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| The lever was used by humans for many thousands of years, but the mathematical properties underlying it were discovered by Archimedes of Syracuse (Sicily). He discovered that in a balanced lever, the weights at each end had the same ratio as the length of lever to each side of the fulcrum. | lever;ratio of weights is equal to the ratio of distance from the fulcrum | Syracuse, Sicily | -260 | Archimedes | physics | lever.jpg | David Marques | https://www.phosphorlearn.co |
| Archimedes was asked to determine if a gold crown gift was solid gold or just gold leaf. He discovered that the ratio of the displacement in water to the weight would tell him the density, which is the key to determining solid gold. He discovered the principle of buoyancy while in his bathtub, and supposedly ran through the streets in his bathrobe shouting 'Eureka!' | Eureka!;buoyancy; density compared to water is the key | Syracuse, Sicily | -245 | Archimedes | physics | buoyancy.jpg | David Marques | https://www.phosphorlearn.co |
| Copernicus did not study the heavens, stars, sun, but studied the data from other astronomers, particularly Ptolemy. He was bothered by the inexact fit of Ptolemy's data to Ptolemy's model of the solar system with the earth at its center. He then showed that a model of the solar system with the sun at the center fit the data better. But they still did not fit perfectly (until Kepler realized that planetary motion was elliptical, not circular), so he did not publish for almost 30 years. This was also probably the first data-driven theory (rather than logic-driven) in modern science. | sun-centered solar system;beginning of conscious data-driven science | Frombork, Poland | 1520 | Copernicus | astronomy | sun_centered.jpg | David Marques | https://www.phosphorlearn.co |

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| Andreas Vesalius was a Belgian scientist/doctor whose father had one of the best medical libraries. Vesalius dissected many animals as a child, and eventually studied medicine in Paris. At his time, anatomy was taught from Greek drawings by Galen, never with actual dissection. Vesalius was to change that, dissecting humans and re-drawing human anatomy much more precisely than ever before, changing medicine forever. | human dissection; anatomical fact replaces guesses in medicine;first scientific accurate guide to human anatomy | Brussels, Belgium | 1543 | Vesalius | medicine, biology | dissection_01.jpg | David Marques | https://www.phosphorlearn.co |
| Galileo Galilei was one of the first experimentalists, meaning he determined natural laws by testing them rather than by just thinking about them. One of his most famous tests is whether the weight of an object makes any difference in how fast it falls, or how fast it rolls down an inclined plane. It doesn't, only friction and other such factors matter. This is the law of falling objects. | law of falling objects; objects fall at the same rate no matter their weight; pendulums swing at the same rate no matter the weight, the length determines the time;dropping weights from the tower of Pisa;launch of experimental science | Pisa, Italy | 1598 | Galileo Galilei | physics | falling_objects.jpg | David Marques | https://www.phosphorlearn.co |
| After Copernicus freed science from an earth-centered universe, Kepler freed science from the assumption of circles as perfect. Kepler kept working to resolve the discrepancies between data and Copernicus's model of planetary orbits around the sun, and, with better data from Tycho Brahe (his mentor), he determined that planets move in an ellipse rather than in circles, thus fitting the data better. | planetary motion as ellipses;better data, better fit for planetary motion eliminating all epi-circles | Prague, Czechoslovakia | 1609 | Johannes Kepler | astronomy | planetary_ellipses.jpg | David Marques | https://www.phosphorlearn.co |

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| Galileo Galilei was convinced of the Copernican theory of planetary motion, and set out to gather more data. When he saw a telescope, he realized it was what he needed. He then proceeded to show that the moon was not perfectly round but had mountains and then discovered the moons of Jupiter and documented them. His and subsequent data on the moons of Jupiter were used for centuries to help determine longitude. For his trouble, and documentation of Aristotle's errors, he was placed under permanent house arrest by the Inquisition. | Jupiter's moons;early telescope, 40X;first clear sighting of the moon that showed mountains and valleys | Padua, Italy | 1610 | Galileo Galilei | astronomy | jupiters_moons_01.jpg | David Marques | https://www.phosphorlearn.co |
