liver.
1865 Life is different than still world by its high complexity. Denies Vitalism.



Neanderthal man

1856 Human ancestors earlier than Homo Sapience were found in Neanderthal. They have different brain volume, position of the eye in the skull and lower jaw.

Herbert Spencer 1820-1903

1855 Started publishing 10 volumes about evolution, with increasing complexity.

Carl Ludwig 1816-1895

1856 Developed perfusion technique that preserve tissue and limbs after separation from the living body.

Albrecht von Kölliker 1817-1905

1857 Described what was later called Mitochondria in muscle cells.

Julius von Sachs 1832-1897

1862 Experimental proof that starch is a photosynthetic product.

Thomas Henry Huxley 1825-1895

1863 Enforced Darwin‘s theory.

Felix Hoppe-Seyler 1825-1895

1864 Called the colorless blood protein „Globin“ and hence, when associated with the heme group: „Hemoglobin“. Studied blood by spectroscopy, and continued by Stokes, proving oxidation and reduction of blood.

Otto Friedrich Karl Deiters 1834-1863

1865 Described a model of nerves valid today: Nerve cell body, Many branched dendrites, and a single axon.

Edmé Félix Alfred Vulpian 1826-1887

1866 Discovered that curare, used as a poison on Indian arrows, breaks the communication between nerves and muscles. Example of biological perturbation applied to understand normal mechanisms.

Ernst Haeckel 1834-1919

1866 Challenged the classification of plants and animals, since unicellular does not fit either category. Phrased “Recapitulation rule”: embryonic development follows the evolutionary development of the species. This is an extension to Baer’s theory, but the latter opposed Haeckel. Although there are some cases to support the rule (tail and gills to human embryo, that disappear later in embryonic development), but Haeckel assembled biased examples to support his rule. His strongest support was from the religious establishment, since he relaxed their dilemmas.
1862Phagocytosis**.**

Max Schultze 1825-1874

1866 Discovered two kinds of retinal receptors.

Hermann Ludwig Ferdinand von Helmholtz 1821-1894

1867 Images are recorded point-by-point, and assembled by a sub-conscious process into a picture that rely on previous experience.

Fleeming Jenkin 1833-1885

1867 Variability will disappear if heredity is a merge of parents properties (like color mixing).
This caused Darwin In late publications to revive Lamarck's theory of acquired traits. The theory was never really disappeared until rediscovery of Mendel's work, 1900.
Trying to understand sexual selection he could not explain why butterfly caterpillars are colorful. Wallace interpreted this as a warning, which was proved true.

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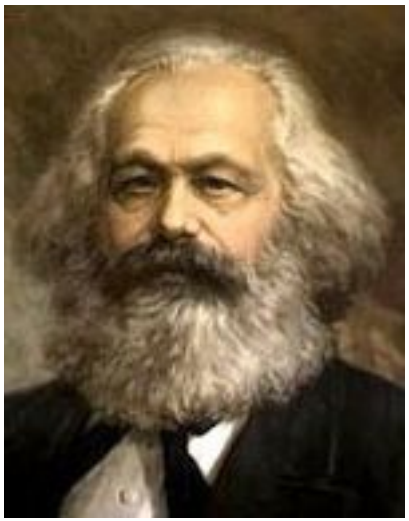
Aleksander Onufriyevich Kovalevsky 1840-1901

1867 Extended the concept of germ layers in mammals.

Karl Marx 1818-1883



1867 "The Capital", edited by Engles, was published.
Preaches that excess of goods and work is profitable to the Employers. Capitalists, such as Adam Smith 1723-1790 believed That free market is profitable to every economical entrepreneur. Presently, modern capitalism is based also on equal opportunities, That is diminished by rich tycoons.

Josef Breuer 1842-1925 & **Karl Ewald Konstantin Hering 1834-1913**

1868 Demonstrated, by blocking the trachea to stop inhaling and exhaling, that the lungs regulate breathing in a closed feedback loop.

John Wesley Hyatt 1837 –1920

1869 Synthesized celluloid, the first plastic material for public usage.

Gustave Theodor Fritsch 1838-1927 & Edward Hitzig 1838-1907

1870 Linked brain activity with electricity, but do not know how electric currents are created in the brain.

1900 Julius Bernstein proposed that electrical pulses in nerves are generated from membrane breaking.

Camillo Golgi 1843 -1926

1870 Demonstrated that nerves from the brain command muscles and receive information from sensory nerves.
Developed a breakthrough technique to silver-stain nerves displaying the anatomy of the whole length of nerves. The novelty was that the Staining enters a small part of the nerves, but once penetrated a nerve cell body, it diffuses throw the whole length of the axon and dendrites. This emphasizes one nerve pathway in a dense packing of nerves. (see following for details).

Herbert Spencer 1820-1903

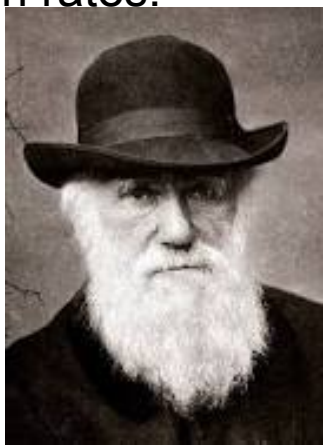
1870 Proposed that learning is better connectivity and communication between nerves.

Friedrich Goltz 1834-1902

1870 Proposed that the bent channel of the inner ear senses body balance.
1870-80 Cell division process is similar to plants and animals: enforces the cell as the basic element of all living systems.

St. George Mivart 1827-1900

1871 Claimed, in contrast to Darwin, that species appear suddenly with substantial changes. According to Darwin, this can happen only with very high mutation rates.



Charles Darwin 1809-1882

1871 Proposed that evolution of humans or other animals did not happen with sharp discontinuities.

Johann Friedrich Miescher 1844-1895

1871 Isolated from white blood cells a nuclear material that dissolved in alkaline solutions, but not in acids. They will be called „nucleic acids“.

John Thomas Gulick 1832-1923

1872 Noted that variety of isolated species is necessary even without environmental changes.

Carl Friederich Wilhem Ludwig 1816-1895 & Eduard Friedrich Wilhelm Pflüger 1829-1910

1872 Oxidation occur in tissue cells, not in the blood.

Friedrich Anton Schneider 1831-1890

1873 Described chromosomes during mitosis.

Moritz Wagner 1813-1887

1873 Studies beetles around the world, and described effect of isolation on species evolution, and environments on animal species.

Ernst Mach, Breuer, & Alexander Crum Brown

1873 All independently, based on **Goltz' 1870** proposal, published that motion of liquid of the inner ear channel excite receptors at the channel terminus. Brown also noted that left and right ears get opposite directions of their stimulations.

Claude Monet 1840-1926

1872 Beginning of impressionism – painting changes in nature due to light, color, hour of the day and seasons. **Paul Cézann** describe images by geometrical shapes, leading to the abstract paintings of **Henri Matisse** and **Pablo Picasso**.

Vladimir Alexeievich Betz 1834-1894

1874 Discovered the front-back segmentation progress from the spinal chord to the Telencephalon in the brain.

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S. Bodkin

1874Found in Leukemia patients that electric stimulation of the spleen caused its shrinking and increased leukocytes (white blood cells) count.

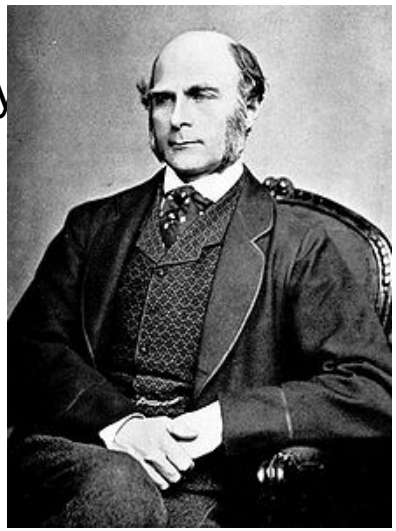
Richard Caton 1842-1926

1875 Demonstrated that electrical brain activity originated at the cortex.

Eduard Seuss 1831-1914

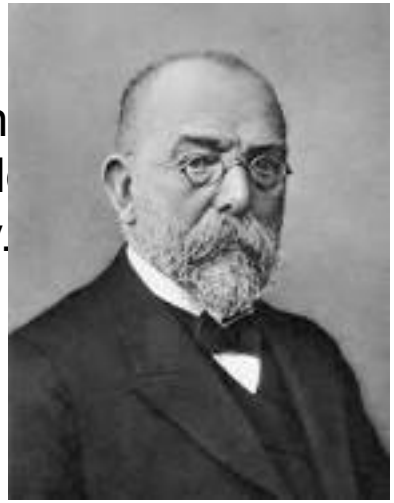
1875 Coined the term “biosphere” for life-supporting environment.

Sir Francis Galton 1822 -1911



1875 Engaged in twin-studies to find environmental effect vs. heredity
Founder of Eugenics, that was recruited by architects of
racial theories.

