Entries for
SAGE Encyclopaedia on Energy and Environment
&
SAGE Encyclopaedia on Decision Sciences

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January 2015

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Acid Rain

Acid rain has an acidity that is higher than that of normal rainwater. Normal rainwater is not neutral (which would be pH 7) but slightly acidic (it has a pH < 5.5), because some of the carbon dioxide CO_2 dissolved in the water is present as carbonic acid H_2CO_3. In acid rain, chemicals from pollution and natural causes such as volcanic eruptions and emissions from vegetation increase the acidity of the water to as low as pH 4.4 to 4 (as measured in the 1990s in various places). Such acidic rainwater is dangerous for people, vegetation, water bodies including the oceans and its inhabitants, buildings and soil. Since the pH scale is logarithmic, a change from 5.5 to 4.5 means a tenfold increase in acidity. The three main pollutants that cause acid rain are the nitric oxides NO and NO_2 (summarized as NO_x) and sulfur dioxide SO_2. These substances react with water to nitric acid HNO_3 and sulfuric acid H_2SO_4. In the 1980s, in nearly all of Northern Europe and in the Northern United States, suddenly and unexpectedly, whole forests began to die (this effect got to be known as forest dieback). German forests especially experienced severe damage: from 8% in 1982 it increased to 50% in 1984, and stayed as such till 1987. The damage occurred amongst various tree species. Researchers established connections of this damage to acid rain. The mandatory installment of sulfur filters in coal power plants and of catalytic converters in cars in various industrialized countries reduced air pollution with the chemicals related to the formation of acid rain, and, although the forests are still not in perfect shape (about 20% are heavily impaired) a complete death was prevented.

Historically, already the Old Romans realized that trees were dying in areas next to factories that were processing galena (lead sulfide). The relation between air pollution and acid rain was first discovered 1852 in London (which was very polluted that time) by the Scottish chemist Robert Angus Smith (1870-1884). The British government in 1863 passed the Alkali Act to curb acidic emissions, and Smith was installed as the first Chief Inspector of the Alkali Inspectorate.

Forest dieback was first seen in Germany as well as in Middle, Eastern and Northern Europe, in the mid 1970s. Already then various stakeholders demanded cleaner air. At the end of the 1970s, large-scale forest dieback and sharply increased acidification of lakes was correlated with acid rain. Some lakes in Sweden looked crystal clear - they contained no more life anymore; their pH was equivalent to the pH of acetic acid (pH 3).

Various pollutants cause acid rain. Reasons for acid rain are anthropogenic and natural. Anthropogenic causes include volatile organic components (VOC) from industry, households, manufacturing, transport, etc., sulfur dioxide SO_2 (a toxic gas), NO_x and mercury (a potent neurotoxin). Burning coal, gas or oil that has impurities of sulfur results in SO_2 emissions to the atmosphere and subsequent transformation of SO_2 to in sulfuric acid in aqueous environments (such as raindrops, dew, fog, etc.). Another anthropogenic source of SO_2 is from the roasting in the mining industry in the course of the extraction of metals from sulfide ores. In the roasting process, the ore is heated at high temperature in the presence of air, resulting in formation of metal oxides and SO_2 as waste gas. In some cars, especially in industrialized Western countries, flue-gas desulfurization is used to remove the sulfur from the exhaust gases. Natural VOC emissions come from terrestrial plants and marine organisms. Natural sources for SO_2 comprise volcanoes and geothermal hot springs. NO_x are generated whenever high temperature combustion processes take place in the presence of nitrogen. Since nitrogen makes up 78% of our atmosphere, this is always the case when something combusts in air at temperatures above 1800^{o}C. The very high local temperature at lightning is also conducive to NO_x generation, as are geothermal springs and some decomposer bacteria that process organic nitrogenous material in the soil. The pollutants are transported in the air over wide distances and can cause effects in far away places.

Effects of acid rain are damages on the leaves and in the root system (death of fine roots, reduced reproductive capacity and less mycorrhization. Mycorrhiza denotes the symbiotic association of a fungus and the roots of higher plants that is necessary for nutrient uptake and therefore healthy growth. Plants that are already damaged by acid rain are more sensitive for fungal infections, insect attacks and epidemics. Further effects of acid rain are acidification of soil and water bodies (rivers, streams, lakes, oceans), yielding alterations of sensitive ecological balances. Reaction products of neutralization reactions in the soil contain important potassium, magnesium and calcium minerals that can be washed out, decreasing the nutrient content of soil and loosing its important buffer capabilities, resulting in drastically reduced pH. At low pH, certain metals such as aluminum and irons ions are released from the rock part of the soil; this damages soil and plants, destructs roots, harms plant growth and yields higher disease susceptibility.

Acid rain has effects on soil, cultural heritage structures, water bodies, the sea (yielding a potential collapse of the marine ecosystem due to acidification) and plants, especially the leaves and the mycorrhiza of trees. Acid rain does not directly kill the trees, but rather long term leaching of nutrients from the soil causes the death. The restoration of soil nutrients is very slow, since it mainly happens due to rock weathering. Acid rain causes weathering of limestone statues, carvings and facades to gypsum by sulfuric acid, which subsequently crumbles away, causing irreversible damage to cultural heritage; a similar effect takes place in sandstone artifacts.

The related chemical reactions that take place in rainwater are as follows:
Carbon dioxide plus water gives carbonic acid, $CO_2 + H_2O = H_2CO_3$; nitrogen dioxide plus water gives nitrous acid and nitric acid, $2\ NO_2 + H_2O = HNO_2 + HNO_3$; nitrogen oxide plus molecular oxygen plus water gives nitric acid, $4\ NO + 3\ O_2 + 2\ H_2O = 4\ HNO_3$; sulfur dioxide plus water gives sulfurous acid, $SO_2 + H_2O = H_2SO_3$; sulfurous acid plus water gives molecular hydrogen and sulfuric acid, $H_2SO_3 + H_2O = H_2 + H_2SO_4$; and sulfur trioxide plus water gives sulfuric acid, $SO_3 + H_2O = H_2SO_4$. These acids yield increased acidity of the rain, and subsequent damages to ecosystems and cultural heritage.

The US installed the Clean Air Act in 1970, and strengthened it in 1990. The United State's acid rain program resulted in a 33% decrease in sulfur dioxide emissions between 1983 and 2002. In the Northeastern United States, the soil is still too acidic, particularly in New York, Vermont, New Hampshire and Maine, but shows first signs of recovery. Currently, China is the country with the highest SO_2 emissions: since the year 2000 they have increased by 27%.

Major research approaches were undertaken as soon as the severe forest dieback started in Germany and the Northeastern United States. Exhaust gas desulfurization have been installed in German power plants (which were the main emitters of SO_2) from the beginning of the 1980s.

Countermeasures against acid rain comprise liming of soils, desulfurization of exhaust gases, e.g. with filters in industrial facilities and catalytic converters in cars (in some Western industrial nations) and generally, resourceful energy management yielding lower emissions and longer preservation of resources. Desulfurization with filters is only possible in stationary applications. The gypsum that is produced from the desulfurization in industrial plants can be used for walls and construction materials, or be disposed safely. In aircraft, cars and other similar applications, sulfur has to be removed from the fuel before burning. However, mainly industrial countries apply such measures, and impose various thresholds while the developing countries still emit high amounts of chemicals polluting the air, resulting in smog and acid rain, also at places far away from the origin of the pollutant (pollution travels long distances in the atmosphere). Liming fertilizes and increases the pH of soil: helicopters and aircraft are used to release grounded limestone above forests and ground. Soil liming is expensive, and large amounts of limestone are needed. Furthermore, it only fights the effects and not the underlying causes; law in Switzerland prohibits calcification, because of potential adverse effects to the environment.

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See also: Biogeochemical Cycles; Green Coal Technology; Coal.

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Air Travel

The first aircraft at the beginning of the 20th century had too weak engines to carry passengers. Air travel that time mainly took place in large airships. The first commercial flight took place on January 1st, 1914, across Tampa Bay, Florida, with one paying passenger. The first regular passenger air transport took place in Germany, between Berlin and Weimar, from 1919. The 1920s brought fast growth of passenger aviation. In 1932, the first serial production of aircraft for passenger air travel started. However, at that time, transatlantic passenger flights were still only performed by airships. Jet aircraft replaced propeller aircraft in the 1950s. Now there are eight million commercial flights every year (status: June 2011). The crew of an airplane consists of the captain, the first, second and third officer, the flight attendants, the flight engineer, the loadmaster, the pilot and the purser. About eight million people fly every day, yielding 3.1 billion passengers in air travel in 2013. Besides people and their luggage, cargo is transported, about 140,000 tons every day, which is equivalent to 50 million tons per year. There are nearly 60 million jobs in air travel; the global turnover of the airline industry is more than 700 billion USD, with about 2.6% net profit. International aviation reached a new record in 2010 with more than 30.5 million commercial flights. 35% of the total departures in 2010 took place in North America, 25% in Asia, 24% in Europe, 10% in Latin America and the Caribbean, 3% in Oceania and 3% in Africa. Fastest growth is in Asia Pacific, Latin America, the Caribbean, Africa and the Middle East. Until 2030, an increase of the number of commercial flights to 52 million is estimated.

History of Aviation

The history of aviation starts with observation of flyers and gliders in living nature. Birds and insects are still unequaled when it comes to the way of flying and its efficiency. The first reported man-made flying devices are hang gliders in ancient China (five centuries B.C.). In the 9th century, the Spanish Muslim scientist Abbas ibn Firnas is said to have built a gliding device that enabled him to fly. In the 15th century, Leonardo da Vinci drafted various flying devices, such as parachutes, helicopters and performed flow studies on aircraft wings and streamlined bodies. None of his constructions was able to fly, but Leonardo's drafts, which were rediscovered at the end of the 19th century, gave valuable inspiration to engineers. First air balloon experiences are reported in the 18th century, for example a 25 minutes long flight by the Montgolfier brothers in France; the first crossing of the English Channel in a balloon was in 1785 (the first crossing with a motorized airplane was years later, in 1909). Also in the 18th century, first construction drawings of aircraft heavier than air with rigid v-shaped wings are reported in Germany and the United Kingdom. Sir George Cayley (1773-1857) is known as the father of aeronautics; he was the one who disposed of the idea of flight based on moving wings, and promoted rigid wing structures and an engine instead. The first systematic flight experiments were performed at the end of the 19th century by the German Otto Lilienthal. He was fascinated by birds, and saw them as basis for aviation. Lilienthal is the father of controlled flight. The development of small, mobile combustion engines by Daimler and Benz provided the basis for a breakthrough of aviation from the very early 20th century. The first passenger on a flight was Frank P. Lahm, who joined the Wright brothers on a one hour-long flight. The Wright brothers were the first to build an aircraft that allowed for a successful, lasting, controlled motorized flight. The first casualty on the passenger side in manned aviation happened in 1908. The most built airplane before WWI was the Etrich Taube, a glider inspired by the tropical Zanonia seed that can glide for 20 kilometers. William Boeing started to build airplanes in 1916; the oldest still operating aviation company, the Dutch company KLM, was founded in 1919. The first manned Atlantic crossing took place in a double decker, in 1919.

The first airport for commercial civil aviation was in Kaliningrad, the then Königsberg. The first movies were shown in a commercial flight in 1925 in Germany. Various airships were in use, however, the tragic Hindenburg disaster, in which 35 people lost their lives in New York in 1937, put an end to the era of airships, and paved the way for motorized airplanes. 1947 marks the beginning of ultrasound aviation, with famous proponents such as the Tupolew Tu-144 and the Concorde. Ultrasound aviation was not commercially pursued further, because of various reasons, including dramatically increasing fuel consumption with speed, and increased environmental consciousness. The last flight of the Concorde took place in 2003.

From the 1970 onwards, with the development of wide body aircraft which can transport hundreds of passengers, flying became cheaper and enabled the general public to use air travel, for example for holiday flights. The increase in the possible passenger number per aircraft led to the introduction of budget airlines, in the United States from the 1980s, and in Europe from the 1990s. Thereby, air travel became a commodity for the masses. The first flight alliance, SkyTeam, was founded in the year 2000. The incident of September 11, 2001, started a major aviation crisis. In 2005, the first Airbus A380 flight took place.