| Blood circulation was considered as two different systems ever since the Greek Galen wrote that food was converted to blood and arteries carried that to tissues. Veins were considered a separate system. WIlliam Harvey was court physician of King James I of England, but also studied human and animal corpses with microscopes, and discovered valves in veins. He was the first to note that the valves made sure blood only flowed toward the heart, never away from it. From this, he deduced that arteries and veins were a single out-and-return system of blood flow, first documenting the human circulatory system. | blood flow;veins have valves for one-way flow;veins bring blood back to the heart; heart as a pump that circulates the blood | London, England | 1628 | William Harvey | medicine, biology | blood_circulation_01.jpg | David Marques | https://www.phosphorlearn.co |
| The Greeks, Romans, Egyptians all worked with mathematics, but without any symbol for the number zero. The Egyptians had a symbol for zero, the Babylonians used a space, but neither was a true number. This made mathematics as we know it today impossible. The first recorded true use of a positional symbol for zero that could be used as part of a calculation in on a stone inscription found at the Chaturbhuja Temple at Gwalior in India. | the number zero; math as we know it today | Gwalior, India | 876 | Indian mathematicians | mathematics | zero_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Today we take for granted that air has weight, but that was a very important discovery for science, and completely changed our understanding of weather and began our study of the atmosphere. Evangelista Torricelli was an assistant to Galileo, and together they discovered that no matter how much air is removed from a tube inverted in water (primitive barometer), water would not rise above 9.7 meters into the tube. Galileo thought the cause was the weight of the water, but Torricelli proved, working with mercury, that the height changed from day to day. He observed that the weather influenced the height, and then inferred that air pressure (the weight of the atmosphere of air) was the cause. | barometer;air pressure;origin of atmosphere study | Florence, Italy | 1640 | Evangelista Torricelli | physics, weather | Barometer_01.jpg | David R. Ingham, CC BY-SA | https://en.wikipedia.org/wiki/Ba |
| Robert Boyle studied vacuums and air pressure, and discovered that any gas will expand inversely proportional to the force pushing against it. The tests involved frictionless piston compressing air, and then varying the force of pressure on the piston. He discovered that the pressure needed to halve the volume of trapped air was double the pressure, and tripling the pressure reduces the air volume to 1/3. He also proved that air (and all gases) will spring back to the exact starting place when pressure is removed. | Boyle's law;volume of gas is inversely proportional the the force on it;gases expand to fill empty space;first quantitative law of gasses | London, England | 1650 | Robert Boyle | physics | Boyles_law_01.jpg | David Marques | https://www.phosphorlearn.co |
| Microscopes revealed a whole new world, and one of the first and most important was that all living organisms are built of cells. Robert Hooke was one of the greatest microscopists of all time, and his book 'Micrographia' is brilliant for its drawings and insights. He discovered and drew cells in a variety of organisms. | cells;building block of all organisms;basic unit of anatomy | Oxford, England | 1665 | Robert Hooke | biology | Cells_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Whether it really happened or not, the apple falling on Newton's head is remembered by nearly everyone, as giving Newton the idea of universal gravitation -- that all bodies with mass attract all other bodies of mass, proportional to their mass and the distance between them. He then saw that gravity acts to keep planets in orbit. | universal gravity; gravity keeps planets in orbit | Oxford, England | 1666 | Isaac Newton | physics | Universal_gravitation_01.jpg | David Marques | https://www.phosphorlearn.co |
| Fossils have been known for a long time, and formed a puzzle for many. Nicholas Steno first recognized what they were, gave a strict definition to the term 'fossil', and started the rigorous process of dating and studying fossils that today is the underpinnings of geology and evolution. | fossils | Copenhagen, Denmark | 1669 | Nicholas Steno | palaeontology, geology, evolution, biology | Fossils_01.jpg | David Marques | https://www.phosphorlearn.co |
| Giovanni Cassini grew started as an astronomer in Italy then became director of the Paris Observatory. While there, he calculated the distance to Mars by measuring (with an assistant) the angle to mars from two far-apart places on earth, and from that calculated the distance to the sun. He was off by only 7% from today's measurements. | first indication of the vast size of the universe;distance from the sun;93 million miles | Paris, France | 1672 | Giovanni Cassini | astronomy | Distance_from_sun_01.jpg | David Marques | https://www.phosphorlearn.co |