Robert Koch 1843-1910



1876 and on- Studies Anthrax. Developed Aniline staining for
Microorganisms. Isolated pure cultures of a single bacteria species, an
proved the bacterial source of of infectious diseases such as Tubercul
Cholera, Plague and Sleep disease: a convincing proof of germ theory.

Alfred Russel Wallace OM FRS 1823 -1913

1876 Published the geography of animal habitats, his version of evolution.

Alfred F. Heinke 1885-1965

1878 Published a study about Herring fish, that became research model in zoology.

Emil Hermann Fischer 1852-1919

1878 Reconstructs the atomic structure of phenyl hydrazine, leading to studies of sugars such as glucose (which he synthesized), purines (he synthesized some 130 purines) and drugs e.g. Novocain, for local anesthesia.

Walther Flemming 1843 -1905

1879 Coined the names “mitosis“ and “Chromatin“ and correctly counted the number of chromosomes and their equal segregation to the daughter cells.

Sydney Ringer 1835-1910

1880 Studies body temperature as a diagnostic tool. Discovered the role of ions in heart beating. Following perfusion of solutions to maintain organs out of the body by **Ludwig**, he developed Ringer Solution that kept frog‘s heart beating. The initial composition was 0.75% NaCl, then he added blood, albumin, Calcium and Potassium.

Eduard Strasburger 1844-1912

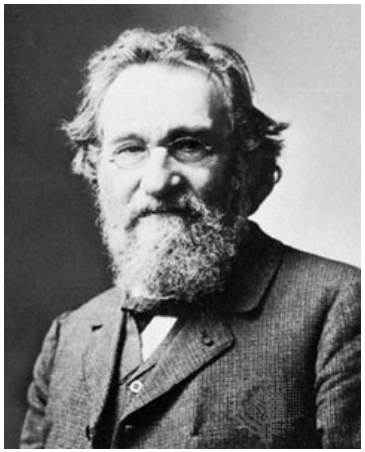
1882 Coined the terms “Cytoplasm“ and “Nucleoplasm“.

Dmitri Iosefovich Ivanovsky 1864-1920

1882 Demonstrated that Tobacco Mosaic disease is caused by a proliferating factor – a virus, that trans pass filters that hold bacteria (therefore is smaller), and cannot be seen by light microscopy, and don‘t grow in rich media. They did grow in presence of bacteria.

Martinus Beijerinck 1851-1931

1898 Use filters to prove that Tobacco Mosaic Disease is caused by something smaller than bacteria, which he called “Virus”.



Ilia Il'ich, also known as **Élie, Metchnikoff 1845 –1916**

1883 Identified the white blood cells as suppliers of immunity to cells, Capable of engulfing and swallowing bacteria (Phagocytosis).
Raised the question of "self" vs. "non self": how can organisms separate between their own components and evading bacteria.
By that time, blood shedding was a common medical practice.

Edouard van Beneden 1846-1910

1883 Studies division of nuclei in warms, and explained the equal contributions of father and mother to progeny properties: Despite the much larger ovum compared to the sperm, each contribute half of the chromosomes. This was the derive to conclude that chromosomes are the carriers of heredity.
He discovered also "Myosis" that halves the number of chromosomes after division.

August Friedrich Leopold Weismann 1834-1914

1883 Proposed „Stem cell theory“ saying: separation and specification of some cells from the bulk soma during embryonic development that live forever. This proposal denies the possibility of Lamarckian evolution through environmental stresses, since the hereditary characteristics were defined at the embryo.

Max Rubner 1854-1932

1883 Rate of material exchange in the body is proportional to surface area.

Oscar Hertwig 1849-1922

1883 Coined the term „Mesenchyme cells“ to cells that segregate into connective tissues in the embryo.

Wilhelm Roux 1850-1924

1883 Proposed that the fibers in the cell nucleus are the carriers of heredity.

Karl Georg Friedrich Rudolf Leuckart 1822-1898
& **Sir Algernon Phillips Withiel Thomas 1857-1937**

1883 Independently discovered that snails are intermediate mediators in the life cycle of a parasite causing ship and caw diseases.

Albrecht Kossel 1853-1927

1884 Isolated protein from Geese blood nuclei that he called Histones. Unlike birds, blood cells of mammals lose their nuclei before joining the blood stream.
Nobel 1910

Julius Kollman 1834-1918

1884 Described amphibian anatomy: early sexual maturity in development allows to proliferate inside water before growing and exiting to dry land, thus adapting to harsh environments.

Sigmund Freud 1856-1939

1884 Published a paper about cocaine, an alkaloid in cocoa effective in relieving fatigue and weakness.

Charles Louis Alphonse Laveran 1845-1922

1880-90 As military medical doctor in Algeria he studied malaria and linked it to the parasite Plasmodium. Proposed that the parasite is transferred by mosquitos, an hypothesis proposed first by **Patrick Manson 1844-1922** and confirmed by **Ronald Ross 1857-1932** who got Nobel prize for it in 1902.
Laveran got Nobel at 1907.

Oskar Hertwig 1849-1922 & Eduard Strasburger 1844-1912

1885 Progress in understanding that the nucleus carries heredity, and that sex is merging of two cells.

Wilhelm Roux 1850 –1924

1885 Following Weismann‘s ideas about eternal stem cells, cultured chick embryonic cells in salt solutions.

Wilhelm His 1831-1904

1887Published results of observations on early development of nervous system in embryos, from dense cluster of cells without axons.

Auguste Forel 1848-1931

1887 Degenerative properties are limited to nerves and dendrites.

Wilhelm Roux 1857-1932

1888 Killed one of the two cells after first division of fertilized frog egg by hot needle, and obtained half an embryo. He proposed “mosaic theory of epigenesis” that embryonic cells play a unique role in the whole body structure. This result was later shown not to be so simply interpreted, and depend on how embryo cleavage is done.

Pierre Paul Émile Roux 1853-1933 & Alexandre Yersin 1863-1943

1888 Identified the toxin from diphtheria bacillus.

George Nuttall 1862-1937

1888 Bacteria killing activity in blood.

Emil von Behring 1854-1917 & Shibasaburo Kitasato 1853-1931

1890 Demonstrated the action of blood antitoxins against toxins of diphtheria and tetanus: „Humors Theory“ in immunology. Von Behring got Nobel 1901 for saving children from diphtheria.

Robert Koch 1843-1910

1891 Demonstrated the delayed reaction of hyper-sensitivity

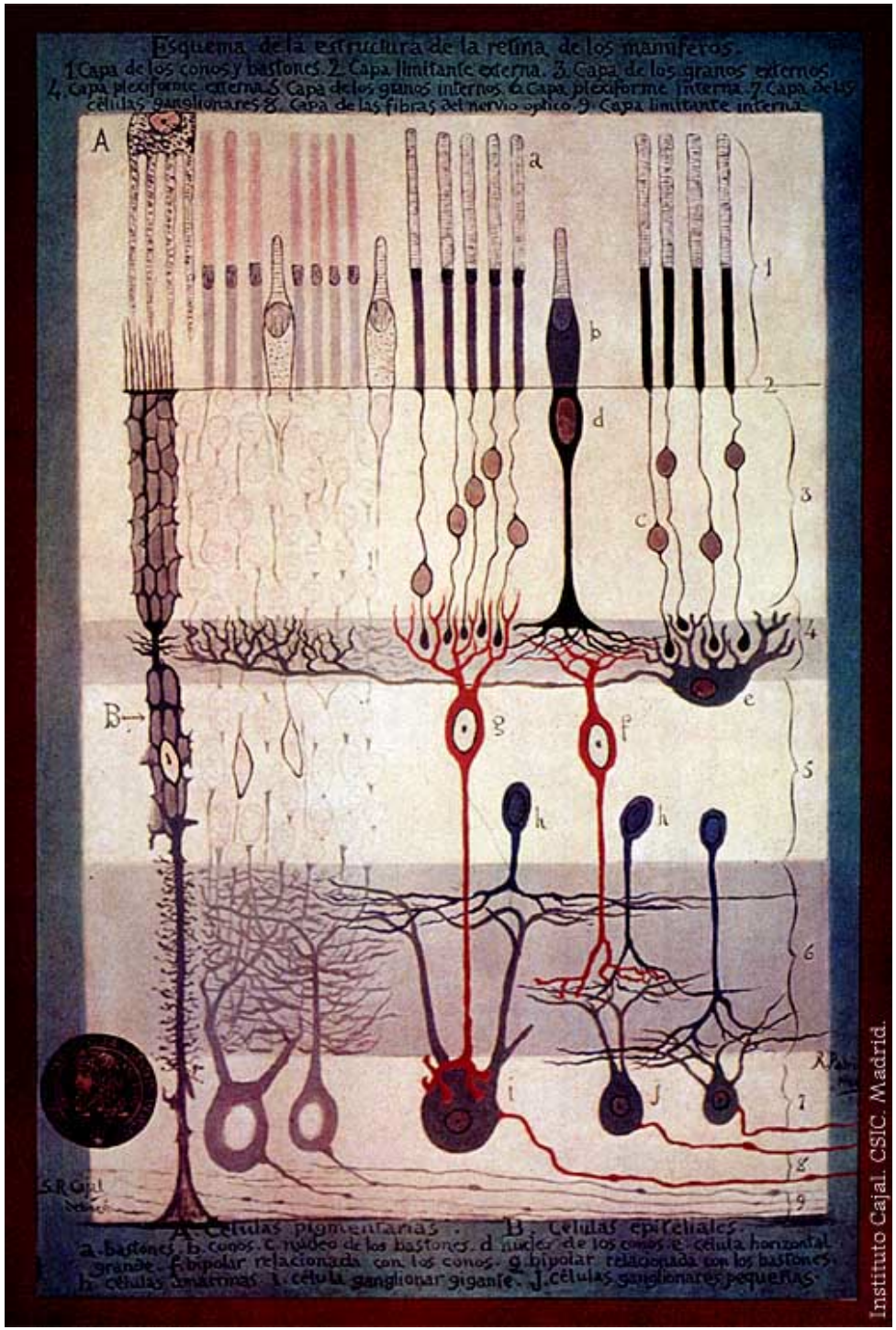
William B. Coley 1862-1936 & Richard Pfeiffer 1858-1945