Organizations and Conventions

Since 1944 international civil aviation of most countries worldwide has been organized in the UN specialized agency ICAO, the International Civil Aviation Organization. Under the auspices of ICAO, the related civil aviation authorities of the 191 member countries establish international standards and recommended practices (SARPs) related to civil aviation, managing the close to 100 000 daily flights in a safe, efficient and secure manner. They are active in training and the issuing of licenses to personnel and aircraft, oversee safety of commercial operators, design and construct aerodromes from where aircraft flight operations take place, and manage air traffic in the country.

The Warsaw Convention is a convention that unifies rules and regulations regarding international transport of people, luggage and freight in international commercial aviation. It originates in 1929. Meanwhile, many countries switched to the Montreal Convention from 1999.

Environmental Factors

Reduction of the emission of greenhouse gases (GHG) is vital in successfully addressing global warming. In the US, from 1990 to 2011, the transport sector contributed 27% of the total GHG emissions. Currently, aviation accounts for 8% of the global fossil fuel consumption; however, further increase in the number of flights might yield an increase of 60% in the worldwide fuel consumption for aviation. Alternative fuels for aviation are still in an experimental stage; promising sources might be biofuels, electricity, natural gas and hydrogen. However, the corrosion resistance of engine parts to biofuels is not as good as to conventional fuels (this mainly comes from the hydrophilicity of many biofuels – they attract water, and subsequently microorganisms), and in many cases the acreage for biomass yielding biofuels competes with cultivable land for food or ancient tropical rainforests. Current batteries for energy storage are not yet powerful and light enough to provide purely electric aircraft. Further sources for the electricity in electric aircraft might be fuel cells, solar cells or ultracapacitors; however, most of these options are still at research or prototype stage. There are currently two aircraft that fly on natural gas; they are from the Russian company Tupolev. Hydrogen powered airplanes either directly burn the hydrogen, or power fuel cells with it. The Tupolev company also developed the first aircraft that uses liquid hydrogen as fuel, in 1989.

About 10% of the total emissions of an aircraft are water vapor and CO_2; the remainder is mainly heated air. From the combustion of the jet fuel, toxic substances are emitted, mainly carbon monoxide, nitrogen oxides, sulfur oxides and carbon in form of soot. These combustion products negatively influence the protective ozone layer. The sulfur oxides can cause acid rain. Because airplanes fly in such high altitudes, their emissions are not washed out by rain, and cannot be taken up by plants – on average they stay for one year in the atmosphere until they start to sink.

Often when airports are built a lowering of the groundwater level is performed. This influences local ecologies. In undeveloped areas of airports, which are sometimes vast areas, fauna and flora can develop in relatively undisturbed ways; on many airports, protected biotopes are established.

In the course of increasingly cheaper flights, the phenomenon of hypermobility can be seen. People fly thousands of miles just for a weekend getaway, or plan short trips that include various flights. This severely impacts the environment, and might have physiologically compromising effects, too. Besides the CO_2 pollution, flights add soot and combustion remains to the atmosphere, cause noise pollution and need extensive surface sealing, for airports, runways, parking areas and aviation related buildings such as hangars. In areas with many flights, the vapor trails of the aircrafts may merge, resulting in a cirrostratus that yields measurably reduced solar irradiation in the areas underneath.

Disasters and Health Aspects of Flying

Between 2003 and 2012, approximately 703 people died each year in aviation disasters. The years 2013 and 2014 were extremes: in 2013, 224 people died, in 2014, 862 people died in airplane accidents. Causes of the accidents were in 56% the flight crew, in 17% the airplane, in 13% the weather, in 4% maintenance issues, in 4% airport or the air traffic control and 6% were miscellaneous (2010 data).

The increased cosmic radiation exposure due to flights at high altitude or across the polar caps is generally seen as low. Nevertheless, pregnant women should consider the increased radiation exposure during flights especially in the time of brain development of the child, from the 8th until the 16th week of pregnancy. The threshold of what is seen as harmless is at 0.5 millisievert. On a flight from Tokyo to New York, the radiation exposure is 0.2 millisievert.

The pressurized cabin technology of modern aircraft adjusts the environment of the passengers to dry, low-pressure conditions equivalent to the pressure in an altitude of about 2400 meters. This can yield health problems such as drying of mucous membranes yielding pain and nose bleeding. In susceptible passengers, the pressure changes can lead to acute cardiovascular failure, for example heart attacks.

The following risk groups should have their flight suitability confirmed before flying: pregnant women from the 7th month, mothers up to seven days after birth (they are generally not transported by airlines), people with high blood pressure, people at risk of thrombosis, people who recently had a heart attack or a stroke, people with acute or chronic cardio vascular or lung diseases, people with severe cases of arteriosclerosis, epileptic seizures or acute psychotic conditions, people after surgery and divers who were diving in the last 24 hours or who had a dive accident.

The increased risk of thrombosis (blood clots) on long distance flights can be lowered by wearing compression stockings, drinking non-alcoholic fluids and by exercising during the flight. Thrombosis affects about 2-5 out of 10 000 passengers in flights that are longer than six to eight hours (the longer the flight, the higher the possibility) and risk can stay increased up to eight weeks after the flight; this is a two- to fourfold increase when compared to the non flying general public. The major reasons for unplanned stopovers due to inflight medical emergencies are in 28% of the cases heart problems, in 20% neurological disorders and in 20% food poisoning.

Aircraft Fuel

The specific energy of jet fuel is about 46 MJ/kg. For comparison, wood has a specific energy that is only about 1/3 of this number, 16.2 MJ/kg. Due to the low specific energy of jet fuel, currently over 80% of the fully laden takeoff weight of a modern aircraft is craft and fuel. Current batteries, e.g. lithium ion batteries, lag far behind such numbers: the best lithium ion batteries on the market only have a specific energy of 0.875 MJ/kg – this is why no battery-powered airplanes are envisaged at the moment.

An airbus A380 uses 2.9 liters of fuel per passenger and 100 kilometers; a Boeing 474-400 uses 3.26 liters of fuel per passenger and 100 kilometers. This is still a lot, even when compared to a 5-seat 2014 Toyota Prius car that consumes 0.98 liters per 100 kilometers. Fuel consumption varies greatly depending on the mode of transport. Modern trains, cars and aircraft consume about 2 liters, 3-5 liters and 3-8 liters of fuel per passenger and 100 kilometers, respectively. Long distance air travel is more fuel-efficient.

In 1990 and 2010, aircraft worldwide were consuming 600 and 1000 million liters of fuel per day, respectively. Annually, 650 million tons of the greenhouse gas CO_2 are emitted by aviation; this is equivalent to 2% of the global CO_2 emissions. There is commitment from the side of aviation companies to increase energy efficiency by 1.5% until 2020, to reduce the net CO_2 emissions from 2020 and to reduce them until 2050 by 50% compared to 2005. Currently, CO_2 emissions of a modern aircraft per passenger and a certain distance are equivalent to CO_2 emissions of a car traveling the same distance.

"Unruly Passengers"

Aircraft crew in the air have no direct access to law enforcement agents. Therefore, various "unruly aircraft passenger" policies are executed by the airlines. In some countries, it is allowed to tie "unruly passengers" to the seat, in some countries, such as in Australia, it is even allowed to stun them with a stun gun. In the US, it is permitted to fix body parts to their body, but not to tie unruly passengers to their seat. Fines for "unruly passengers" can be very high, and include monetary penalty as well as prison sentences. Hundreds to thousands of "unruly passenger" incidents per year are reported on commercial airlines in the United States alone.

Lost Luggage

25 million people do not receive their luggage after their flights, but it is lost or delayed; about half in transport, and about 16% are forgotten at the place of departure, due to wrong handling or labeling. Most luggage reappears within two days, but about 850 000 pieces are never picked up or are reported as stolen.

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See also: Acid Rain; Air Cargo; Batteries; Biogeochemical Cycles (water cycle, carbon cycle, nitrogen cycle, etc.); Fuel Economy; Mass Transportation; Transportation Networks; Transportation Sector.

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Atomic Mass Unit

The unified atomic mass unit (or Dalton, after the scientist John Dalton) is the standard unit for mass on an atomic or molecular scale. One unified atomic mass unit, 1 *u*, is equivalent to 1 dalton (*Da*). $1\ u = 1\ Da = 1.660\ 538\ 86(28) \times 10^{-27}\ kg$. This mass is equivalent to one twelfth of the mass of a free Carbon-12 atom at rest and in its ground state. A Carbon-12 atom has six protons, 6 neutrons and six electrons. The atomic mass unit is a non-SI unit whose value in SI units must be obtained experimentally. SI denotes the International System of Units. The unit dalton can be combined with SI prefixes, for example to express the mass of a large molecule in kilodaltons (1 *kDa* = 1000 *Da*) or Megadaltons (1 *MDa* = 1 000 000 *Da*), or of small mass differences in molecules or atoms, in nanodaltons (1 *nDa* = 10^{-9} *Da* = 0.000 000 001 *Da*) or picodaltons (1 *pDa* = 10^{-12} *Da*).

Mass is a fundamental concept of physics. Its SI unit is kilogram (kg); it is set by the international prototype kilogram, a chunky cylinder made of a Platinum-Iridium alloy (90% Pt, 10% Ir) whose edges have a four angle chamfer. Since the kilogram is an inconvenient measure on the atomic scale, the concept of unified atomic mass unit *u* has been developed. One *u* is exactly one twelfth of the mass of a Carbon-12 atom at rest, in its ground state. The mass of a Carbon-12 atom is not the sum of the masses of 6 protons, 6 neutrons and 6 electrons, because of the mass defect. The mass defect originates in the equivalence of energy and mass: Part of the mass that results from summing up the electrons, neutrons and protons that make up a Carbon-12 atom (and any atom) is stored as potential energy. If one is to separate an atom into its constituents, this energy has to be injected to the system. This energy can be computed by using Einstein's equation $\Delta E = \Delta m\ c^2$. Δm denotes the difference of the mass of the atom and its constituents. The mass of a proton at rest is 1.007276466812(90) *u*, the mass of a neutron is 1.00866491600(43) *u* and the mass of an electron is $[1822.8884845(14)]^{-1}$ *u*. Therefore, more conveniently than basing the definition of mass on the atomic scale on free nucleons (protons and neutrons), when defining the unified atomic mass unit, the Carbon-12 atom is used:

$$1u = m_u = \frac{1}{12} m(^{12}C)\ .$$

Water has 18 *u*, ribonuclease (a small protein) has 12,600 *u*, and the Tobacco mosaic virus (a plant virus) has 40,000,000 *u*.

In chemistry the SI unit mole (symbol *mol*) is used for the amount of substance, rather than mass. Reason for this is that it provides a convenient way to express the amount of reactants and products in chemical reactions. One mole is defined as the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kilogram of Carbon-12. When mole is used, the elementary entities must be specified. Such entitites may be atoms, molecules, ions, electrons, other particles, or defined groups of such particles. The unified atomic mass unit is related to the SI unit for the amount of substance, mole, via $N_A u = 0.001 kg/mol$.

In a balanced chemical equation, the mole ratio gives the stoichiometric ratio of the substances that perform the reaction and the reaction products. For example, in the balanced equation $2Al(OH)_3 + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O$, twice as many moles of $Al(OH)_3$ and three times as many moles of H_2SO_4 form each mole of $Al_2(SO_4)_3$ and six times as many moles of water. The mole ratio of $Al(OH)_3$: H_2SO_4 : $Al_2(SO_4)_3$: H_2O in this equation is 2:3:1:6, which is equivalent to two molecules of $Al(OH)_3$ reacting with 3 molecules of H_2SO_4, resulting in one molecule of $Al_2(SO_4)_3$ and six molecules of H_2O. The number of chemical atoms on both sides of the equation is the same: 2 Al, 18 O, 12 H and 3 S.