| The microscope is often attributed and associated with Anton van Leeuwenhoek. Completely self-taught, he never read any scientific papers, but became fascinated with microscopes, designed and built his own far better than others at a time, and discovered bacteria. He also was the first to see a variety of other single-celled organisms, blood cells, sperm, and capillaries. When he finally shared his drawings and writings with the Royal Society in London, they translated them into English. When he claimed that bacteria caused disease, no one believed him for almost 200 years. | bacteria;single-lens microscope | Delft, Netherlands | 1680 | Anton van Leeuwenhoek | biology | Bacteria_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Once he understood gravity as a universal force proportional to mass, and planetary motion as a result of interacting forces, Isaac Newton made the brilliant leap to the formula everyone knows, F=ma, force required to move a mass equals mass times the resulting acceleration. To test his equations, he needed to know the mass of the Earth, which was published finally by Jean Picard, and enabled Newton to validate his formula. He did not share or publish his formula or laws until forced to by others claiming credit, in his 'Principia', one of the most famous of all science texts. | F=ma;laws of motion; for every motion, there is a force that caused it acting on the object's mass; Principia | Oxford, England | 1687 | Isaac Newton | physics | Laws_of_motion_01.jpg | djem at 123RF | https://www.123rf.com/profile_ |
| Humans are driven to create order from chaos, and one of the greatest leaps forward was the grouping and naming conventions invented by Carl Linnaeus of all living things, in the famous book 'Systema Naturae'. This systematization is called taxonomy, and is a hierarchy (tree) of species, organized into genus, family, class, order, phyla, kingdom. Every living thing can be identified in a unique genus/species, and Linnaeus was the first to name humans homo sapiens. He was started in his thinking by reading a shocking paper describing that plants reproduce sexually and have male and female parts. | genus and species; taxonomy of living things;Systema Naturae | Uppsala, Sweden | 1735 | Carl Linnaeus | biology | Taxonomy_01.jpg | David Marques | https://www.phosphorlearn.co |
| Before William Herschel, astronomers believed that stars were individual things, and our solar system unique. Herschel made his own very powerful telescopes with almost no distortion, and was able to discern galaxies as new kinds of objects comprised of millions of stars. Thomas Wright first theorized that our own solar system was part of a much larger cluster of stars he named a galaxy, and Herschel's observations provided proof. | galaxies;shape of the universe;An Original Theory or New Hypothesis of the Universe;statistical methods to count stars | Bath, England | 1750 | Thomas Wright, William Herschel | astronomy | Galaxies_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Static electricity and lightning were known and studied for a long time before Benjamin Franklin proved that they were the same thing by observing static electricity traveling down a kite string to a key and then jumping across a gap (exactly like static electricity) to his finger. Fortunately, it was not lightning that struck his kite (a French scientist was killed by such a lightning bolt trying to replicate Franklin's experiment) but there is static electricity all through the air during a lightning storm, not all is bound into lightning bolts which just happen to be concentrated chunks. | lightning;the key to electricity;lightning is static electricity | Philadelphia, American Colonies | 1752 | Benjamin Franklin | physics, weather | Electricity_01.jpg | marinini at 123RF | https://www.123rf.com/profile_ |
| Benjamin Franklin was a true multi-disciplinary scientist, not just studying electricity. One of his most important discoveries is that global weather is controlled mostly by ocean water currents and temperature. Franklin heard while in London that American ships traveled from the colonies to England much faster (by 2 weeks!) than English ships. When he looked into it, he discovered that American ships took advantage of the Gulf Stream but that the British Navy did not seem to know about it. In an effort to convince an unbelieving British Navy, he started making regular temperature readings across the Atlantic. He then noted that weather was closely related to the direction and temperature of water movement across the Atlantic. | weather from ocean temperature and movement;global weather;weather as a science;Gulf Stream; British Navy refuses to believe in the Gulf Stream | Philadelphia, American Colonies | 1770 | Benjamin Franklin | climate, weather | Oceans_weather_01.jpg | designua at 123RF | https://www.123rf.com/profile_ |

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| Joseph Priestley was the first to isolate a single element in gas form from air, that being oxygen. For a number of years, scientists had known that there was something in air that was needed for life, for breathing, and for fire. Priestly first proved that air was not a single uniform thing, but a mixture. Priestly called the isolated substance 'pure air' and later Lavoisier named it oxygen. | oxygen;pure air;air is a mixture;fire and breathing need the same thing, oxygen | Leeds, England | 1774 | Joseph Priestley | chemistry, biology | Oxygen_01.jpg | David Marques | https://www.phosphorlearn.co |