1893-4 Use of live bacteria and extracts to treat cancer –immunotherapy

Santiago Ramón y Cajal 1852 –1934

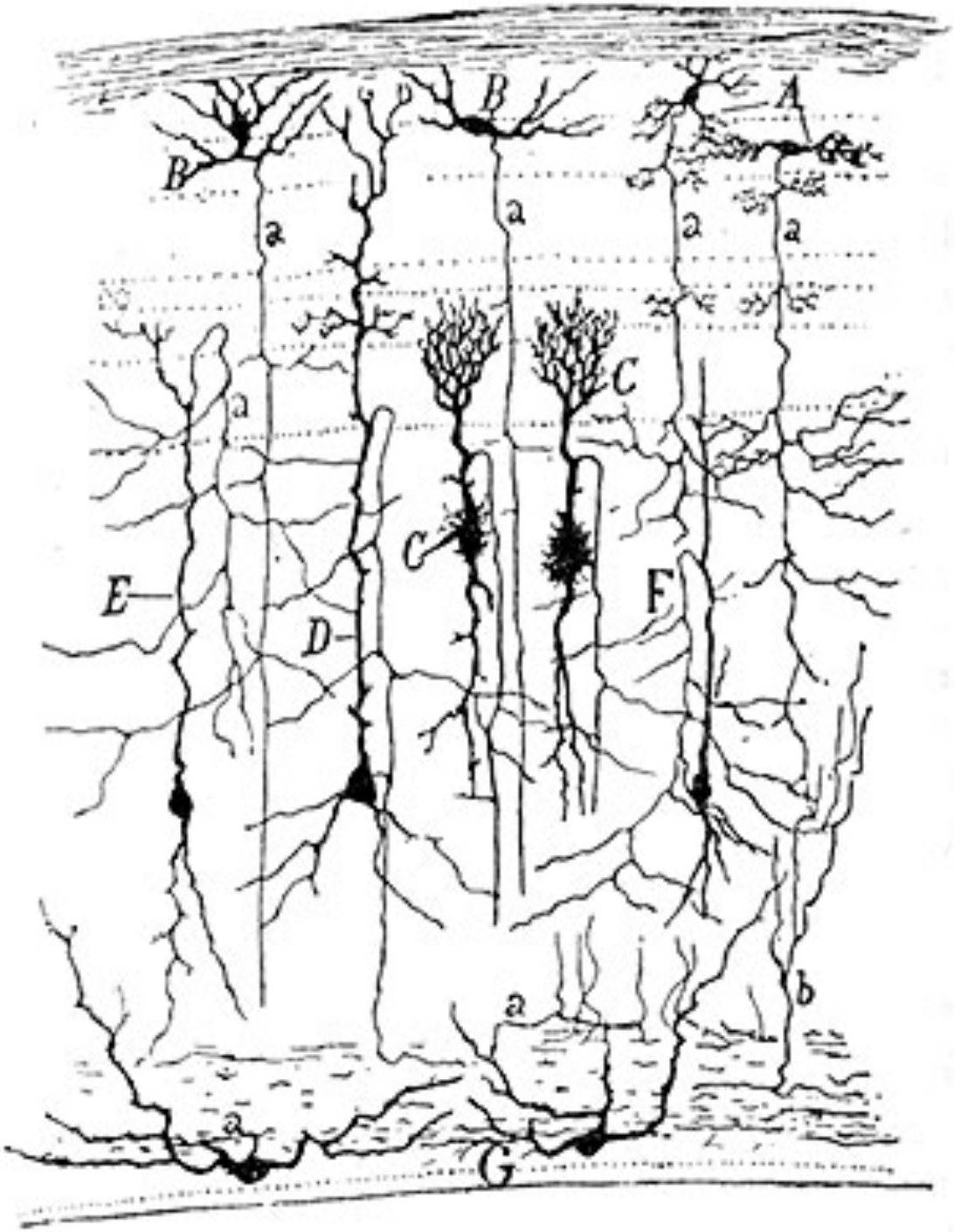
1888 Used Golgi's staining technique to stud brain anatomy, and disproved the network model of the brain. He showed that dendrites are not interconnected but are connected via cell bodies. Connections between dendrites and axons were only observed by electron microscopy at 1950.

The beauty (as well as the limitation) of Golgi and Cajal's technique is the only a small number of nerve cells are stained and "extracted" visually from the dense mass of nerves in the brain. Golgi & Cajal got Nobel at 1906.