The Avogadro constant (L, N_A) is defined as the number of entities per mole of a given substance. N_A=6.02214129(27)×10^{23} mol^{-1}. N_A relates molar mass on an atomic scale to physical mass on a human scale. Amedeo Avogadro (1776-1856) was an Italian scientist who in 1811 first proposed that at given pressure and temperature, the volume of a gas is proportional to the number of atoms or molecules regardless of the nature of the gas. Johann Josef Lohschmidt was scientist from the Austrian empire who developed a method to determine how many molecules are present in a given volume of gas. He was first to determine the physical size of molecules, in 1865. The Loschmidt constant n_0 denotes the number density, which is the number of particles of an ideal gas in a given volume. Its value is n_0 = 2.686 7774(47)×10^{25} per cubic meter at standard temperature and pressure (0 °C and 1 atm).

Butane (C_4H_{10}) for example has a molar mass of 58.12 g. Four moles of Carbon (molar mass 12.01 g, subtotal mass 48.04 g) react with 10 moles of Hydrogen (molar mass 1.01 g, subtotal mass 10.08 g) to one mole (58.12 g) of Butane. The molar mass of Uranium is 238.03 g. This means that 238.03 g of Uranium comprise 6.02214129(27)×10^{23} atoms. An example to illustrate the size of this number: 1 milligram of Uranium polluting some environment amounts to 2 500 000 000 000 000 000 polluting Uranium atoms.

The Loschmidt constant n_0 is related to the Avogadro constant N_A : $n_0 = \frac{p_0 N_A}{k_B T_0}$, where p_0 is the pressure, k_B is the Boltzmann constant and T_0 is the thermodynamic temperature. Especially in the German literature the term Loschmidt constant is often incorrectly used when referring to the Avogadro constant.

The previously used abbreviation *amu* is not an acceptable unit symbol for the unified atomic mass unit. The atomic mass unit *amu* (without the prefix unified) was a unit initially based on naturally occurring Oxygen (comprising the isotopes ^{16}O, ^{17}O and ^{18}O). With the discovery of Oxygen isotopes in 1929, the definition of the *amu* was based on Oxygen-16. The *amu* became obsolete in 1961. However, many modern sources still use the abbreviation *amu*, but refer to 1/12th of the mass of Carbon-12.

The English scientist John Dalton, teacher of James Prescott Joule, developed an atomic theory in the first years of the 19th century. The main points in his atomic theory were that elements are made up of atoms, that atoms of one element are similar in size, mass and other properties and differ from atoms of other elements, that atoms cannot be divided, created or destroyed, that atoms combine in simple, whole number ratios when they form chemical elements (e.g., two parts of Hydrogen with one part of Oxygen, forming H_2O) and that atoms in chemical reactions are combined, separated or rearranged. With this theory, Dalton set important basics for modern chemistry. In honor of his work, the unit dalton is used equivalently to unified atomic mass unit.

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See also: Watts; Joule.

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Austria

The Republic of Austria is a landlocked country in the center of Europe, with 8.5 million people and alpine climate. It has been member of the European Union since 1995. Austria has an area of 83,860 square kilometers; its capital and largest city is Vienna, with 1.6 million inhabitants. Austria's GDP (2013) is 416 billion USD, with a growth rate of 0.3%. The inflation rate is 2.1%; unemployment rate is 4.9%. Its exports in the year 2013 were 125.8 billion EUR, its imports 130.7 billion EUR. Austria is one of the richest countries in the European Union. Its GDP (PPP) per capita is 43,796 USD; its human development index is with 0.881 very high. Austria is a highly developed industrial country, with a fast growing service sector and important agriculture and forestry. Major export goods are chemical products, machines, non-precious metals and their products; gemstones, precious metals and bijouterie as well as pharmaceutical products. Major import goods are pharmaceutical products, machines, non-precious metals and their products, chemical products, and vehicles as well as aircraft. The major portion of energy for its electricity supply comes from renewable resources, mainly hydropower. Its inhabitants are nature conscious, and nearly 20,000 square kilometers of the country (more than 20%) are protected areas, nature parks and national parks.

In the year 2013 the Austrian domestic primary energy production was 513.29 petajoule (PJ). 1 PJ = 10^{15} J = 277.78 million kWh. The outputs/shares per energy carrier were: biomass (222.81 PJ/43.41%), hydropower (151.12 PJ/29.44%), natural gas (47.06 PJ/9.17%), crude oil

(37.08 PJ/7.22%), combustible waste (26.69 PJ/5.20%), wind (11.34 PJ/2.21%), geothermal and pumped heat from environment (7.55 PJ/1.47%), solar thermal energy (7.44 PJ/1.45%), photovoltaics (2.10 PJ/0.41%) and others (0.10/0.02%).

Renewable energy in the electricity supply in Austria is larger than 60%, mainly coming from hydropower (more than 50%), wind, solar and biomass power plants. The remainder is provided by oil and gas power plants. 20% of the gas comes from own resources, 70% are imported from Russia. Oil is mainly imported from Kazakhstan, Nigeria and Russia. Nuclear power for the generation of electricity is banned in Austria. Austria is the 17th largest producer of wind power in the world, with a nominal capacity of 995 Megawatts.

Austria has diverse topography and a large number of species of fauna and flora. The central European country has six UNESCO biosphere reserves (Wienerwald, Lobau, Neusiedler See, Gurgler Klamm, Grosses Walsertal, Grossenköllsee), six national parks (Thayatal, Donau Auen, Neusiedler See – Seewinkel, Gesäuse, Kalkalpen, Hohe Tauern), forty-six nature parks, and four hundred and forty protected areas. Austria has more plant species than neighboring Germany, the size of which is four and a half times as large. More than one thousand plant species in Austria are on the IUCN (International Unit for Conservation of Nature and Natural Resources) Red List. The IUCN list of threatened species has been published since 1966. National plants of Austria are the Edelweiss, Clusius' gentian and the mountain cowslip. More than 45,000 animal species live in Austria, 2800 of which are on the IUCN Red List. Austria lies in a geologically active area, with hot springs and more than 600 earthquakes per year, half of which are caused by blasting due to mining. However, major earthquakes are rare: only about every 100 years an earthquake causes major destructions in buildings.

Austria is a small, narrow country, and therefore a typical transit country, mainly in North-South direction. Many streets are dimensioned larger than the countries population itself would need. These streets sometimes pass through ecologically sensitive areas - a fact that often raises resistance in the population. The balance between ecology and economy is often reached via policies regarding vehicles, for example early (since the end of the 1980s) mandatory use of catalytic converters in cars that reduce the amount of dangerous emissions such as carbon monoxide and nitrogen oxides, NO_x, by nearly 90%. Carbon monoxide is a major polluter in urban areas that binds to red blood cells and prevents them from binding oxygen. NO_x contribute to smog, and lead to respiratory diseases.

Austria signed the Kyoto protocol. The Kyoto protocol is an international treaty of the United Nations regarding climate change that started to be effective in 2005. It is the first international law that gives compulsory limits for the emission of greenhouse gases in industrial countries. The pillar of its climate strategy is environmental protection. Until 2011, 191 countries and the European Union have ratified the Kyoto protocol. The US never joined, and Canada left in 2011.

The three pillars of Austria's energy policy are security of supply, energy efficiency and renewable energy sources. The use of renewable energy has continued to grow, while fossil fuel use has decreased. Austria invests major funds in energy research, development and demonstration. One example is the installment of the MSc course “Biomimetics in Energy Systems” at the Carinthia University of Applied Sciences. In this unique international program, students from all over the world are trained in learning from living nature for better, more sustainable energy conversion.

After having reached a peak in 2005, Austria’s greenhouse gas emissions from energy use are steadily decreasing. Austria has adopted an economic style of careful resource management that is sustainable and internationally competitive. It has bridged traditional economic goals with the recommendations of a climate-oriented approach. The Austrian Council on Climate Change (ACCC) was established in 1996. The ACCC recommends in its 2014 report various measures to help guide the country towards a more secure and sustainable energy future. These include

Major anthropogenic influences on biogeochemical cycles have begun with the industrial revolution at the end of the 19th century. Since then, emissions of greenhouse gasses from industry (the major emitter), the transport sector and the burning of fossil fuels and other human activities that influence our global radiation balance affected the average global temperature. It has increased by almost one degree centigrade; in Austria, due to local effects, the mean warming since 1880 was two degrees centigrade and is expected to increase further. Half of this temperature rise occurred since 1980! About half of this temperature increase stems from human activities, the other half from natural climate variability. Seasonal changes regarding rain and snow show an increase in the winter, and decrease in the summer, with a rise of annual sunshine duration of more than 300 hours per year in the last 130 years. Glaciers are shrinking, and the duration of the snow cover has decreased. The temperature increase in Austria shows significant regional differences and a distinct increase of temperature extremes, with major economic impact. The ACCC recommends as countermeasure a rapid transformation into a low carbon society, with fundamental changes the interaction of economy, society and environment.

The current spectrum of Austrian environmental organizations reflects their different genesis. Traditionally environmentalism started with nature conservation activities. The “Naturschutzbund” (Nature Protection Association) has its origin in 1913, and is the oldest such organization. In the year 1961 “WWF Austria” was founded, with focus on nature conservation and wildlife (expanding its activities later). Modern environmentalism started in the 1970s, focusing on topics such as pollution by unfiltered emissions of power plants and industrial sites, chemical releases into water bodies, illegal dumping and projects affecting nature sites. Energy policy conflicts (frequently reduced to electricity policy and technology choice) became a major issue culminating in the Zwentendorf (1978 – nuclear power plant never put into operation) and Hainburg (1984 project for a Danube run-of-river plant conflicting with riparian forests now forming a National Park) events. Both turned out to be successful for the environmental movement and found their place in contemporary history. The Zwentendorf initiatives disappeared; organizations having their origin in the Hainburg movement still exist (“Forum Wissenschaft und Umwelt-FWU”, “ÖGUT” and “VIRUS”). In 1982 “Global 2000” and “Greenpeace Austria” were founded, as a grass root initiative and as part of an international organization with top-down structure, respectively. Global 2000 later became part of “Friends of the Earth International”. Together with the

WWF, these are forming the three largest environmental NGOs (budget wise). From the 1980s, additional topics including transport policy, genetic engineering and global aspects such as climate policy and rainforest protection have emerged, anti-nuclear movement still remaining present in the portfolio.

"Umweltdachverband" and "Ökobüro" are the two rooftop-organizations in this field; the first being more active on its own with a special focus on water-related activities, the second providing coordination and "law and environment" services. "VIRUS" decided to remain independent on a third path. Following a system-oriented approach when covering the fields of activity ranging from energy, transport climate policies to rivers and wetlands and public participation. The activity spectrum ranges from scientific in-depth analyses to performance and direct action.

Since 2005 environmental NGOs can get legal standing in environmental impact assessment procedures. The respective list of the ministry of environment currently contains 46 organizations fulfilling the criteria specified by law with a share of 20 covering whole Austria.

Environmental issues in Austria are forest degradation caused by air and soil pollution, soil pollution from intensive agriculture, air pollution from coal and oil power stations, industrial plants and transit traffic, and endangered species. Nearly 50% of the country is covered with forests. In the year 2011, Austria spent 11.2 billion Euros on environmental protection measures. More than 50% of these funds went into waste and water body management; the remainder was spent on protection of clean air, climate, biodiversity, landscapes, protection and remediation of soil, groundwater and surface water and noise as well as vibration protection. More than 15% went into research and development, radiation protection and other environmental protection activities.

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See also: Electricity; Energy; European Commission; European Association of Environmental and Resource Economists; European Atomic Forum; European Biomass Association; European Energy Programme for Recovery; European Energy Research Alliance; European Environment Agency; European Nuclear Disarmament; European Recycling Platform; European Renewable Energy Council; European Union Emission Trading Scheme; European Wind Energy Association; Joule; Trans-European Transport Networks; United Nations Development Group; United Nations Environment Programme; Water Consumption and Withdrawal; Water Quality Impacts; Watts.