| Plants do not breathe, they create oxygen from sunlight by photosynthesis. Jan Ingenhousz discovered this process. Priestly had shown that plants can live without oxygen, and that a mouse living in a jar without air but with plants could survive. Ingenhousz performed over 500 experiments to isolate what was happening, showing that humans could breathe the substance emitted by plants (kept in sunlight but underwater, so he could trap the oxygen) and that plants could use what humans breathed out (carbon dioxide) but not oxygen. He also showed that plants added mass from the sunlight and air, not by taking mass from the ground. | photosynthesis; oxygen and carbon dioxide roles for green plants and animals;Experiments Upon Vegetables; plants get mass from sun and air, not from ground | Breda, Netherlands | 1779 | Jan Ingenhousz | biology, chemistry | Photosynthesis_01.jpg | Olga Nikitina at 123RF | https://www.123rf.com/profile_ |
| The concept is simple, but it took experiments by Antoine Lavoisier to demonstrate the conservation of matter -- that the total mass in a closed system remains the same no matter the chemical or physical changes. Most scientists, even the great Robert Boyle, believed that mass was created when something was changed, for example when tin or other metals are heated. Lavoisier did not believe this, and demonstrated that if you do the same experiments in a closed flask, the overall weight remains the same. Lavoisier was unfortunately executed by the French Revolution. | conservation of matter;mass in a closed system remains constant no matter the chemical and physical reactions in that system;matter is not created or destroyed | Paris, France | 1789 | Antoine Lavoisier | physics | Conservation_of_matter_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Benjamin Thompson was born in Massachusetts but discovered the nature of heat while overseeing canon manufacture for the King of Bavaria. Scientists had believed that heat was something acquired or a property of substances, and burning was releasing that into the world. Thompson measured heat flowing from a canon mold that was being drilled, and decided that too much heat flowed out to have been stored in the (rather cool) canon. He decided that it was the motion of the drill against the canon, what we now call friction, that created the heat. | nature of heat;friction; canon manufacture where drilling the bore creates massive heat | Munich, Bavaria | 1790 | Benjamin Thomson | physics | Nature_of_heat_01.jpg | vladischern at 123RF | https://www.123rf.com/profile_ |
| James Hutton looked at rolling hills and did not believe they could have been caused by sudden catastrophes, such as was believed at the time. He studied pebbles in a stream bed and decided that they had formed by rolling around after breaking off hills and mountains, and from that concluded that the earth was shaped by gradual wearing down by water and wind. This meant the earth was millions of years old and completely changed the way we think about the earth, and paved the way for geology and even evolution. | geology, weather | Edinburgh, Scotland | 1792 | James Hutton | geology, weather, climate | Weathering_erosion_01.jpg | illarionovdv at 123RF | https://www.123rf.com/profile_ |

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| Smallpox used to be one of the deadliest and most disfiguring diseases, but was eradicated from the world in 1979. Lady Mary Wortley Montagu, a poet, learned from tribal women in Turkey (where smallpox was rare) that they prevented smallpox by injecting a tiny amount of smallpox pus into children. No one in England listened to this 'silly poet', and some children did die from this technique (using live virus). A few years later, Edward Jenner noticed that milkmaids never got smallpox (hence the 'complexion of a milkmaid') but did get cowpox. He then injected 20 children with cowpox, all came down with hand blisters but none with smallpox, and inoculation or vaccination was discovered. | smallpox vaccination; milkmaid complexion | Berkeley , England | 1798 | Lady Montagu and Edward Jenner | medicine, biology | vaccination2.jpg | By Rhoda Baer for NCI, public domain | https://commons.wikimedia.or |
| Friedrich Wilhelm Herschel (or William Herschel) measured the heat of different colors of sunlight, using a prism projecting a rainbow on the wall. The hottest was red, at one end. On a whim, he also measured right next to the red, where no color was visible, and discovered that the area right next to the red was hotter than the red. He named that 'infra-red'. Johann Ritter heard about the experiment and tested how quickly the different colors darkened silver chloride (later the basis of photography). Although red and infrared hardly darkened the silver chloride, violet darkened it the fastest, and he discovered the invisible area next to that darkened the paper fastest, then named it ultraviolet. Thus was discovered non-visible radiation from the sun. | infrared;ultraviolet; non-visible radiation | Bath, England | 1800 | William Herschel, Johann Ritter | physics | Invisible_radiation_01.jpg | Cody.pope, CC BY-SA | https://en.wikipedia.org/wiki/In |