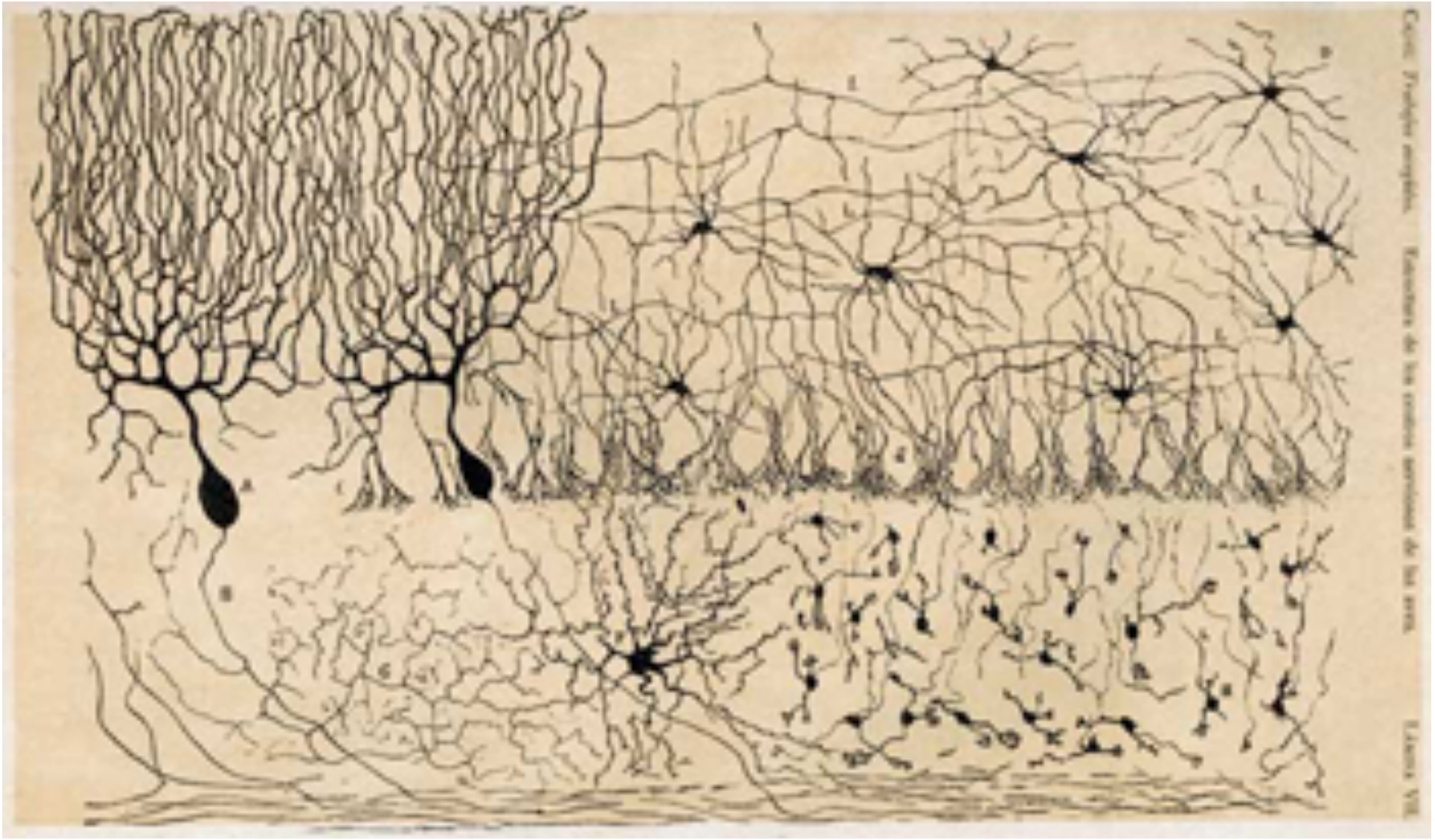
Structure of the retina in mammals

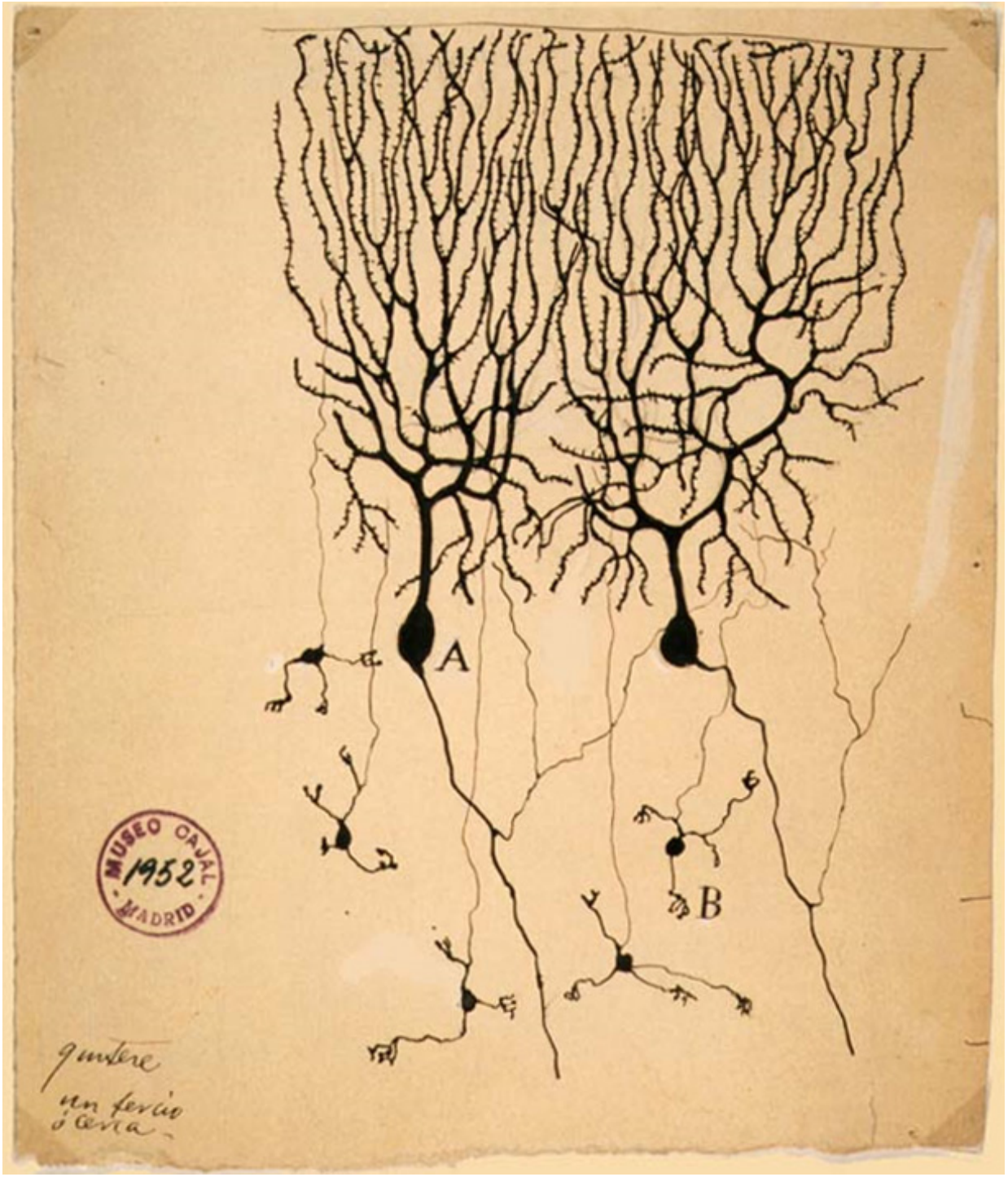
From Cajal's work



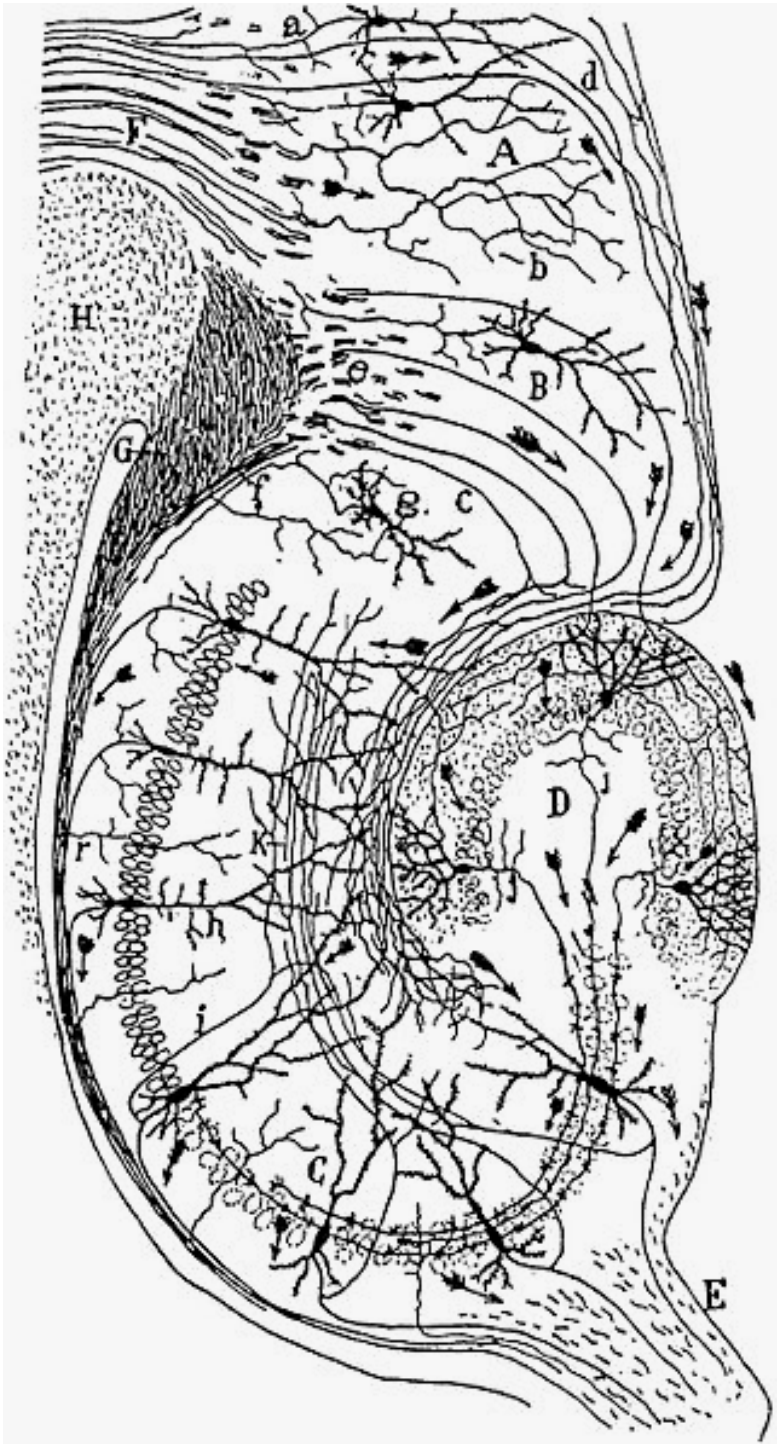
Prinia (bird) optic nerve
Cajal's work

Chick hypothalamus – from Cajal's work





Dove Purkinje cells
From Cajal's work



Rat's brain – from Cajal's work

George Henry Falkiner Nuttall 1862-1937

1888 Showed that blood kills bacteria, and wrongly concluded that white blood cells only help the protection supplied by the serum.

Heinrich Wilhelm Gottfried Waldeyer 1862-1937

1888 Calls "Chromosomes" to Roux 1883 "Nuclear fibers" .

1891 Coined the name "Neuron" to nerve cell.

Theodore Boveri 1862-1915

1888 Described the centrioles residing over the nucleus in animals and many plants. Was first to claim that cancer spreads by sending cell extensions: metastases.