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Batteries

Batteries and accumulators (rechargeable batteries) are galvanic cells that provide chemical energy storage and conversion to electrical energy. About 15 billion batteries are sold every year, most of them lithium ion batteries, lead acidic batteries and manganese alkaline batteries. Major applications for batteries are in mobile applications (such as handheld electronic devices, starter batteries for conventional cars and fuel for electric cars), to provide uninterrupted power supply (in case of electric grid failures) and for the storage of energy from power plants that do not continuously provide power (such as solar and wind power plants). Electrochemical energy storage is still the most commonly used type of energy storage, however, it requires high amounts of material and batteries may have large weight. Electrochemical storage systems comprise batteries and rechargeable batteries (accumulators), flow batteries such as the redox flow battery, and supercapacitors. Alternative systems to electrochemical energy storage are storage of thermal energy, mechanical energy, electrical energy and energy storage in chemical fuels such as hydrogen or methane. For a more complete shift towards renewable energy power plants, which in many cases do not continuously supply energy, and for envisaged future applications such as electric ships, aircraft and spacecraft, the energy density in batteries needs to be improved, the leakage needs to be minimized and dangerous substances in batteries such as mercury and further toxic metals need to be replaced by more benign ones.

Electrical energy is one of the most versatile forms of energy in modern technological societies. It can easily be transported. However, it is still demanding to store it directly, therefore it is often converted from other forms of energy when needed. In batteries and accumulators, energy is stored electrochemically. Energy conversion is not lossless, and can render some interesting types of storage methods uneconomical.

Below, to give an overview of the wide possibilities, various ways of energy storage are introduced (incl. practical examples), starting with chemical energy storage, with a special focus on electrochemical energy storage in batteries and accumulators, and then introducing various further forms of energy storage systems.

Chemical energy can be stored organically or inorganically. Organic chemical energy storage systems comprise biomolecules such as adenosine di-, tri- and monophosphate (ADP, ATP and AMP; provide energy needed to do work in biological systems), glycogen (provides short- and midterm storage and provision of energy in animals and humans), carbohydrates (products of photosynthesis; the largest part of biomass), fats (the most important energy storage for humans, animals and some plants, very high energy density of 37 kJ/g = 10.28 kWh/kg). Inorganic chemical energy storage devices comprise galvanic cells (batteries, accumulators), redox-flow batteries (rechargeable), hydrogen and battery storage power plants.

A galvanic cell is an electrochemical energy storage and conversion system. It consists of a cathode, an anode and an electrolyte. The materials of the electrodes (the cathode and the anode) determine the nominal voltage. The mass of active material determines the maximum possible stored energy (the capacity of the battery). The capacity of a battery is the charge of a battery, it is generally given in Ampere-hours A·h, only rarely in the SI units A·s = C (Coulomb, SI unit of electrical charge). Note that battery capacitance is different from the capacity of a capacitor, which is given in F (Farad) = C/V (Coulomb per Volt). The capacitance A·h can be converted to energy, W·h and thereby to W·s = J, by multiplying the value in A·h with the voltage of the power source, a value that is approximate since the voltage is not constant during discharge of a battery. The equation for determining battery energy is $E = P \cdot t = V \cdot I \cdot t$, with I being the current (in amperes), V being the electromotive force expressed in volts, P the power expressed in watts, t the time expressed in seconds and E the energy expressed in joules. Energy equals voltage times charge, which is the same as voltage times current times time (since current is charge per time). 1 J = 1 W·s = 1 C·V = 1 A·s·V, with C = A·s, charge C (in Coulomb) equals current (in Ampere) times time (in seconds). 1 Ampere = 1 Watt per Volt.

The word battery originally denoted the combination of several galvanic cells into one unit. Nowadays, also single cells are called battery. Rechargeable cells are called accumulators. Non-rechargeable cells are called batteries; when they are discharged, their contents, which are valuable and in many cases environmentally toxic substances such as metals, need to recycled. Mercury is used to seal batteries against leakage. Since mercury is highly toxic, its maximum content in batteries is strictly limited (in Germany for example to $0.5*10^{-3}$ weight-% in conventional batteries and – until fall 2015 - 2 weight-% in button cells. After fall 2015, mercury is not allowed anymore in button cells). Button cells are for example used in wristwatches, hearing aids and further small portable electronic devices. Galvanic cells self-discharge when stored. Self-discharge is dependent on the battery type and the temperature, at higher temperature, discharge happens faster.

Non-rechargeable batteries (also known as primary batteries) have a market share of nearly 24%; the remainder is rechargeable batteries (also known as secondary batteries). Regarding revenue, lithium ion batteries have with 37% the largest share on the world market. Second are lead-based starter batteries (such as the starter battery in a car) with 20%. Alkaline batteries have 15% market share. Stationary lead acid batteries (8%), primary carbon zinc batteries (6%), deep cycle lead acid (5%), nickel metal hydride (3%), primary lithium (3%), nickel cadmium (2%) and other batteries (1%) share the remainder (2009 numbers).

Lead-acid batteries are still amongst the most common electrochemical energy storage devices. They are rechargeable, and mainly used as car batteries, as well as for battery storage in power plants. Their energy density is quite low (35 Wh/kg), and they are heavy. Further lead based batteries are the lead gel battery, the lead cobalt battery and the lead fleece battery. Increasingly, lead free car batteries are used, and the trend generally goes towards batteries that use less toxic materials.

One of the most widely used forms of electrochemical energy storage in galvanic cells is the non-rechargeable alkaline manganese battery, with zinc and manganese electrodes and acidic electrolyte. The electrode materials in this type of batteries are zinc as anode material and manganese dioxide as cathode material. The materials of the electrodes determine the nominal voltage in electrical cells; the amount of material determines the capacitance. A wide spectrum of electrolytes is used. For the alkaline manganese battery, the nominal voltage is 1.5 V. The electrical energy is delivered via the chemical oxidation of the zinc and the chemical reduction of the manganese dioxide. The electrons (negatively charged particles) that are released in the oxidation process at the cathode travel via the external electrical circuit (which is the consumer, for example a torch, a watch, a bell) to the anode, performing work on the consumer. Negatively charged OH^- ions travel through the electrolyte from the cathode to the anode, thereby maintaining the balance of charge. Larger voltages can be achieved by using several alkaline manganese batteries connected in series (for example, a 9 V block battery made up of six internal single cells). Alkaline manganese button cells (nominal voltage 1.5 V) are cheap, and mainly used in calculators and LED torches. Since they leak easily, they should not be used in wristwatches. Very common alkaline manganese batteries are the AA and AAA cylindrical batteries. One AA battery has a nominal voltage of 1.5 V and a capacity of 2850 A·h; one AAA battery has a nominal voltage of 1.5 V and a capacity of 1150 A·h. Therefore, a AA battery can supply 4275 W·h = 4.275 kWh, since 1.5 V * 2850 A·h = 4275 W·h = 15.39 MJ; and a AAA battery can supply 6.21 MJ.

Lithium ion accumulators utilize ions (electrically charged particles) of the alkali metal lithium in chemical compounds in both electrodes as well as in the electrolyte. They have high specific energy (95-190 Wh/kg) and are used in mobile devices with high energy consumption such as laptop computers, mobile phones, digital cameras, torches, electric cars and wheelchairs and in some aircraft. Large lithium ion battery systems are used in battery storage power plants, for example a system that can store an energy of 36 MWh in China or a 32 MWh system that stores energy converted by a wind power pant in California. Lithium button cells are used in devices that need long-term voltage supply, such as car keys and buffer batteries for the clock in computers. Types of lithium ion accumulators are lithium polymer, lithium titanate, lithium manganese, lithium iron phosphor and lithium air accumulators. Thin-film batteries are rechargeable solid state lithium batteries, that are used in microelectronic systems.

Most wristwatch batteries are silver oxide button cells (nominal voltage 1.55 V), most hearing aid batteries are zinc air button cells (nominal voltage 1.4 V). Recently, rechargeable button cells have reached the market.

Redox flow batteries are similar to conventional electrical cells, as electrolytes they use ionic liquids or other ionic solutions (that are normally stored outside the cell, and only fed into the cell when energy is needed) as electrolyte. Ionic liquids are salts that are fluid at room temperature. They are applied as buffer batteries in wind power plants.

Examples for iron-based batteries are the iron air and the iron silver battery. The first one uses the chemical energy that is released from the oxidation of iron in air. There are interesting new developments on the research front regarding this environmentally friendly, low cost battery. Iron silver batteries are high energy density alkali batteries with KOH as electrolyte. They have the highest capacity of all commercially available batteries, but are expensive.

Recent developments on the research front comprise paper, cellulose and Chlorophyll batteries. Paper batteries have their name from the similarity with paper. They are ultra flat, elastic, bendable, and in some cases lithium free. A paper battery developed by the Rensselaer Polytechnic Institute (RPI) in Troy, New York contains carbon nanotubes, ionic fluids (molten salts that are fluid at room temperature) and 90% plant cellulose. It is biocompatible, and can therefore be used for medical implants: it recharges with blood, sweat or urine.

A battery developed at the Swedish Uppsala University contains naturally nanostructured cellulose from algae, with high surface area, coated with a 50 nm thin layer of electrically conductive polymer, saltwater as electrolyte. This battery is still at the research stage; its energy density is 25 Wh/kg; it can be recycled without major harm to the environment.

Various biobatteries are available for lab-on-chip applications, analyzing urine and blood and using the same substances for generation of the power needed for the analysis. Japanese NoPoPo (Non-Pollution Power) batteries are rechargeable AA and AAA batteries are made from manganese and carbon and can be activated with urine, water or other fluids. They are offered with a mini lantern that can reversibly be converted from torch to desk light. Chlorophyll batteries are based on the biomolecule known from photosynthesis. They can be activated with any fluid, including urine, have very low production costs (3-6 US Cents) and are completely free of toxic substances.

This concludes the section on batteries and accumulators. In the following, electrical, thermal and mechanical energy storage as well as fuel production is treated, to give an overview of alternative, non-chemical ways of energy storage.

Electrical energy can directly be stored in the electrostatic field of capacitors. The energy E of a capacitor is $E = ½ C·U^2$, with C being the capacitance and U the electrical potential difference (the voltage). Magnetic energy can be stored in coils, for example in superconducting magnetic energy storage (SMES) coils, with very small loss of power compared to other storage methods. The magnetic energy E stored in a coil is $E = ½ L·I^2$, with L being the inductance of the coil, and I being the current.

Thermal energy can be stored in hot water, steam or air, in thermochemical heat storage devices (compact heat storage with minimal heat losses, mainly for applications in concentrated solar power plants) as well as via latent heat storage in phase change materials. Popular portable latent heat storage devices are the rechargeable heating pads with fluid that solidifies and releases comfortable heat when a small peace of metal in the fluid is bent.

Mechanical energy can be stored as kinetic energy in flywheels and as potential energy in springs as well as in pumped and compressed air power plants. Flywheel energy storage systems store kinetic energy in huge rotating masses. They can provide short-term backup energy to electricity grids and telecommunication systems. Pumped storage power plants store energy by pumping water against gravity. The stored potential energy can be converted to electrical energy with an efficiency of 75 to 80%. Compressed air power plants are storage power plants that use compressed air as energy storage medium. The two such power plants that are currently in operation in Germany and the United States are hybrid power plants, combining compressed air energy storage (CAES) in hollow, airtight salt domes, with gas turbine power plants. These power plants have certain demands concerning the landscape, and cannot be erected in all places. Compressed air powered cars, trains and trams are in operation in various countries worldwide.

Hydrogen has an energy density of 33 kWh/kg; it is the basic fuel for fuel cells. Electrolyzers split water H_2O into is components oxygen and hydrogen, which can subsequently be fed into the cell.

The future of large energy storage may well be pumped storage plants, even though they are far away from production and consumers. Furthermore, research will focus on large electrolyzers, hydrogen storage, feeding into the natural gas grid and redox flow batteries. For smaller amounts of energy, current battery systems are improved and new ones developed.

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See also: Chemical Energy Storage; Compressed Air Energy Storage; Compressed Air Storage; Electricity; Energy; Grid Energy Storage; Hydrogen Storage; Joule; Molten Salt Storage; Pumped Storage Hydro; Renewable Energy Storage; Solar Electric Generating Systems; Solar Power; Thermal Energy Storage; Watts; Wave Power; Wind Power.