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| Anesthesia was known since at least the Greeks and Egyptians, who used mandrake root to create unconsciousness, and ancient Chinese who used acupuncture to block pain. Later, Inca medicine men used coca leaves (cocaine) to numb tissue. Chloroform was in regular use for operations after Queen Victoria heard of it and used it to help the birth of her seventh child, and was used regularly in the US Civil War. Ether was used and became the standard for many years after Boston dentist William Morton used it for operations in 1845. But anesthesia was discovered in the western world by Humphry Davy earlier than that when he created nitrous oxide and became delirious and then passed out. He named it laughing gas. | laughing gas; anesthesia in the West | Bristol, England | 1801 | Humphry Davy | medicine | Anesthesia_01.jpg | David Marques | https://www.phosphorlearn.co |
| The term 'atom' was in widespread use in science to mean the smallest indivisible piece of matter since coined by Democritus, but based purely on theory, no evidence. That evidence came when John Dalton, a self-trained chemist, discovered that every time elements combined to form a specific compound, they always combined in the same ratio. He called the units of each of these atoms. He also created the nomenclature of compounds (eg, H2O) to indicate these ratios. | first evidence for atoms;elements combine always in the same ratios; nomenclature for compounds | Manchester, England | 1802 | John Dalton | physics, chemistry | Atoms_01.jpg | David Marques | https://www.phosphorlearn.co |
| After the invention of the battery by Alessandro Volta, Humphry Davy experimented with changing the liquid in the battery and the electrode composition. In doing so, he created a number of simple compounds building up on the electrodes and gasses released from the liquids, such as hydrogen and oxygen released from water. From this, he discovered electrochemical bonding in simple compounds and discovered the element potassium. | electrochemical bonding;potassium discovery;battery electrodes | Bristol, England | 1806 | Humphry Davy | chemistry, physics, electricity | Electrochemical_bonding_01.jpg | David Marques | https://www.phosphorlearn.co |

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| Scientists Dalton and Gay-Lussac had shown that combining one liter of oxygen with 2 liters of hydrogen gives 2 liters of water vapor, not 3 liters. Looking into this puzzle, Amedeo Avogadro postulated the existence of molecules, and that the number of molecules of water was the same as the number of atoms of hydrogen, and thus the core unit of compounds is the molecule, which is preserved. He postulated that every liter of gas contains the same number of molecules, and this goes for pure elements as well as for compounds. He further calculated this number (6.23 x 10 to the -23 power) as that number of molecules, now called Avogadro's number. | molecules;same number of molecules in a liter of every gas;6.23 x 10 to the -23 power;Avogadro's number | Turin, Italy | 1811 | Amedeo Avogadro | chemistry, physics | Molecules_01.jpg | David Marques | https://www.phosphorlearn.co |
| The modern world of machinery is built to a large extent on electromagnets -- magnetic properties induced in metals by electric current. After Ben Franklin showed the nature of electricity, the experimentation exploded on electricity. Hans Oersted was one scientist fascinated by electricity, and discovered by accident, while teaching, that passing current through platinum (his demonstration was about heating the platinum) a compass also on the table suddenly pointed to the platinum. Twice in previous years there had been a prize offered for anyone who could connect electricity to magnetism, neither had a winner. Oersted studied his phenomenon and showed the now-familiar curved field around the electromagnet created. | electromagnetism;magnetism from electricity;first demonstration of the relationship between electrical and magnetic forces | Copenhagen, Denmark | 1820 | Hans Oersted | physics, electricity | Electromagnetics_01.jpg | blueringmedia at 123RF | https://www.123rf.com/profile_ |

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| Everyone loves dinosaurs, and fossil bones (bones turned to stone by time) were known before being properly identified as belonging to dinosaurs. Mary Mantell found some very large teeth and gave them to her husband, Gideon Mantell, who asked Charles Cuvier to identify them. He could not. Mantell later studied modern iguana teeth, and decided they were very much the same, so published his discovered teeth under the name if Iguanodon. At the same time, William Buckland found a jaw and thigh fossil bones of a huge creature, and he published them under the name of megalosaurus. These were the first identified dinosaur fossils. | first dinosaur fossils; megalosaurus; iguanodon | Taynton, England | 1824 | Gideon Mantell, William Buckland | palaeontology, evolution, biology | Dinosaur_fossils_01.jpg | David Marques | https://www.phosphorlearn.co |