Jules Jean Baptiste Vincent Bordet 1870-1961

1894 Discovered phagocytosis by white blood cells In Mechnikov lab in Pasteur institute

1898 Described hemolysis when white blood cells are exposed to foreign cells.

Nobel at 1919.

Louis Lewin 1850-1929 & **Arthur Heffter 1859-1925**

1889 Isolated from the cactus Mescalin the peyote alkaloid mezcal, an active psychedelic hallucinogenic material.

Alfred Russel Wallace 1823 -1913

1889 Published his book on natural selection he called „Darwinism“.

Theodor Boveri 1862-1915 & **Jean Louis Léon Guignand 1852-1928**

1890 Established the equal number of mother and father chromosomes in fertilization.

Hans Adolf Eduard Driesch 1867-1941

1890 Separated the first cleavage two cells of sea urchin embryo. Opposite the results of Roux similar experiment with frogs, he obtained two complete embryos. When Roux's experiment was repeated with inversion of the cell one gets a completer embryo. Roux did not give up, and opposite Weismann's stem cell theory, he claimed that embryonic development mechanism is distributed throughout the cytoplasm, and every stage depends on the proceeding stage.

Who was right? Embryonic development mechanisms were genetically segmented only 80 years later in Drosophila by **Lewis**, **Nüsslein-Volhard** & **Wieschaus.** Although analogues of the embryonic segmentation genes in Drosophila are found in mammals, details of the processes vary between species.

Richard Altmann 1852-1900

1890 Reported about mitochondria, an organism that lives inside cells in symbiosis.

Emil Adoph von Behring 1854-1917 & Shibasaburo Kitasato 1853-1931

1890 Showed that anti-toxins antibodies can be generated without knowing their structure, such as Tetanus, diphtheria, Botulisms.
Behring got Nobel, 1901.

Theobold Smith 1859-1934

1890 Demonstrated transmission of diseases by a pathogenic vector via a host (mosquito, Tick).

William Coley 1962-1936

1898 Noticed that cancer patients showed cancer retraction following severe bacterial infection. Tried to stimulate the immune system in cancer patients and sometimes succeeded in holding cancer progression.

Marie Eugene Dubois 1858-1940

1891 Discovery of the Java man „Homo Erectus“.

Emil Theodor Kocher 1841 -1917

Studied and operated surgically on thyroid gland and its pathologies.
Nobel 1909

George Redmayne Murray 1865-1939

1891 Treats hypothyroid patients with processed thyroid from sheep.

Andreas Franz Wilhelm Schimper 1856-1901

1893 Proposed that the photosynthetic system in plants originated from Cyanobacteria.

William Bateson 1861-1926

1894 Emphasized the significance of discontinuous genetic changes - **–**homeotic mutations

Henry John Horstman Fenton 1854-1929

1894 Fenton reaction – the main cause of oxidative damage in live cells.

$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + HO\bullet + OH^-$

$Fe^{3+} + H_2O_2 \rightarrow Fe^{2+} + HOO\bullet + H^+$

Ramón y Cajal Santiago 1852 –1934

1894 Extended E. Tanzi and E. Lugaro‘s idea of plastic changes in nerve networks in the brain, caused by learning.

George Oliver 1841-1915 & **Eduard Albert Sharpey-Schaeffer 1850-1935**

1894 Demonstrated effects of hormone gland extracts on contraction of blood vessels and muscles, and on raising blood pressure.

Hermann Emil Fischer 1852 –1919

1894 Proposed “key to keyhole” fitting of three-dimensional matching between compounds as the basis of the specificity of enzymatic reactic Nobel 1902.

Richard F. J. Pfeiffer 1858-1945

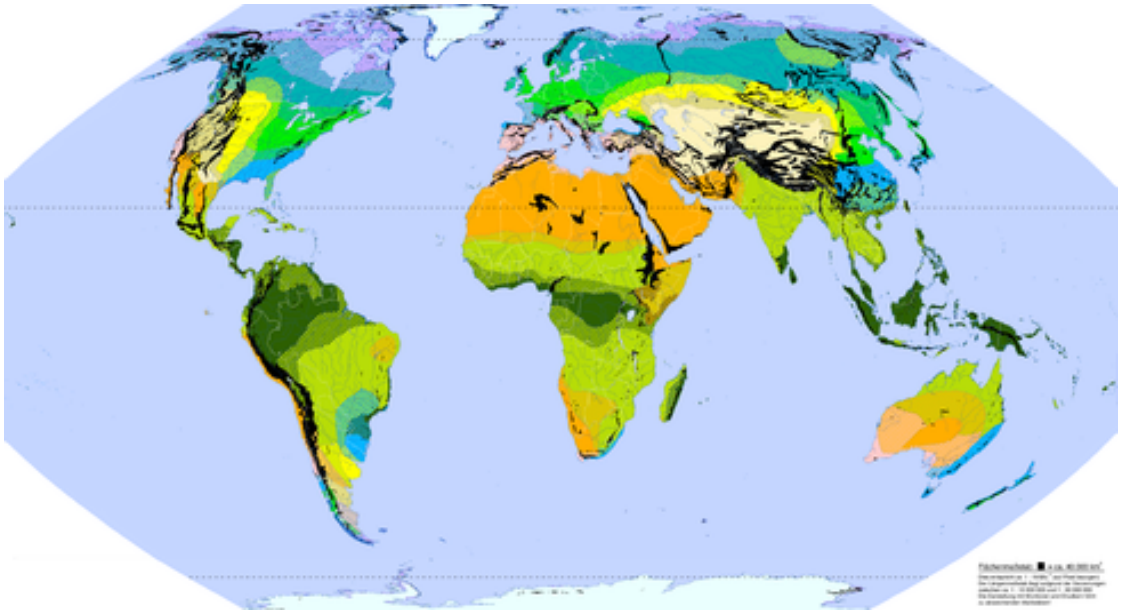
1895 Proposed that antibacterial active materials “antibodies“ are created by body cells and are employed in the process of eliminating bacteria.

Smith

1895 Induced anemia in guinea pigs when green leaves are excluded from their nutrition.

Johannes Eugenius Bülow Warming 1841 –1924

1895 Mapped the habitats of plants according to temperature and humidity.



Ferdinand Isidore Widal 1862-1929

1896 Put to practice serological test (blood test) based on precipitation of typhus bacteria.

Eduard Buchner 1860-1917

1896 Isolated from yeast material that fermented sugar „Zymase“: Start of biochemical enzymology.
Nobel in chemistry 1907

Paul Ehrlich 1854 –1915

1877 Identified mast cells in the blood.
1897 Toxins work by binding to a fitting site (receptor) on cells. The disease does not burst when there are no receptors. If there Are just a few receptors, the cell synthesizes and ejects to the blood antibodies: the first theory of selective generation of specific Antibodies. Ehrlich later changed his theory, claiming that antibodies are continuously generated.
Nobel with **Mechnikov** 1908 on the theory that the body generates antibodies against cancer and destroys it all the time.

Charles Sherrington 1857-1952

1897 Coined the term “synapse“.

Christiaan Eijkman 1858-1930

1897 Identified that addition of the shells to rice diet prevents beribery disease (today known to be a result of Vitamin B1 = Thiamine)

Gabriel Bertrand 1867-1962

1897 Call inorganic compounds that were found necessary for enzyme activity “co-enzymes”.

Felix Hoffman 1868-1946

1897 Synthesized a form of acetylsalicylic acid that enabled two years later to mass-produce aspirin. Re-synthesized diamorphine, which was popularized under the Bayer trade name of "heroin".