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Bicycles as Delivery Vehicles

In the second half of the 19th century, the pedal drive for the bicycle was invented, and with this, the use of bicycles as delivery vehicles started, for example for courier services via bicycle messengers, or for the transport of people and/or goods on bicycle rickshaws. Bicycle messenger services today are used for legal, medical or financial documents, and various other things that the sender and/or the receiver do not want to send per mail or other express services, such as medical specimens for the health-care industry. Inside cities, transport by bicycle is generally the fastest way (door to door) to transport goods. Bicycle messengers have communication devices with which they talk to the coordination center, positioning devices (or maps), bicycles that are either self- or company provided and a large volume waterproof bag in which to transport goods and personal items. Clothing of bicycle messengers and especially their bags (also known as messenger bags) became fashion items. Bicycle messenger services are currently available in various countries in the Americas and in Northern Europe, as well as in Japan, New Zealand and Australia. Besides bicycle messenger services, which provide courier services, also normal surface mail is often delivered by the postman via bicycle. Further uses of bicycles as delivery vehicles are rickshaws and load bicycles with two, three or four wheels, sometimes with a trailer. In Copenhagen in Denmark, where the number of bicycles outnumbers the amount of cars by a factor larger than five, and where 50% of the workforce rides their bike to work, sometimes three or even more kids are transported on a single bicycle (with trailer) to kindergarten or school. Bicycle rickshaws are especially popular in Asian countries. The man pulled rickshaw was invented in Japan in the 1860s; the bicycle rickshaw with a person pedaling was invented in the 1880s. Rickshaws are tricycles. In the 1950s they were a common sight all over South and East Asia; at the end of the 1980s, there were still about 4 million of them. Especially in large Asian cities rickshaws are banned – they are too wide and block the traffic, so the argument. Counter developments were the production of more narrow rickshaws (where, for example, the driver sits behind the passenger) and the move of rickshaws out of the city centers towards the slum areas. In many Asian countries, bicycle rickshaws are still used in tourist areas – for most tourists they are fun. Furthermore, they are environmentally safe and reasonably quick. Postmen started to use the bicycle as delivery vehicle for mail and packages only at the end of the 19th century. Currently, load bicycles, electric bicycles and electric tricycles are used to deliver mail to households and to collect mail from post mailboxes; the Germany Mail used in 2014 for example 16 000 bicycles and about 9000 electronic ones, all of them especially equipped to carry high loads.

If the bicycle is to be used consequently, also in rainy, hot and cold countries, also the infrastructure at work and school needs to change. Safe ways to store bicycles and bicycle gear, showers, hair dries, and further necessary infrastructure need to be provided by the school/employer. The bicycle undergoes a shift in its public perception, from something that only environmentalists use to something that provides a fast, simple and cheap mode of transportation. Only 1% of the bicycle users in the capital of the European country Denmark, Copenhagen, where in 2012 more than 50% of the workforce rode their bikes to work every day, say they ride bikes because of the environment. 56% do it because it is fast and simple, 19% see it as physical training and 6% value the financial advantages. Slowly, bicycles, especially customized ones, become status symbols, and thereby introduce major societal changes – changes that cannot be introduced just by political policies. A man in a suit on a bicycle cycling in the center of a European capital is seen in a different light today than in the 1990s. However, especially in the United States, cycling is not popular among the urban poor (yet), and cars serve in many cases as status symbols, representing social success.

In the course of green city initiatives, various cities around the world financially support the purchase of cargo bicycles (electronic as well as pedal drive) for delivery use for companies and educational institutions. The last mile (a term from supply chain management and transport planning) is most often the most expensive one when it comes to delivery of people and goods to their final destination, and so environmental advantages meet cost reduction requirements (transport by bicycle is in many cases faster, cheaper and easier than transport by motorized means).

The bicycle has a fixed place in many of the smart cities initiatives that are currently pursued worldwide. In the US, from 1990 to 2011, the transport sector (goods and people) contributed 27% of the total greenhouse gas emissions. Sustainable urban mobility concepts stress the importance of public transportation (incl. the possibility to transport bicycles on public transport networks), bike-rental systems, bike paths and availability of bicycle repair shops.

Delivery by bicycle is fast gaining ground. In Portland, Oregon, for example, the most bicycle friendly city in the United States, where a high number of citizens bike to work each day, various items and services such as vegetables, freshly roasted coffee, plumbing services and even matrasses can be delivered to the doorstep by bicycle. Increasing environmental consciousness led to such initiatives also in other parts of the United States, such as in New York City, St. Louis and San Diego. Whole Foods, an organic food store in Northern America, now offers delivery by bicycle all over the country.

Cargo bicycles and tricycles are cycles that can carry large and heavy loads. Some have trailers. Bakeries, mailmen, ice cream vendors, rickshaw drivers or miners often use cargo cycles; sparks from electric bicycles could be disastrous in coal mines, because of ignitable gas and coal dust that can result in explosions. There are various specialized trailers and baskets available, for food delivery, animal delivery, and others. Especially animals with inbuilt navigation, such as pigeons, or cats, are less confused when transported at the slow pace of a bicycle – it makes it easier for them to adjust to new places, for example when moving within a city, or when being transported to the vet.

Meal delivery by bicycle can be much faster than by cars, especially in densely populated urban areas such as downtown San Francisco. Bicycles can also be used for energy transformation; the most used way is the dynamo that transforms mechanical energy to electrical energy powering the lights of the bicycle. But bicycles can also be used to deliver electricity for the stereo, for example with human-powered stationary exercise bicycles.

In Bangladesh, the bicycle rickshaw is the most popular mode of transportation. In Dhaka, the capital of the country, more than 300 000 bicycle rickshaws are transporting people and goods. The man-pulled rickshaws disappeared in the 1950s, and were replaced by bicycle or electronic rickshaws.

In various poor countries medicine delivery by bicycle is paramount for basic supply with necessary pharmaceuticals for the general, poor population, to break the disease-poverty cycle. In India, a high percentage of people are very poor, and disease outbreaks can threaten whole cities due to the fragile health system.

Bicycles as disaster response have increasingly been considered since the recent tsunamis in Japan, Sri Lanka and Thailand. Especially in urban areas, they can be used for fast and efficient delivery of first aid, food and water, and also to move out population, when the streets are obstructed by debris from tsunamis, earthquakes or further disasters. It is faster and easier to clear a path for a bicycle than for cars or trucks. The US American based NGO World Bicycle Relief was founded by F. K. Day und Leah Missbach Day after the 2004 tsunami in Sri Lanka; it started with a major effort in disaster relief in the country, by providing 24 376 bicycles to the population. Together with World Vision (a Christian humanitarian organization) and TANGO International (an engineering consultant that provides technical assistance to NGOs), they produced and distributed specially designed bicycles, and provided mechanical training on site.

In 2012, according to a Harvard Medical School study, about 700 people (88% male, 69% in urban areas, 24% with elevated blood alcohol concentration) died and 49 000 were injured in bicycle related accidents (29% when hit by a car) in the United States, which is about 2% of traffic related deaths and injuries; however, bicycle trips comprise only about 1% of all trips taken in the US. Compared to 2001 bicyclist data, this represents a decrease in the number of deaths, and an increase in the number of injuries.

A study on occupational injuries in Boston bicycle messengers shows that this group has a high number of injuries that are not well documented because of their contractor status and missing health insurance (only 32% had insurance). Injuries are mainly bone fractures, dislocations, sprains, and strains, and lead in 70% of the cases to days off work and in 55% to hospital or clinic visits. Initiatives such as the US American Bicycle Messenger Emergency Fund, that has raised over 20 000 USD in the last five years, aim to give initial financial support to injured bicycle messengers worldwide.

Bicycles have been used for weapon, ammunition and message delivery as well as for the mobility of scouts in wars all around the world since the end of the 19th century. One famous example is the bicycles that were used extensively by the Vietcong and the regular North Vietnamese army during the Vietnam War. These bicycles, which were pushed by 60 000 men and women for about 25 miles per day, could transport up to 200 kg (440 lb). Also during the Korean and Indochina wars major parts of the military transport was performed on bicycles. Currently, for example Sri Lankan, Finnish, British and US American bicycle infantry use special military bicycles. Also many militias use bicycles.

Cost comparison between bicycles and cars need to include the direct costs for the driver/rider as well as the costs for society. The costs for the driver/rider include purchase, taxes, insurance, maintenance, fuel costs, accidents, operation and the time needed to drive/ride a certain distance. Concerning accidents, the costs per distance ridden/driven is about four times higher in bicycles than in cars, the costs for operation of cars are about four times more for cars than bicycles and concerning driving/riding time per given distance, the costs are about equal. When it comes to societal costs, the benefit of bicycles for health is high compared to cars, noise pollution with bicycles is virtually nonexistent (unlike cars), however, the costs of accidents are about four times as high per kilometer ridden with the bicycle than driven with the car, and there are also no polluting emissions from bicycles (unlike cars).

The bicycle boom years in the United States were 1972-1974; during these years, more bicycles were sold in the US than cars. Reason for this bicycle boom was the first oil crisis, which was marked by a drastic increase in the price of crude oil, by about 70%. A potential final oil crisis in combination with increased environmental consciousness and the will to curb greenhouse gas emissions drives many people to considering bicycles rather than cars when thinking about transportation and delivery.

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See also: Bicycles as Transportation; Energy Efficiency; Renewable Energy and Energy Efficiency; Transportation Sector.

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Bicycles as Transportation

The bicycle is the most used mode of transport by a man-made device in the world. It is environmentally friendly, and always available. Many large companies with huge areas offer bicycles for their workforce. The bicycle was the first successful man-made device that allowed for an individual mode of transport. Karl Drais invented the first bicycles in the early 19th century; in these early models people had to run, there were no pedals driving the device, but it already had a stirring wheel. Only few countries, such as the South West of the German Association (a confederation of 39 German states in Central Europe) that time provided smooth enough streets that the draisine, as the device was called back then, could be used. Centrifugal forces of the wheels stabilized its position. At the time of its invention horse food was scarce due to various bad harvests following the eruption of the volcano Tamboa, the increasingly fewer horses were available. After 1816, the year without summer due to loads of volcanic aerosols in the atmosphere, the situation improved again, and the draisine was forgotten. Decades later, in the second half of the 19th century, industrialization started and the bicycle was developed further, by invention of the pedal drive and gear shifts (from the beginning of the 20th century). From the first half of the 20th century, bicycles became cheaper, and the first mass individual mode of transport, mainly for workers who used it to commute to their factories; but the bicycle was also used to reach holiday destinations. About 50% of the workers in larger German cities used the bicycle to commute to work in the 1930s, and already back then bicycle lanes were widely available. When the countries increasingly became richer, motorbikes, and subsequently cars replaced bicycles - a development that can also be seen today in countries that become industrialized countries. Because of the oil crisis in the 1970s and increasing environmental consciousness the bicycle became more and more important, especially for urban commutes and transport (more than half of the journeys in a city are less than five kilometers), with a parallel development of high quality bicyclist infrastructure. Many cities also allow the transport of the bicycles in public transport (underground, trains, buses), so the device can be used in more versatile ways.

About 130 million bicycles are produced every year, which is about double the number of cars produced each year, and about four times the number of bicycles that were produced in the 1970s. Of all countries, China produces the most cars, and the most bicycles. In the United States, nearly 10% of the bicycles were produced in the country in the early 1990s; this number decreased to less than 1% in the year 2000.

Nearly 60% of all the bicycles in the world are produced in China. 80% of the 30 million electric bikes that were globally sold in 2011 were sold in China. The number of e-bikes in China is estimated to be 120 million, their maximum allowed speed is 20 km/h, and about 2500 people die in e-bike accidents in this country every year. Countries with the highest number of bicycles are the Netherlands (with more than 16.5 million bicycles, and a population of 16.8 million people; the percentage of cyclists in the Netherlands is higher than 99%), Denmark, Germany, Sweden, Norway, Finland, Japan, Switzerland, Belgium and China (with 500 million bicycles, and a population of more than 1.3 billion people; the number of cyclists in China is about 37%).

The bicycle is very important in Germany. 4 million bicycles are sold annually in Germany, there are 73 million bicycles in Germany, and 83% of all households have at least one bicycle. Transport by bicycle in the German cities Berlin, Munich and Hamburg is about 14% of all possible modes of transport.

In many congested cities and generally for short distances, transport by bicycle can be the fastest mode of individual transportation. In Germany, about 20% of the workforce uses the bicycle for the daily commute to work; the percentage is higher for the ones below 35 years of age, and smaller for the older ones. Men ride their bike to work more often than women.