| Louis Agassiz was a naturalist and college professor who like to walk through the mountains and valleys of the Swiss Alps. He noticed that glaciers were always in V-shaped or U-shaped valleys or notches. When he saw the same u-shaped valleys in the hills of England and Scotland, he realized that glaciers had carved them also. He then spent two years documenting such places all over Europe, and then published the radical theory that the earth had previously had ice ages, where glaciers were all over Europe. | ice ages;glaciers carve valleys;first theory of climate change | Neuchâtel , Switzerland | 1837 | Louis Agassiz | climate, geology, weather | Ice_ages_01.jpg | Michael Heywood at 123RF | https://www.123rf.com/profile_ |
| James Joule believed that there should be a basic unit of energy, and believed that heat was the basic unit. His measurements led to the postulation of the calorie as the basic unit of heat, and later investigations named the basic unit of energy (that can be converted into heat) as a joule. Joule's clever experiments showed that adding pressure to a contained gas under water released heat into the water, and adding movement to contained water under mercury released heat into the mercury. | basic unit of heat; calorie;basic unit of energy;joule | Salford, England | 1843 | James Joule | physics | Calories_01.jpg | Somchai Thongseeda at 123RF | https://www.123rf.com/profile_ |

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| Perhaps the most fundamental principle of physics is the conservation of energy, which forms the first law of thermodynamics. It was discovered by Hermann von Helmholtz when he wanted to disprove 'vital force' theories, which had postulated that energy was created and lost in actions. By carefully replicating other experiments and measuring all results, he showed that all energy 'lost' was put out in the form of heat or gas or something tangible, and that energy always required a source and a conversion. Astronomers challenged him with the sun, which seemed to radiate heat with no source, until Helmholz realized that the massive gravity of the sun was creating the heat and the energy release. Thus the sun was collapsing and would in time run out of energy. | conservation of energy;first law of thermodynamics; gravity converts mass to heat;sun is shrinking | Heidelberg, Germany | 1847 | Hermann von Helmholtz | physics | Conservation_of_energy_01.jpg | David Marques | https://www.phosphorlearn.co |
| We all know that the whistle of a passing train is higher in pitch when coming at us and lower in pitch after it passes us. This is known as the Doppler Effect, first explained by Christian Doppler. Doppler loved to watch trains and decided that the waves are compressed in front of a train as it releases each sound bit closer to the hearer than the previous one, and the waves are elongated when the train moves away from us. He then postulated the same for light, and this became the most important tool of astronomy, to measure the speed of stars moving toward or away from us, giving us the data that led to the big bang theory. | Doppler Effect;waves are compressed when the source moves towards us, expanded when the source moves away; foundation of measuring expansion of the universe;trains sound higher pitch when moving toward us and lower when moving away | Vienna, Austria | 1848 | Christian Doppler | physics, sound | Doppler_Effect_02.jpg | Doleron, CC BY-SA | https://upload.wikimedia.org/w |

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| Scientists at the time believed that disease was caused by the spontaneous generation of bacteria or other organisms from spoilage, 'bad' air (miasma), or other rot. Louis Pasteur did not believe that, having already discovered that yeast used to ferment beer and wine are present everywhere, especially in the air. He first proved that bacteria were also in the air, and merely had to be concentrated (by sucking air through a cotton filter) to grow. Then he showed that bacteria never form in a sterile environment. Thus he created the germ theory of disease, the most important pillar of medicine today. | germ theory of disease;no spontaneous generation of bacteria;bacteria are in the air | Paris, France | 1856 | Louis Pasteur | medicine, germs | Germ_theory_01.jpg | yupiramos at 123RF | https://www.123rf.com/profile_ |
| The most important theory in biology today is the theory of Evolution. Although contested by some religious extremists, this theory has so much evidence that it is often (incorrectly) called fact. It was discovered by a brilliant leap of thinking from data by Charles Darwin (and at the same time by Alfred Russel Wallace) after minute and careful observation of the variation in closely related species, especially the finches of the Galapagos Islands, when he joined the idea with the extreme age of the earth as postulated by Charles Lyell, published in the most famous science text, 'The Origin of Species'. Species change constantly, and when the are isolated or their environment changes, or move into new environments, they either fit or die out. Some fit well, and those who fit best produce more offspring. | evolution;finches of Galapagos Island; Voyage of the Beagle;Origin of Species | Downe, Kent, England | 1858 | Charles Darwin | evolution, biology | Evolution_01.jpg | redrockerz at 123RF | https://www.123rf.com/profile_ |