Jean Henri Fabre 1823-1915

1897 Observed a typical continuum of actions in insects, called by **Konrad Lorenz** “fixed patterns of activity”

Wilhelm Fliess 1858-1928

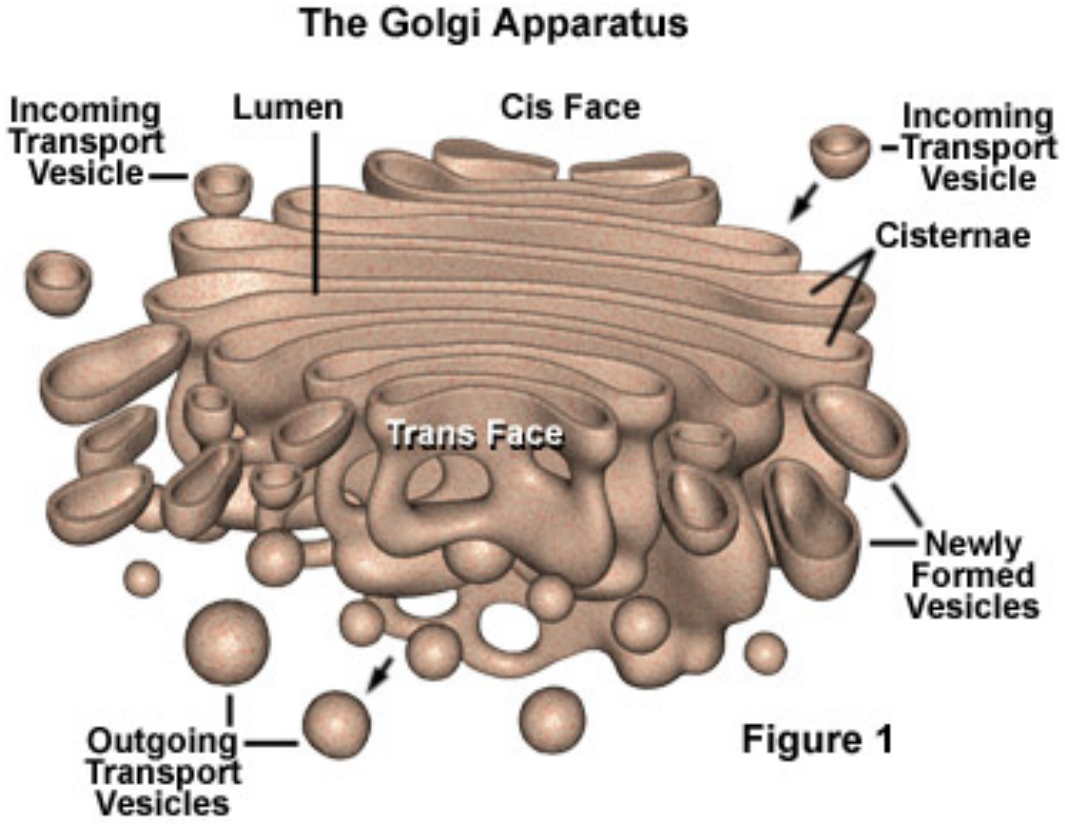
1897 Proposed that all living is bisexual, and maturity is sexual. This is not true for example for insects. Had bizarre theories of biorhythm. Biorhythms.

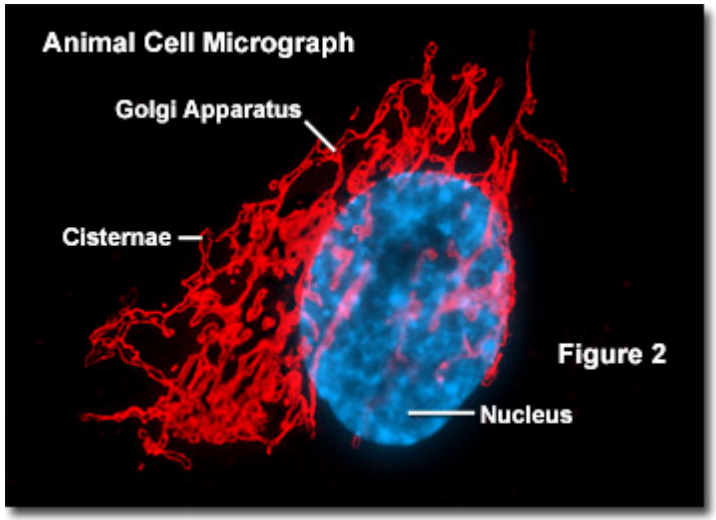
Henry Fairfield Osborne 1857-1935

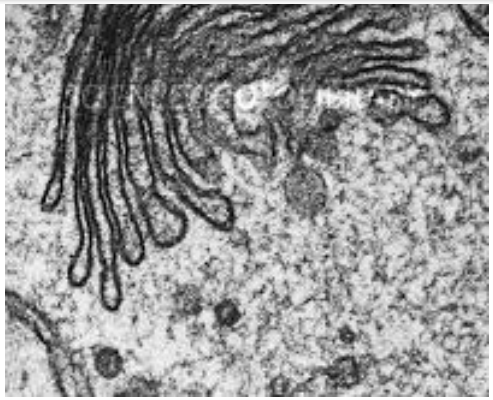
1898 “Adaptive Radiation“: proliferation of species from a common father that overtake each one habitat, Darwin‘s concept that Osborne described. He was not an important scientist, but had an important contribution by heading the American national nature museum and created magnificent displays of the world of nature.

Camillo Golgi 1843 -1926

1898 Described the organelle system called after him: “Golgi apparatus”. Today we know the Endoplasmic Reticulum, ER, synthesizes proteins that are transported to the Golgi for “post-translational modifications” (e.g. conjugation of sugars, phosphorylation) and transferred to their final locus via vesicles. Nobel with Cajal 1906



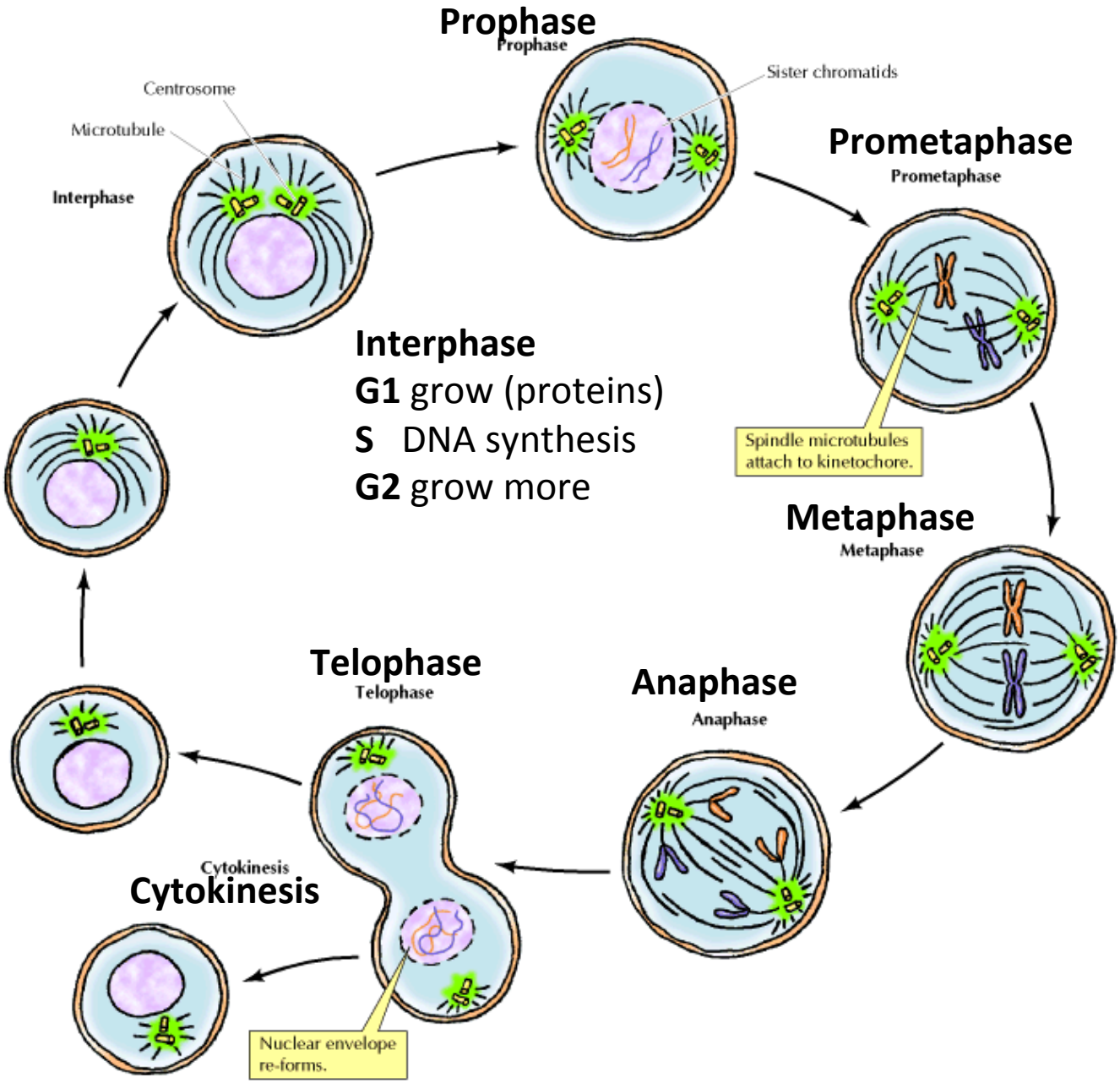


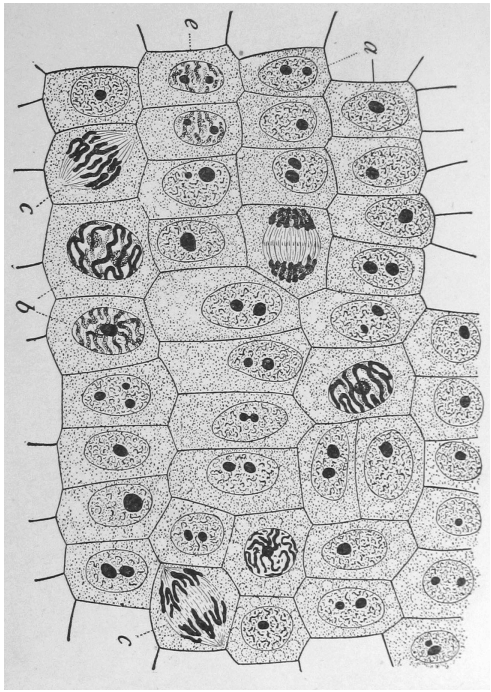


Charles Otis Whitman 1842-1910 & **Oskar Heinroth 1871-1945**

1899 Studying doves and ducks independently found that stereotypic responses of birds provide method of classification (taxonomy). Ethology.