Nearly 3 million bicycles are stolen each year in Europe, most of them - nearly one million - in the Netherlands. In China, about 4 million bicycles (700 000 of these being e-bikes) are stolen each year.

Rental Bicycles

Various countries such as Germany, Australia, Austria, Belgium, Canada, China, Denmark, Spain, USA, Finland, Israel, Italy, Japan, Norway, Portugal, the United Kingdom, Sweden, Switzerland, France and the Netherlands have introduced rental bicycles. The city of Paris, the capital of France in Europe, has since 2007 established more than 20 000 rental bicycles at nearly 1500 rental places. Each bicycle has since then been used by 8-10 different people per day and has until now been used for accumulated transport over more than 10 000 kilometers, which is way more than private bicycles.

Bicycle related plans for New York include the installation of first 6000 Citi Bikes in 333 stations, and then 10 000 bikes in 600 stations, in Manhattan und Brooklyn.

The most bicycle friendly cities are Amsterdam, Kopenhagen, Utrecht, Sevilla, Bordeaux, Nantes, Antwerpen, Eindhoven, Malmö and Berlin. Also Munich, Hamburg, Tokio, Montreal, Nagoya and Rio are amongst the 20 most bicycle friendly cities.

Policies

Cities that are starting to go car-free but that have no plans to go completely car-free are Madrid in Spain, Paris in France, a city next to Chengdu in China, Hamburg in Germany, Helsinki in Finland, Milan in Italy and Copenhagen in Denmark. Hamburg in Germany severely suffered from smog in 2014. When it started to ban cars, the smog dropped by 30% in some areas. Also the Italian city of Milan suffers from smog. As a countermeasure, the city introduced free public transit vouchers that are handed to commuters when they do not use their cars. In 2001, 40% of Parisians didn't own a car - now that number is 60%. A new satellite city planned in Southwest China next to the city Chengdu could serve as a model for a modern suburb: Instead of a layout that makes it necessary to drive, the streets are designed so that any location can be reached by 15 minutes on foot. Hamburg plans to erect a new green network that will connect parks across the city, making it possible to bike or walk anywhere. It will be completed in the next 15 to 20 years. The network will cover 40% of the city’s space. In Helsinki, a new smartphone application allows citizens to shared bike, car, or taxi, or find the nearest bus or train. Within the next ten years, the city hopes to make it completely unnecessary to own a car. Forty years ago, traffic was as bad in the Danish city of Copenhagen as in any other large city. Now, over half of the city’s population bikes to work every day and the city has one of the lowest rates of car ownership in Europe. The number of bicycle commuters in Copenhagen is nine times the number of bike commuters in Portland, Oregon, the city with the most bike commuters in the United States.

The Victoria Transport Policy Institute in Canada identified ways to encourage non-motorized modes of transport such as walking or bicycling, including improvement of sidewalks, crosswalks, paths and bike lanes, correction of specific roadway hazards to non-motorized transport, improvement of non-motorized facility management and maintenance, development of pedestrian oriented land use and building design, ensuring road and path connectivity, vehicle restrictions, safety education, law enforcement and encouragement programs, bicycle parking options, integrated transit (e.g. possibility to transport the bicycle on trains and buses), rental systems, maps and other information on how to walk and cycle to a particular destination.

Various initiatives aim at increasing the number of people using bicycles worldwide. In Columbia cars were banned from the city center of the capital, Bogota, on Sundays and holidays, and in 2015 a referendum will take place in prohibition of cars during rush hours. In the Netherlands (the first country with an official national bicycle policy) and in Germany, more than 19 000 and 30 000 kilometers, respectively, of bicycle paths and bicycle lanes allow for fast, safe and secure transport via bicycle. In Nagoya in Japan, employer contributions to car commuters were halved in the year 2000, and contributions to people using the bicycle were doubled. Tokyo in Japan has an automated parking house for nearly 6500 bicycles. The capital of Peru gives low interest loans to poor families for buying bicycles.

At the beginning of 2014, the star architect Sir Norman Foster proposed his project Skycycle for the city of London, comprising 220 kilometers of elevated lanes, only for bicyclists. Arguments against the Skycycle project are that cyclists want to the see the neighborhoods they are cycling through, and want to move inside the city, not above it.

Transportation systems influence quality of life and health. In this respect, the US Center for Disease Control and Prevention recommends transportation policies that support health and reduce health care costs, for example by healthy community design, the promotion of safe and convenient opportunities for physical activity by supporting active transportation infrastructure, the reduction of human exposure to air pollution and adverse health impacts associated with these pollutants and by ensuring that all people have access to safe, healthy, convenient, and affordable transportation. Active transportation relates to walking, bicycling, moving with a wheelchair, or on a small-wheeled device such as a skateboard. CDC recommendations for active transportation ensure safe and convenient physical activities by providing respective supportive infrastructure such as sidewalks and trails, financial support of non-motorized modes of transportation, incentives for the reduction of vehicle use and the implementation of environments that promote walking and biking, for example via the Safe Routes to School program.

The Copenhagen Example

Copenhagen is an exemplary city when it comes to individual transport via bicycle. Until about ten years ago Copenhagen was just another European city, with a city center congested by cars, and lots of pollution originating from these cars. Then, the policy of the city changed, and it decided to substantially promote and support individual transport per bicycle.

In 2012 more than 50% of the workforce in Copenhagen commuted to work on bicycle. Even two thirds of the members of the Danish parliament reach work on bike. The bicycle lanes in Copenhagen are 4 meters wide, with several lanes. Nearly 35 000 bicyclists ride on one of the most important streets in Copenhagen per day. The people of the city own 650 000 bicycles and 125 000 cars. Annually, Copenhagen invests more than 10 million Euros in bicycle lanes.

Only 1% of the bicycle users in Copenhagen say they ride bikes because of the environment. 56% do it because it is fast and simple, 19% see it as physical training and 6% value the financial advantages. In Denmark, the costs related to cars are extremely high. Copenhagen also tunes the traffic lights to the speed of the bicyclists. 20 000 parking spaces for cars disappeared in Copenhagen in the last years. Family bicycles are adapted in a way that they can, besides the rider, transport children, plus shopping goods.

The Danish experience concerning bicycles as transportation is an important economic factor for the country, and an important export good, within Europe, but also for South America and South East Asia.

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See also: Energy Efficiency; Mass Transportation; Renewable Energy and Energy Efficiency; Transportation Sector; Urban Mass Transportation.

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Biogeochemical Cycles (water cycle, carbon cycle, nitrogen cycle, etc.)

The concept of *biogeochemical cycles* refers to the periodic turnover of substances through the activity of living and non-living processes on Earth. Matter undergoes cycles of deposition, combination, transformation and emission that are mediated by the atmosphere, the hydrosphere (water bodies such as the oceans, rivers and lakes), the lithosphere (stones, rocks, mountains) and the biosphere (living matter). Human activity represents a relatively new addition to these processes. Biogeochemical cycles play roles in more temporally extensive cycles, such as the geological and rock cycles. Specific biogeochemical cycles such as the water cycle, the nitrogen cycle, the carbon cycle, the oxygen cycle and the phosphorous cycle are not separated. Instead, they are fundamentally interconnected, and are, even individually, governed by complexly recursive feedback loops that defy easy analysis. Human commercial, industrial and military activity globally influences each of these specific biogeochemical cycles. Activities related to industrialization, agriculture, deforestation and fossil fuel burning establish dangerous precedents whose complex outcomes are both unpredictable and potentially devastating — ecologically and commercially. Earth systems science investigates, analyses and predicts global changes that comprise the interaction between land, atmosphere, water, ice, biosphere, society, technology and economy as changes in the physical and biogeochemical environment, due to natural and anthropogenic (man-made) causes.

The flux through biogeochemical cycles is not constant; it remains variable and adaptive at all times. The biogeochemical cycles show natural fluctuations and instabilities; understanding them is essential to modern human cultures because our activity is directly and dramatically modulating them. There is increasing interest and discussion in the intentional exertion of human control upon them, and yet we must question both the purposes and the underlying intelligence of such agendas. The Russian geologist Vladimir Ivanovich Vernadsky (1863-1945) is the founder of the scientific fields of geochemistry, radiogeology and biogeochemistry. Vernadsky also introduced the concepts of the biosphere as the sum of all ecosystems, and the noosphere as the part of the biosphere that is controlled by human consciousness. It is clear that we have made a permanent imprint upon the face of nature and our world; what is not clear is whether or not we have ever been (or can yet become) intelligent enough to survive our own seeming sophistication.

Peak changes in certain parameters due to volcanic eruptions, human influences and extraterrestrial material from meteorite impacts are normally buffered. A well-buffered system shows no reaction to parameters that experience steady increase until a threshold is reached. This may generate an erroneous feeling of safety regarding the stability of the system. It is difficult to overstate the inter-relatedness of each of the cycles. Outside certain boundaries, nonlinear abrupt changes of environmental conditions may occur.

The bandwidth of environmental conditions in which human beings can survive is surprisingly narrow. Humans began to thrive only relatively recently, and the environment we faced was resistant to dramatic anthropogenic change until the onset of the industrial revolution. Healthy ecosystems depend upon complex phenomena that can change abruptly, and we are not inclined to observe many of the signals that might alert us to dangerous conditions instigated by our own activities. One common example of such problems is a lake into which runoff from agricultural fertilizers are continuously flowing. The lake ecosystem buffers the increased nutrient load until a critical threshold is reached and it suddenly changes, often resulting in major simplification of its ecosystemic diversity, with one or few dominating species. Such a shift might be approaching for the Earth's biosphere as a whole, resulting in the sixth mass extinction of species and changes in the environment that might not favor human survival.

We shall now briefly examine some of the key features of specific cycles as distinct systems in order to gain an overview of their components, composition and activity.

The water cycle

The biogeochemical water cycle encompasses the global and regional transport and storage of water. This is driven by precipitation, infiltration, surface runoff, evaporation and condensation. Organisms, especially plants, contribute via active water uptake, storage and release. Soil stores water on the surface of its particles and in soil pores. The global reserve of free, available water is about 1,400 million cubic kilometers. 97% of this is salt water. 74.9% of the remaining fresh water exists as ice and snow, 24.5% as groundwater. Only 0.6% of this store is held in water bodies such as lakes and rivers, in the atmosphere and in organisms. Most organisms consist of 70-80% water, while some plants consist of up to 90% water, and some aquatic organisms of up to 98%. Annually, half a million cubic kilometers of water evaporate, and come back to the Earth surface as rain, most of it directly into the oceans. 9,000 cubic kilometers of this water are used by people. In some geographic regions water is scarce, and anthropogenic activity continues to cause ecologically alarming impacts, resulting in global changes to the water cycle. These include regional increases or decreases in the amount of rain, altered drainage properties in cities, deforestation and desertification (a form of land degradation that is often a consequence of the removal of most of the vegetation).

The nitrogen cycle

The Earth's atmosphere contains 78% molecular nitrogen, N_2. In this form, nitrogen is not directly usable by most organisms. It must first be converted to nitrate, NO_3^-, or ammonia, NH_4^+. In the environment, this conversion is performed via lightning and fire, leguminous plants and, most importantly, microorganisms. The optimum temperature for the conversion reaction in microorganisms is 20 degrees centigrade. The atmosphere, organisms and dead biomass (including humus, soil and sediments) represent environmentally important nitrogen storage assets for the biosphere. Nitrate is converted back to molecular nitrogen via denitrification by anaerobic soil bacteria in aerobic conditions.

The modern anthropogenic influences of commercial cultures on the biogeochemical nitrogen cycle are severe. Incessant burning of fossil fuels releases nitrogen oxides, NO_x, into the atmosphere. Nitrogen oxides are one of the main ingredients of smog, which is chemically harmful to plants and the human respiratory system. Reactions of the nitrogen oxides with water result in nitric acid and nitrous acid, which are major ingredients of acid rain. The greenhouse gas N_2O is generated via microbacterial reduction of fertilizers, and 40% of the total environmental N_2O emissions originate in human activity. Since the ban of fluorocarbons, N_2O is the single most dangerous emission involved in stratospheric ozone depletion (see *ozone hole*, below). Factory farming, sewage treatment plants and industrial processes release ammonia into the atmosphere, leading to eutrophication of water bodies and sudden changes in ecosystems via fertilization of wild vegetation and smog. *Eutrophication* refers to the ecological response to increased presence of specific substances such as dissolved nitrates or phosphates in the rivers lakes and aquifers, leading to the collapse of the aquatic ecology, animal death and explosive growth of water plants and algae. The artificial concentration of nitrate in water can also lead to human diseases such as methemoglobinemia (the blue-baby syndrome) as well as playing a causal role in cancers of the stomach and gastrointestinal tract.