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| When Darwin proposed evolution acting through inherited traits, he did not know how that inheritance worked. An Austrian monk, Gregor Mendel, was a gardener curious about how inheritance worked and experimented with pea plants to carefully cross-breed and discovered recessive and dominant traits, and the key to our understanding of genes, chromosomes, and DNA. | heredity; crossbreeding green and yellow peas | Brno, Czech Republic | 1865 | Gregor Mendel | evolution, biology | Heredity_01.jpg | David Marques | https://www.phosphorlearn.co |
| For a long time, scientists did not believe that life could be sustained without sunlight, so assumed the sea floor was lifeless. Charles Thomson was dredging the sea floor off Norway as part of laying telegraph cable, and pulled up strange fish and other creatures. No one believed him, assumed they were caught on the way down or up. He finally convinced the Royal Navy to dredge systematically over 3 summers, and proved his point, that strange but very real fish and molluscs and plants lived on the floor of the deep sea, beyond the reach of sunlight. | lightless ocean floor contains life | Dublin, Ireland | 1870 | Charles Thomson | biology | Deep_sea_life.jpg | Citron, CC BY-SA | https://en.wikipedia.org/wiki/D |
| Dmitri Mendeleyev was a chemist frustrated by the lack of any organizing principles in the elements, thought that there must be in nature, and tried to discover them. He made cards for each of the known elements with their characteristics (weight, how they combined with carbon hydrogen and oxygen, and their room-temperature state, other things) and tried to arrange them in some kind of recurring pattern. When they didn't fit, he realized there must be other elements not yet discovered, so created 'holes' and the periodic table of elements was born. | periodic table of elements;first organizing principles of basic earth elements | Saint Petersburg, Russia | 1880 | Dmitri Mendeleev | chemistry, physics | Periodic_table_01.jpg | conceptw at 123RF | https://www.123rf.com/profile_ |

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| Cells were known for over a century before dyes were discovered that would highlight structures inside cells. Specifically, Walther Flemming discovered that a coal-tar-based dye stained stringlike substances inside the nucleus of cells, and through a series of time-lapse-like microscopic images (the dye killed the cells) he was able to see and draw cell division. | mitosis;cell division;chromatin;process by which cell chromosomes split | Kiel, Germany | 1882 | Walther Flemming | biology | Cell_division_01.jpg | David Marques | https://www.phosphorlearn.co |
| X-rays were discovered by accident. Wilhelm Roentgen was doing research passing a electricity thorugh a variety of gasses and noticed incidentally that a photographic plate buried deep in a desk drawer had the image of a key on it. The key had been in another drawer, and he was able to trace back the direct path to one of the experimental tubes. He then tried putting his hand between the electrified gas and a different plate, and was amazed to see his bones. | X-rays;high frequency radiation goes through flesh but not bone | Würzburg, Germany | 1895 | Wilhelm Roentgen | physics, medicine | X_rays_01.jpg | vampy1 at 123RF | https://www.123rf.com/profile_ |
| Karl Landsteiner was a doctor who did autopsies at a Vienna hospital. He noticed one day that 4 patients had died during surgery and all of them died of their own blood clotting. They had all been given transfusions. Landsteiner then tested blood from 20 random patients to see how they reacted to each other and discovered that some clotted when combined, and some did not. He further noticed that those that did not clot with each other would not clot with a set of others -- they all had the same blood type, which he had discovered. Humans have 4 blood types (A, B, AB, O), cows have over 800 blood types. | A, B, AB, O;blood types;necessary before transfusions! | Vienna, Austria | 1897 | Karl Landsteiner | medicine, biology | Blood_types_01.jpg | Chatchon Jirajitmeechai at 123RF | https://www.123rf.com/profile_ |

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| Cathode ray tubes emit rays that were not understood for a long time. J.J. Thomson set up experiments to determine what they were. He discovered that when they hit a metal plate, the metal plate took on a negative charge. He discovered that the rays could be deflected by both magnets and by electrical fields. By moving those close to a slit where the cathode ray emerged, the place the ray hit the metal or phosphorus plate. He then calculated the mass of these 'electrons' by F=ma, measuring how much force moves the electrons how far. These were TINY, the first subatomic particles discovered. | electron;first particle of atoms discovered; negative charges in atoms | Cambridge UK, England | 1897 | J.J. Thomson | physics | Electron_01.jpg | David Marques | https://www.phosphorlearn.co |