THE CELL CYCLE





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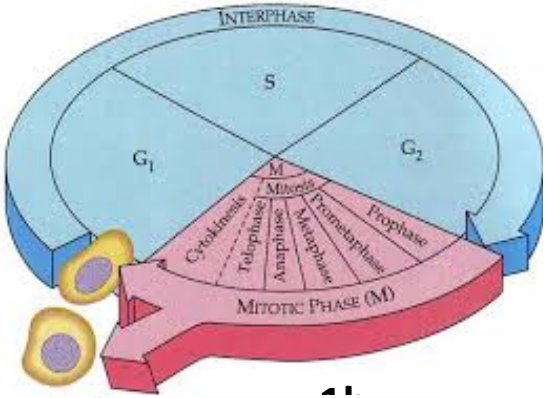
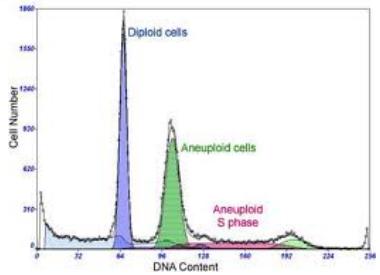




MEDICINE

Medical Invention

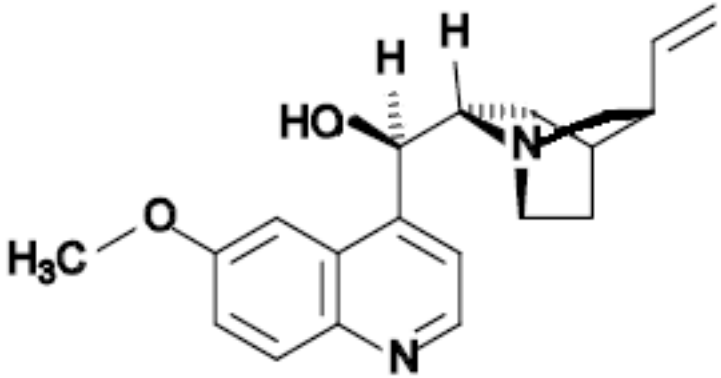
* 1540, artificial limb, by Ambroise Paré
* 1714, mercury thermometer, by Gabriel Fahrenheit
* 1775, bifocal lenses, by Benjamin Franklin
* 1792, ambulance, by Jean Dominique Larrey
* 1796, vaccination, by Edward Jenner
* 1816, stethoscope, by René Laennec
* 1817, dental plate, by Anthony Plantson
* 1827, endoscope, by Pierre Segalas
* 1846, anesthetics, by James Simpson
* 1847 Ignác Fülöp Semmelweis wash their hands before attending to women in childbirth
* 1851, ophthalmoscope, by Hermann von Helmholtz
* 1853, hypodermic syringe, by Alexander Wood
* 1865, antiseptic, by Joseph Lister, based on Pasteur‘s work
* 1880 Pasteur produced a vaccine against rabies
* 1885, rabies vaccination, chicken cholera vaccination and by Louis Pasteur
* 1887, contact lens, by Adolf Fick
* 1895, X-ray, by Wilhelm Rontgen
* 1903, electrocardiograph, by Willem Einthoven
* 1905, sphygmomanometer by Nikolai Korotkov
* 1928, penicillin, by Alexander Fleming
* 1938, penicillin as an antibiotic, by Howard Florey and Ernst Chain

Medical inventions (cont.)

* 1957, artificial pacemaker, by Clarence Lillehei and Earl Bakken
* 1967, heart transplant, by Christiaan Barnard
* 1970, MRI and fMRI, by Paul Lauterbur and Peter Mansfield (and others)
* 1973, CAT scan, by Godfrey Hounsfield and Allan Cormack
* 1979, ultrasound scan, by Ian Donald
* 1982, artificial heart, by Robert Jarvik

Pierre-Joseph Pelletier 1788-1842

1820 Isolated Quinina from the cinchona tree bark for treating fever.



Rene Theophile Hyacinthe Laennec 1781-1826

1816 Used statoscope to measure heart beat rate as a diagnostic method.

Replaced epidemiology with bacteriology

1843 Usage of Nitric Oxide NO (laughter gas, known for 40 years), for anesthesia in surgeries.

Ignaz Philipp Semmelweis 1818-1865

1847 Large decrease in child death on birth following hand washing practice – indirectly advanced germ theory.

Robert Alexis Bárány 1876-1936 & Henry Dakin

1914 Developed during the First World War wound sewing methods. “Dankin’s solution” was antiseptic solution used on open wounds.
Bárány gets Nobel 1914 for his work on the balancing mechanism in the ear, which was announced while he was a war prisoner in Russia. He was released due to the Swedish prince efforts, and stayed as a professor in Stockholm.

X-ray & electrocardiograph
Methods for diagnosing functioning of inner body organs.

Vaccination

Edward Jenner (1749-1823)

During the 18th century smallpox was mainly a death cause of babies.

1798 Jenner published his finding that cow and man smallpox are loosely related: cow's version induces immunity to man smallpox – the pioneer of vaccination. Jenner's training was as a military doctor, but he spent his life as a country doctor in Gloucestershire, west of England. He followed carefully hundreds of sick people – "case study", and knew cases that cow smallpox patients became immune to the human deadly disease. He injected healthy people serum of cow smallpox, (a procedure he called "vaccination" from the Latin word for cow-Vacca), and after the procedure was accepted in 1840 by the British authorities it reduced the number of cases by a factor of 30 to 40, and extended by Pasteur for other diseases.

1980 The International Health Organization claimed that the world is smallpox-free. Children of the last infected pocket in Bangladesh were vaccinated by the organization.

Medical debates about the acquisition of body natural immunity vs. vaccination:

1. The struggle against spread of AIDS: so far failed to offer vaccines, due to the fast mutation of the virus coat protein, the target of vaccine development.
2. Fight against cancer: so far no cell surface "epitope" typical of a wide range of cancers that distinguished them from normal cells was identified. Immunotherapy is based on stimulating our immune system nonspecifically, to depict itself the cancer and attack it. Recently some progress was reported.
3. The war against bacterial resistance to antibiotics: the development of new antibiotic agents and the use of antibodies is only partially successful.
4. Preventing or slowing down Alzheimer: so far stimulation of the immune system has partial success only.

penicillum antibiotics

Louis Pasteur 1822 -1895 & Claude Bernard 1813-1878

1865 Published “experimental medicine“ based on sterilization.

& Robert Koch 1843-1910

1882 Discovered **tubercle** bacillus. **1883** Discovered **cholera** bacillus.

Phrased “Koch‘s criteria“ for the involvement of bacteria in diseases:

1. Bacteria are abundant in injured tissues, but absent from healthy ones.
2. When isolated it proliferates in pure cultures in the lab.
3. The culture induces the disease in healthy tissues.
4. Bacteria isolated from secondary infected tissues are identical to the original.

Koch retracted #1 & 3 after finding that there are disease carriers that do not have symptoms, and found #4 hard to implement (e.g. syphilis and Leprosy)

Nobel 1905. The founder of bacteriology.

Florence Nightingale 1820 –1910

1852 During the Crimea war and in St. Thomas hospital she implemented hygiene and sterilization procedures that dramatically reduced mortality. Founder of the nurse profession.

Elizabeth Blackwell 1821 –1910

The first woman physician in the US.

Alexander Wood 1817-1884

1853 Distributed needle-injection of Morphine during the American Civil War.

Rudolph Virchow 1821-1902

1854 Published the wrong hypothesis that disease mechanisms would be understood at the level of cell chemistry.

Thomas Addison 1793-1860

1855 Described a brain symptom related to degradation of the cortex: Addison disease.

John Snow 1813-1858

1855 Proved graphically, mapping diseased cases, that spread of cholera in London started from one of the water pumping stations. The source was identified as a cholera-sick woman.

Crawford Long 1815-1878

1842 Used Sulfuric ether for Anesthesia.

William Thomas Green Morton 1819-1898

1846 Demonstrated anesthetic during surgical procedures – Anesthesia.

James Esdaile 1808-1859

1847 First to apply hypnosis during surgeries.

Henry Bence-Jones 1813-1873

1847 Identified specific proteins in urine of myeloma patients.

Marie-Jean-Pierre Flourens 1794-1867

1847 Discovered the amnestic properties of Chloroform.

Ignaz Philipp Semmelweis 1818-1865

1861 Published his conclusion that newborn fever is transferred by the doctor during his inspections.

Joseph Lister 1827-1912

1865 Used carbolic acid to clean surgical tools, demonstrating the effectiveness of antiseptic and sterilizing procedures in disinfecting wounds and surgical cuts.