The carbon cycle

About 0.1% of Earth's mass is carbon. Before there were organisms on Earth, the carbon cycle was a long-term inorganic geochemical cycle that took place over thousands to millions of years. This inorganic cycle was intensified as soon as photosynthesizing organisms appeared. Carbon from atmospheric carbon dioxide is fixated during photosynthesis as organic biomass, and released again through respiration. Decomposition of organisms and fecal matter provide bioavailable carbon sources for organisms. About the same amount of carbon is set free via respiration as is fixed again via photosynthesis. This biological carbon cycle is a fast subcycle that takes place over periods ranging from days to hundreds of years. Incompletely degraded biomass accumulates in internal carbon depots, as coal, oil and gas, and contributes to a long-term organic carbon subcycle that couples fast biochemical processes with long-term geological processes.

The CO_2 content of the atmosphere has varied over geological periods, depending on factors such as the temperature of the oceans, the amount of ice and snow, and the extent of volcanic activity. The oceans represent vitally important carbon storage in the carbon cycle. CO_2 is dissolved in water in complex chemical equilibrium, and may sediment as carbonate after organically or inorganically induced processes, yielding vast mountain ranges. Anthropogenic influences on the carbon cycle mainly result from releasing stored carbon by utilizing fossil fuels (an addition of about 5 billion tons of carbon per year to the atmosphere) and burning rainforests (an addition of about one billion tons of carbon per year to the atmosphere). The destruction of rainforests further reduces future carbon dioxide uptake capacity in this important sink. CO_2 is a greenhouse gas. Increasing CO_2 concentration in the atmosphere results in problematic effects on climate and biosphere, such as changes in vegetation, the extinction of native species, and the intrusion of opportunistic alien species in their place. Carbon influx from deeper layers of the Earth still occurs via volcanism and mineral-rich springs, as carbon dioxide, carbon monoxide and methane.

As a consequence of the increased amount of carbon dioxide, the oceans are becoming increasingly acidic, which results in less calcium carbonate biomineralization and a potential collapse of the marine ecosystems. Specific concentrations of greenhouse gases such as water vapor, carbon dioxide, methane, nitrous oxide and ozone are crucial to sustain survivable environmental conditions on Earth. They absorb and emit thermal radiation; without them the surface of the Earth would be about 33 degrees centigrade cooler. In larger concentrations, they contribute to destabilization or destruction of terrestrial ecologies and possibly catastrophic warming effects.

The oxygen cycle

The oxygen cycle refers to the transport and storage of oxygen in the atmosphere, the biosphere and the lithosphere. Until about 2.4 billion years ago, before photosynthetic organisms such as plants inhabited the Earth, there was very little or no free oxygen available in the atmosphere. The organisms that existed at that time were anaerobic microbes, and oxygen was poisonous to them. The establishment of photosynthesis with oxygen as byproduct caused the first mass extinction of species. Most anaerobic organisms went extinct. Today, for most organisms, oxygen is necessary for survival, and photosynthesis is one of the largest driving forces of the oxygen cycle.

The oxygen cycle is connected to other cycles via oxidations and reductions. The largest oxygen storage capacity is found in the silicate and oxide minerals of the Earth’s crust and mantle (99.5%). Only 0.01% of the Earth’s oxygen is in the biosphere, and only 0.36% in the atmosphere. The average time oxygen spends in the lithosphere is 500,000,000 years; in the biosphere, it is 50 years, and in the atmosphere 4,500 years. Gains and losses of atmospheric oxygen are balanced. Losses of approximately $300*10^{12}$ kg O_2 per year due to weathering, respiration and decay, stand against gains of approximately $300*10^{12}$ kg O_2 per year due to photosynthesis.

An important subcycle of the oxygen cycle is the oxygen-ozone cycle in the ozone layer of the lower stratosphere (20-30 kilometers above the Earth's surface). This layer protects us from harmful UV radiation and associated diseases such as skin cancer. The sun produces about 12% of the ozone layer every day. Anthropogenic influences induced an abrupt change in the chemistry of the lower stratosphere, and unexpected formation of an *ozone hole*. Chemists identified chlorine and bromine free radicals from man-made chlorofluorocarbons and halones as the reason for the ozone depletion. In 1987, chlorofluorocarbons were banned; in 2006 the ozone hole reached its largest extension and since then, slowly, has been shrinking. Chlorofluorocarbons have a half-life of various decades in the atmosphere; therefore, it will take at least until the second half of the 21st century until the ozone hole is completely closed again. Some natural processes such as volcanic eruptions contribute to an increase in ozone-depleting free radicals in the atmosphere; one example is the Toba supervolcano that erupted 74,000 years ago, severely damaging the ozone layer.

The phosphorous cycle

On Earth, phosphorous mainly exists as phosphate, PO_4^{3-}. It is water-soluble; therefore the hydrosphere is its primary depot. Fine roots and mycorrhiza (a symbiotic association between fungi and vascular plant roots) rapidly absorb free phosphate in the soil. Phosphate leaves the biosphere via transport in rivers for the oceans, where it is sedimented in the lithosphere, and is available again for the biosphere over geological periods, when the seafloor resurfaces, or when upwelling marine currents such as the Humboldt current or the Benguela current locally transport phosphates back to the ocean surface, allowing for increased fish populations. Land birds eat the fish; their manure subsequently provides nitrogen and phosphorous rich nutrients for terrestrial ecosystems (guano). Phosphate can also be released from sediments during algal blooms, when the oxygen concentration decreases and PO_4^{3-} is released from iron (III) complexes in anaerobic conditions (internal fertilization of water bodies). The role of the atmosphere is negligible in the phosphorous cycle.

These are not the only cycles we are aware of; there are other important biogeochemical cycles such as the sulfur cycle, the hydrogen cycle, metal cycles and the carbonate-silicate cycle. The mercury cycle and the atrazine cycle are recent objects of investigation. The amount of mercury in the atmosphere has increased by a factor of three to five in relation to pre-industrial times due to human activities, mainly because of the burning of coal. Mercury is ecologically toxic and is poisonous to humans (it is a potent neurotoxin). It cycles for hundreds to thousands of years in the air, water bodies and terrestrial systems before it returns to deep-sea sediments. Atrazine is a pesticide that acts as dangerous groundwater pollutant with highly detrimental effects on mammals (incl. humans), fishes, amphibians and insects. It was banned in Europe in 2004, but is still widely used elsewhere. Humans have significantly altered various metal cycles, with the same amount or multiple amounts of influx to the oceans and the atmosphere (due to wastewater from industrialized communities and combustion) as from natural weathering. Metals and plastics are amongst the most prominent materials in modern industrialized societies.

In rural ecosystems close to nature, the ecological cycles are mostly closed; apart from carbon, little matter enters or leaves. Producers such as photo- and chemoautotrophic bacteria and plants transform matter that is stored in abiotic 'banks' such as the atmosphere, the soil and sediments, from inorganic to organic molecules. Photoautotrophic organisms use light as an energy source to synthesize their own organic building blocks from inorganic substances. Chemoautotrophic organisms derive energy from chemical reactions and synthesize all organic compounds from simple inorganic sources. Consumers such as animals and people then consume such organic matter, which is finally returned by decomposers such as bacteria and fungi to its inorganic state, from where the cycle starts again.

Due to the anthropogenic influence on various biogeochemical cycles, new concepts such as the anthropocene era, novel ecosystems, global human impacts and technoecosystems are being invented. The anthropocene is the era in which the human influence on the living environments of Earth became paramount. It started with the industrial revolution, at the end of the 18^{th} century. Technoecosystems result from urbanization, massive agricultural activities and technology. As opposed to natural ecosystems, technoecosystems are partly powered by fossil and nuclear fuels, and have no natural analogs. New dynamics develop in such situations, and need to be taken into account when investigating biogeochemical cycles. Mankind has already altered 75% of the Earth's ice-free land area, but we are now altering the fundamental biogeochemical processes upon which life on Earth depends.

Industrial processes globally influence the carbon and the nitrogen cycle, change ecosystems and damage their stability. Some ecosystems (and thus their histories) are simply obliterated. Fertilizers produced by the Haber-Bosch process as well as increased planting of nitrogen fixating legumes such as soybeans, peas, beans, lentils, peanuts and alfalfa, harmfully influence the phosphorous and nitrogen cycles. Burning fossil fuels contributes to global warming and climate change.

Human activities influence global storage, transport and regeneration cycles of matter. Industrial chemical synthesis allows for the rapid generation of novel materials, in large quantities. Some of them are highly stable, and can spread rapidly through ecosystems. Mining and the extraction of fossil fuels release large qualities of organic and inorganic materials from their natural deposits and waste becomes an increasing problem, especially in megacities with millions of inhabitants. It is unclear how we will cope with dangerous or deadly outcomes that become irreversible.

One instructive example of how man-made substances can be widely and uniformly distributed via global cycles is the insecticide Dichlordiphenyltrichlorethan (DDT). It was used widely since the 1940s, and banned in the US and in Europe in the 1960a and 1970s. It is still used in North Korea, China and India. Besides being lethal for insects, DDT is toxic for humans and animals. It is chemically highly stable, its reduction to less poisonous substances via organisms in free water is negligible, and it can be transported via the atmosphere. It is easily absorbed in organisms, but not metabolized, therefore it accumulates and increases in concentration up the food chain. It also attaches to the microplastic particles of the Great Pacific garbage patch, increasing its toxicity for local organisms and, finally, us. *Currently, each and every living cell on Earth, be it in animals,* *plants or microorganisms, contains at least one molecule of DDT.*

A set of nine tentatively quantified parameters, termed planetary boundaries, were introduced by planetary and environmental scientists led by Johan Rockström from the Stockholm Resilience Centre in 2009 to estimate conditions under which human development can safely proceed without significant danger. These parameters are chemical pollution, climate crisis, ocean acidification, ozone depletion, biogeochemical nitrogen and phosphorous cycles, the freshwater cycle, deforestation and other land use changes, biodiversity loss and particle pollution of the atmosphere. For three of these nine parameters, namely the biogeochemical nitrogen and phosphorous cycles, the climate crisis and biodiversity loss, we have departed the safety margins outlined by these parameters.

The anthropogenic removal of nitrogen from the atmosphere was zero in preindustrial times, and the boundary was estimated to be at 35 million tons per year. We exceeded this boundary, and current activities result in the removal of more than 121 million tons per year. The anthropogenic influx of phosphorous into the oceans is approaching the boundary of 11 million tons per year, with currently 8.5-9.5 million tons. The preindustrial value was -1 ton, so there was an outflow of phosphorous from the oceans rather than influx.

Exceeding these three boundaries will probably have disastrous consequences for humanity, but these are not yet completely understood, due to gaps in our knowledge of how to best quantify the single boundaries and their complexly interlinked relationships.

Humankind increasingly has deeper understanding and control of the local and global impacts of its activities on the connective complexity of environmental processes and ecologies. Well-educated people with insight into present and future trends and developmental potentials are the driving force to successfully respond to these challenges, via re-establishment of human and analytical sensitivity to the connective complexity of environmental processes and ecologies. By developing this awareness in perspectives and activity humankind may protect the foundations of life on Earth and establish more intelligent and humane cultures at the same time, helping to insure livable conditions both for human beings, and for the vast and delicate ecologies from which humanity descends... and upon which its future is dependent.

Insight into present and future trends and developmental potentials, of biogeochemical cycles in general and of subcycles that are of specific importance to life on Earth in particular might allow for successful response to man-made and/or nature induced challenges. In the case of the ozone hole, rapid and intelligent human intervention improved the conditions in the complex ozone-oxygen cycle that we had previously degraded. This gives us a model for the future that we may hope to replicate and exceed.