| Viruses are the smallest life forms yet also some of the most deadly, including not only flu but flu, rabies, yellow fever, Ebola, AIDS. They puzzled Pasteur because he could not isolate them, they were too small to catch on any filter to grow and too small to see. Dmitri Ivanovsky was not able to isolate the organism, but did isolate fluid that contained it, and showed that diseases were carried from organism to organism through fluid the same as most bacteria. Because they were so small, the medical community did not believe in their existence until the experiments were repeated by American surgeon Walter Reed studying yellow fever. | viruses;smallest life forms on earth; reproduce only by infecting a host cell and directing it to reproduce the infection;colds, yellow fever, rabies | Saint Petersburg, Russia | 1898 | Dmitri Ivanovsky | medicine, biology | virus_generic.jpg | By Kateryna Kon, purchased royalty-free from Shutterstock | https://www.shutterstock.com/ |

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| Mitochondria is DNA (though this was not known until 65 years after their discovery) that is not in the nucleus of a cell, and is not passed down through sexual reproduction. Instead, it floats in the cell body in its own organelle, and is passed along as an exact copy from mother to offspring in animals. These were discovered by Carl Benda after microscopes became powerful enough and DNA staining became robust. Mitochondrial DNA are used to date species divergence because they do not change except by random mutation, not by adaptation and inheritance in the usual way. Their role is to create energy for the cell. | DNA outside the cell nucleus;mitochondria; energy provider for a cell | Berlin, Germany | 1898 | Carl Benda | biology, energy | Mitochondria_01.jpg | David Marques | https://www.phosphorlearn.co |
| Marie Curie was a woman scientist in the days when women could not be professionals. She worked in the lab of her professor husband and discovered radium and plutonium as elements in addition to uranium in a substance called pitchblende. She noticed that too much radiation was coming from this substance to be uranium only, and gradually isolated the others to account for the extra radiation. She was the first woman to receive the Nobel Prize, and one of only 4 people ever to receive the Nobel Prize twice. | radioactivity;polonium and radium from pitchblende;discovery of radium | Paris, France | 1901 | Marie Curie | physics, radioactivity | Radioactivity_01.jpg | David Marques | https://www.phosphorlearn.co |
| ;The earth's atmosphere is composed of several layers, distinct from each other. They have different gas compositions, therefore densities, but also different temperatures. Understanding these through unmanned balloon flights with instruments and recording devices has moved us far forward in our ability to understand and predict weather. | unmanned balloon instruments | Paris, France | 1902 | Leon Philippe Teisserenc de Bort | climate | Earth_atmosphere_layers.jpg | NOAA & User:Mysid, public domain | https://en.wikipedia.org/wiki/At |
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| Quiz | Who made this discovery? | date | | | | | | |
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| claimsList | What is air? | Barometer_01; Boyles_law_01 | Air contains what life needs and what fire needs to burn. | Oxygen_01; Photosynthesis_01 | | | | |
| | How old is the earth? | Fossils_01; Weathering_erosion_01; Dinosaur_fossils_01 | The earth is only a few thousand years old. | @@Fossils_01; Weathering_erosion_01; Dinosaur_fossils_01 | | | | |
| | How big is the universe? | Distance_from_sun_01; Galaxies_01 | The universe is a set of shells of stars around the earth. | @@Distance_from_sun_01;Galaxies_01 | | | | |
| | Is the number and kind of species of life constant or always changing? | Fossils_01; Dinosaur_fossils_01; Heredity_01 | Life on earth is fixed the way it always was. | @@Fossils_01; Dinosaur_fossils_01; Heredity_01 | | | | |
| | Are there forms of life smaller than insects? | Cells_01; Viruses_01; Bacteria_01 | Living cells contain their own energy factories and divide to make more cells. | Cell_division_01; Mitochondria_01 | | | | |
| | Is there light that we cannot see? | Invisible_radiation_01; Radioactivity_01; X_rays_01 | If you can't see it, it doesn't exist. | @@Invisible_radiation_01; Radioactivity_01; X_rays_01 | | | | |

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| | What causes disease, and how do we fight it? | Viruses_01; Bacteria_01; Germ_theory_01 | Our body fights disease by recognizing foreign organisms. | Vaccination_01; Germ_theory_01 | | | | |
| | How do elements make more complex stuff? | Molecules_01; Electrochemical_bonding_01; Periodic_table_01 | It is still a mystery how elements combine. | @@Molecules_01; Electrochemical_bonding_01; Periodic_table_01 | | | | |