BRAIN
and
PSYCHOLOGY

Arthur Schopenhauer 1788-1860

1819 Calls sex organs and mating the focus of will embodied in natural desire for persisted existence of the species.

Brain & Nerves

Franz Joseph Gall 1758-1828

At the beginning of the 19th century Gall estimated that cerebral cortex presents the highest level of mammal brain. He wanted to prove that “high“ abstract properties, such as mother‘s love, are concentrated in defined loci, that would grow with the development of the property, much like muscle grow with training.

In collaborated with **Johann C. Spurzheim** they followed cranial nerves from the medulla oblongata to the brain stem and the thalamus in the basal ganglia. They found in the cortex contralateral decussation of the pyramid nerves, resulting with the right hemisphere controlling the left side of the body, and the left hemisphere controlling the right side. They published 4 volumes of brain structure and the nervous system, and established psychology as a hierarchy in biology, but also introduced phrenology – relation between structure of organs and abstract properties, such as intelligence, a wrong theory that drove large crowds of supporters e.g. **G. W. F. Hegel, Otto von Bismarck, Marx, Balzac, the Brontës, George Elliott, President Whitman, and Victoria..., as well as in the scientific writings of Auguste Comte, G. H.Lewes, Spencer, Chambers, and A. R. Wallace“**

Emil Kraepelin 1856-1926

1899 Classification of mental diseases in the 6th edition of “Psychiatrics”.
1930 Medical procedures in psychiatry using electric shock, insulin and other medications, dissections of brain segments (leucotomy – of forebrain, lobotomy – of prefrontal cortex).
By 1970 these were the accepted procedures for treating schizophrenia.
After the Second World War, brain dissections were arrested, but sexual sterility treatments continued for many more years.

1950 antipsychotic drugs (e.g. chlorpromazine) were developed in labs for medical usage.

Francis Galton 1822 -1911

1865 Galton was a physician and statistician, trying to prove that ingenuity and high intelligence are hereditary, and require correct mating to produce quality human race. He also attempted to correlate measures of body limbs (anthropometry) especially skull (phrenology).
His “theory“ found many supporters in the US, to prove inferiority of blacks, and in Nazi Germany. **Alexis Carrel**, the French Nobel laureate (for his work on blood vessel linking and implantations) was an enthusiastic supporter of Galton.
1883 Galton preached selective mating of people, Eugenics (Nobel heritage in Greek).

Johannes Peter Müller 1801-1858

1833 Published his findings that experiences are not controlled by senses and not by stimuli, where every sensing organ creates his own experience: for example optical nerves produce sensation of light.

Marshall Hall 1790-1857

1833 Demonstrated a mechanism of stimulation creating response independent on sensing or cognitive awareness. Coined the term “reflex”.

Marie-Jean-Pierre Flourens 1794-1867

1824 Claimed that brain parts have assigned functions, working in harmony to combine all sensations acting from the respective parts of the hypothalamus.
Was a strong opponent of Gall's phrenology.

Jean Baptiste Bouillard 1796-1881

1825 Localized the site of language and speech in the frontal lobe of the cortex. In accord with Gall's finding. They also found that injury in limb functions may affect speech.

James Mill 1773-1836

1829 In a book about human brain, two resembling incidences converge to a simultaneous event memory, a special case of chronological order.
Acted as an editor for Encyclopedia Britannica, with interest in psychology.

Auguste Comte 1796-1857

1830 Intellectual development has three stages: religious (supernatural events), metaphysical (natural phenomena attributed to basic forces) and positive (phenomena attributed to inspections, assumptions and experiments). Coined the terms Sociology and Altruism.

Wilhelm von Humboldt 1767-1835

1836 Wrote in paper published after his death, that learning is bringing forth what is already sealed in the brain.

Ralph Waldo Emerson 1803-1882

1837 Claimed that life is what one thinks all day: „know yourself“ and „study nature“ are the same.

James Braid 1795-1860

1843 Coined the name „hypnotism“ from Greek sleep (previous name was human magnetism)

Jacques-Joseph Moreau 1804-1884

1845 Mental sickness does not originate from external stimuli, but from diminished brain functioning and remnants of psychic activity.

Carl Gustav Carus 1789-1869

1846 Psychological research of conscious and subconscious.

Gustav Theodor Fechner

1860 Tried to claim that physical and psychic are two aspects of the same reality. Phrases a law that sensational feeling is proportional to logarithm of stimulus strength. Had great influence on Freud.

Paul Broca 1801-1887

1861 Showed that injury in the left hemisphere cause loss of speech (Aphasia) proving asymmetry not realized by Gall.

Theodor Meynert 1833-1892

1867 Demonstrated that the layered structure of the cortex originate from parallel layers of different nerve types.

Wilhelm Griesinger 1817-1868

1867 Mental diseases are brain diseases.

Robert Eduard von Hartmann 1842-1906

1867 Started researching unconsciousness, including **Georg Frederick Hegel**‘s ideas and Schopenhaue‘s desires.

George M. Beard 1839-1883

1869 Distinguished between men and women‘s mental diseases (e.g. women‘s hysteria).

Karoly Maria Benkert 1824-1882

1869 Classified homosexuality as a behavioral property.

Francis Galton 1822-1911

1869 “Genetic basis of intelligence“. Invented standard deviation scale to treat diversity of populations.

Franz Brentano 1838-1917

1874 Thinking processes are voluntary, not passive.
Was among the teachers of Kafka & Freud.

George Henry Lewes 1817-1878

1875 Studied responses to combination of factors, but different than the sum or average of the response to each.

Carl Wernicke 1848-1905

1876 Described a new form of Aphasia as impaired understanding and not defected performance as **Broca** characterized it. He attributed complexity to connectivity between different brain loci.

Wilhelm Wundt 1832-1920

1878 Founded the first lab for psychology and physiology. Believed that sleep is related to fortification and suppression of brain regions.

George John Romanes 1848-1894

1883 Published „mental development of animals“ – first time comparison of man and animals.

1896 Behavior is species-dependent and is hereditary. Coined “Neo-Darwinism” to evolution post Weismann and embryonic stem cells.

Jean-Martin Charcot 1825-1893

1883 Accepted Hypnosis, and treated hysteria, like hypnosis, as pathological conditions.

J. Hughlings Jackson 1835-1911

1884 Observations on epileptic cases and aphasia. Segmented brain into lower – spinal chord, bone marrow controlling motion, medial – motoric part of cortex, and high – forebrain. Every part suppresses the one below, and when injured, there is positive hindrance below and negative above. Assumed that neurological pathology of dissolution cause inversed functioning.

Friedrich Wilhelm Nietzsche 1844-1900

1883-5 Published “Also sprach Zarathustra“ dealing with the identity of human desires, inhibitions and aspirations.

Hippolyte Bernheim 1840-1919

1886 Everyone can be hypnotized. Separated conscious and unconscious behavior. The subject takes important, sometimes disproportional, place in medicine, social studies and literature, e.g.: :**E. T. A. Hoffman**, **E. A. Poe**, **Honoré de Balzac**, **Alexander Dumas**, **Victor Hugo**, **R. L. Stevenson**, **Fyodor Dostoevsky**

Pierre Janet 1859-1947

1886 Coined the term “subconscious“.

Richard Freiherr von Krafft-Ebing 1840-1902

1886 Coined the term “Sadism“ (after Donatien de Sade) and “Masochism“ (after Leopold Sacher-Masoch).

William James 1842-1910

1890 Every behavior originates from the nervous system. Learning is related with increased activity, short-range memory is a selective awareness.

Eugen Bleuler 1857-1939

1890 Schizophrenia is treatable.

Sigmund Freud 1856-1939 & **Josef Breuer 1842-1925**

1893 Published a book that started psychoanalysis.

Emile Durkheim 1858-1917

1893 Wrote a series f books about sociology.

Conwy Lloyd Morgan 1852-1936, **James Mark Baldwin 1861-1934**
& Henry Fairfield Osborn 1857-1935

1896 All independently proposed how acquired properties can be inherited. **Morgan** concluded that evolutionary changes in anatomy lead to behavioral changes. **Baldwin** called his version “organic selection“ since it required organism involvement in the learning process that creates better fit to selection and mating.

Sigmund Freud 1856-1939

1896 Proposed to test child conflicts with neurosis. Developed method of associations to bring up sensitive subjects in treatment sessions. Further on he employed dreams, stumbled words, failing actions, forgotten names and child memories.

Edward L. Thorndike 1874-1949

1898 Established a way to measure learning in animals.

Emil Kraepelin 1856-1926

1899 Diagnostic criteria for classifying mental diseases (dementia, schizophrenia, mania, paranoia).