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See also: Acid Rain; Carbon Footprint; Carbon Monoxide; Energy and the Environment; Environment; GHG Emissions Factors/Carbon Intensity; Global Environment Facility; Life

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Conscious and unconscious thought

The concept of a thought either means a result of thinking, or the process itself. Results of thinking can be understanding and decisions. Thoughts are different from perception and intuition. Perception and intuition are generally considered non conceptual, thinking is generally considered conceptual. Thoughts can be conscious, subconscious or unconscious. Most of the processing in the brain takes place in unconscious ways. This even holds for perception: in seeing, more than 30 different regions of the brain are involved, and only few of these regions produce anything like consciousness or awareness of sight. Similarly, all conscious decisions of people are based on unconscious, preconscious and/or subconscious processing.

The concept of cognition denotes the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses as well as a perception, sensation, idea, or intuition resulting from the process of cognition. Cognitive processes are all processes of understanding, knowing and information processing. This includes planning, reasoning, decisions, fantasies, imagining, perceiving, reflecting, thinking, learning, and others. Cognitive processes influence the behavior of people more than external events. For actions and reactions of people it is not important what happens to them, but which meaning they attribute to their experiences. There are cognitive processes such as thinking and reasoning that take place without consciousness. Most cognitive processes can be traced back to the three basic processes of perception, memory and emotions, and are not accessible for the conscious mind. Perception is a dynamic, unique, subjective and constructive process: top-down and bottom up processes act together and integrate sensory stimuli from the environment with experience, knowledge, expectations and intentions. By far not all perception is conscious. Implicit perception takes place beyond the normal conscious threshold of perception and center of focus of attention.

Thinking is an attempt to sort the world. Important factors in thinking are intuition, experience, knowledge and unconscious thought. According to Gerd Gigerenzer, German researcher in decision-making, intuition is a form of unconscious intelligence.

The concept *conscious* refers to what a person is aware of in the present moment, such as breathing. The concept *subconscious* refers to what a person can access if awareness is focused on it. The concept *unconscious* refers to emotions, memories, experiences and information that we cannot access. Especially after strong, specific triggers, unconscious memory may become subconscious, and then conscious, when for example a long-forgotten childhood memory suddenly emerges after decades.

Various disciplines deal with thinking, and investigate the theme with different motivations, underlying assumptions, and visions: brain science and related fields, biology, psychology, epistemology (the study of knowledge and justified belief), game theory (the study of strategic decision making), logic (the study of valid reasoning), artificial intelligence, philosophy and sociology. Thoughts in the subjective sense are the field of cognitive psychology, and thoughts in the objective sense are the subject of logic. When solving problems or making decisions, conscious and unconscious thought cannot be separated. Generally there are two different ways of thinking: automatic thinking and controlled thinking. Automatic thinking takes place unconsciously, without intention, involuntarily and with ease. Controlled thinking, on the other hand, takes place consciously, intentionally, voluntarily and is full with effort. Two further ways of thinking that are discriminated are the thinking of groups and the thinking of individuals. Points of investigations are their general ways of thinking, specifically for the group or the individual.

Fields that deal with thinking such as brain science and related fields investigate the psychological, neuronal and biochemical mechanisms that are the basis for the tangible act of thinking. Epistemiology, game theory, logic and the psychology of reasoning investigate, which rules have to be followed by thinking, so that perceptions are processed in a meaningful way, so that one reaches justified beliefs or so that problems are solved in correct ways or the lines of reasoning are meaningful. The psychology of thinking deals with three main areas, problem solving, logical reasoning and the formation of concepts. The main categories of thinking, conscious, unconscious and preconscious thought, are inseparable in problem solving.

Belief systems and ways of thinking are formed by the society one grows up in, via socialization and via other factors. Belief systems constitute the worldview, and make people to what they are. Belief systems and paradigms can be changed, albeit slowly.

Thinking is different in different cultures, in men and women, in archaic wild types of thinking and in modern tamed types of thinking. Contrary thinking styles are for example analytic thinking and holistic thinking – representatives of these groups organize and structure information in completely different ways. The French anthropologist Claude Lévi-Strauss coined the term *wild thinking* for the thinking style of peoples who live close to nature.

There are ways of knowledge that can be verbalized, such as explicit knowledge, and ways of knowledge that cannot be verbalized, such as implicit knowledge and tacit knowledge.

According to Nobel Prize winner Daniel Kahneman, there are two basic modes of thinking in each person: fast and slow thinking. The fast, instinctive and emotional way of thinking is automatic, always active, emotional, stereotyping and unconscious. The slower, analyzing and more logic way of thinking is demanding, rarely active, logic, calculating and conscious.

Dijksterhuis and coworkers state in their “deliberation-without-attention” hypothesis that some decisions are too complex and contain too many parameters to be thought through consciously. Instead of immediate decisions or long, careful conscious thinking about the problem, especially in cases with many parameters thinking unconsciously about the problem can yield the best decision. This unconscious thinking about an issue can for example take place in the night (when one “sleeps over it”) or when people are distracted and then make their decision, without having the time to think things through thoroughly. Until then is was common understanding that the amount of conscious thought that needed to be invested rose with the complexity of the problem that needed to be solved. Dijksterhuis indeed showed that simple problems are easier to solve with conscious thought than complex problems, and that consumer happiness increases when complex decisions are made in an unconscious way. In this way, consciously reflecting on highly complex decisions may result in less beneficial outcomes as when letting one’s unconscious decide. The reason for this difference might be that the conscious mind tends to confine attention to specific details, whereas the unconscious mind distributes attention more evenly on a much broader array of details. This change in the width of focus of attention may explain some of the benefits of unconscious thinking over conscious deliberation.

Memory is a dynamic and constructive process. Memory does not save recordings of experiences and knowledge like a man-made current computer memory, but rather (re)constructs them in the moment of retrieval. Nonconscious or implicit memory denotes memory systems in which the processing of information, i.e., the encoding, the storage and the retrieval, and their content is not known to the conscious mind. Implicit learning denotes the process of the acquisition of knowledge without the contribution of conscious processes. Especially in cases when the rules are so complicated that they cannot be consciously found/described, implicit learning seems to be superior to explicit learning. As opposed to informal learning, implicit learning can take place in formal educational institutions and can be initiated intentionally.

In a classic experiment by Haynes and coworkers from the year 2008, functional magnetic resonance imaging, a modern way of brain-imaging, showed that the high level control centers prefrontal and parietal cortex in the brain highlight the outcome of a decision on whether to push a left or right button up to ten seconds before the person consciously decides. These control centers obviously prepare an upcoming decision. The conscious decision on which button to push was made about a second before the act. This has ignited discussions between neuroscientists and philosophers on whether decisions are under our conscious control, i.e. if we have free will, and on who or what decides if a person decides.

The mind-body problem relates to the question how mental states relate to physical states, and is one of the central questions of the philosophy of mind. Today, most philosophers agree that mental states must be material states, but that most current reductionist proposals are unsatisfying: mental states cannot be reduced to behavior, brain states or functional states. They are rather emergent states that arise from the complexity of the interactions in the causing system. Emergence is a concept that denotes the fact that in some systems, especially in highly complex, interconnected and interdependent ones, the whole is more than the sum of its parts, and that the whole cannot be fully understood by investigating parts of the whole and summing up the results. Examples for emergent phenomena are spatial vision (which is possible with two eyes, but not with one), swarm intelligence (for example the ability of ants to coordinate the building of bridges which are made up of their bodies over rivers) and decisions via quorum sensing in bacterial communities (quorum sensing in bacteria refers to the ability of these single celled organisms to communicate and regulate gene expression in response to fluctuations in cell-population density).

Apart from the description that consciousness denotes in the widest sense experiencing mental states and processes, there is still no generally accepted definition of consciousness. Also the transition of a thought, idea or decision from being unconscious to conscious remains unexplained. Verbalization, a method that is highly used in psychoanalysis and that should help people gain access to their unconscious mind, might be of paramount importance to ignite this transition.

Automatic decisions, expert decisions and emotional decisions without time pressure are mainly made unconsciously (or with little accompanying consciousness). And even in reflected, rational decisions the last word often comes from one's emotional components, most of which are based in the unconscious mind.

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See also: Center for Cognitive Brain Imaging; Groupthink; Magical Thinking; Systems Thinking.

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Cuba (with Prof. Ernesto Estevez Rams)

The Republic of Cuba is the largest island of the Greater Antilles in the Caribbean Sea, with 11.3 million people and tropical climate. The length of the island is 1250 kilometers; its maximum width is 191 kilometers. The largest part of the island is flat; the mountains in the Sierra Maestra in the East reach 1974 meters. Cuba has an area of 109,886 square kilometers and more than 6000 kilometers of coastal line; its capital and largest city is Havana, with over 1.5 million permanent inhabitants and up to 2.1 million floating population. Cuba's GDP (2013) is 78.7 billion USD, with a growth rate of 2.7%. The inflation rate is 6% (2013); unemployment rate is 3.3% (2013). Its exports in the year 2012 were 6 billion USD, its imports 13.72 billion USD. Cuba's GDP per capita is 6,051 USD (2011); its human development index is high, 0.815. Cuba is an atypical third world country, while it has a fast growing tourism sector as its surrounding Caribbean neighbors its major export are specialized services being medicine their biggest economical "asset". They also export services in sport training, education and engineering. Major export goods are nickel, raw sugar, refined petroleum, rolled tobacco, sea fish, medical products, citrus fruits, hard liquor and coffee. Major import goods are refined petroleum, wheat, corn, poultry meat and milk concentrate. Since 1960, the United States of America have imposed commercial, economic and financial sanctions against Cuba which, according to United Nations approved resolutions against them, can be considered an economical, financial and social "blockade" against the country. Cuba is a net oil importer. The major portions of its energy portfolio come from petroleum and natural gas. Cuba's first solar farm was built in 2013; until 2030 the country aims to generate 24% of its electricity from renewable resources. Cuba has six UNESCO biosphere reserves, seven national parks and three hundred nature reserves, ecological reserves, wildlife refuges, touristic natural areas and ecological reserves.

In Cuba the ministries of energy and mining are responsible for the energy, geology and mining, and basic chemistry sectors of the Cuban economy. The energy sector deals with matters related to oil and gas as well as electricity, and comprises two major organizations, Cubapetroleo known as CUPET and the Electric Trust. They are responsible for prospecting, exploration, drilling and extraction, refining and commercialization. Cuba has twenty oil fields and four oil refineries with a capacity of 5.6 Mt per year. 95% of the country has access to electricity. The installed electricity capacity is more than 3000 MW. Electricity mainly comes from the 17 thermoelectric power plants; other options, such as solar and wind energy, biogas from manure and biomass from sugar cane husk and straw, are increasingly utilized. There is no nuclear power plant in the country.

Major anthropogenic influences on biogeochemical cycles have begun with the industrial revolution at the end of the 19^{th} century. Since then, emissions of greenhouse gasses from industry (the major emitter), the transport sector and the burning of fossil fuels and other human activities that influence our global radiation balance affected the average global temperature. It has increased by almost one degree centigrade; in Cuba, due to local effects, the average maximum temperature since the second half of the last century increased by 0.9 degrees centigrade, and the average minimum temperature increased by 1.9 degrees centigrade. About half of this temperature increase stems from human activities, the other half from natural climate variability. During the same time span, the average rainfall decreased by ten percent, with longer severe droughts in the summer and more severe rainfalls in the winter.

Already in 1991, Cuba installed a commission for climate change related studies to identify risks, hazards and vulnerabilities for the country; after the Rio summit on climate change in 1992 Cuba amended its constitution to include environment protection issues; its National Group of Climate Change was established in 1997. Main effects of climate change on the island are a rise in sea level (1.5 meters by 2050, with accompanying vulnerability of coastal settlements, damage of mangroves and coastal ecosystems), increasing temperature and changing rain pattern, loss of biodiversity and forest cover, reduced agricultural yields and decreased water availability and quality combined with increased impact of vector-borne diseases.

Environmental issues in Cuba are the pollution of the Havana Bay (over the past thirty years the contamination load of the bay has decreased by 60% following a master plan for environmental sanitation of the harbor), forest degradation caused by air and soil pollution, soil pollution from intensive agriculture, air pollution from oil power stations and industrial plants, desertification and endangered species. According to the World Resources Institute, Cuba's greenhouse gas emissions, i.e. its carbon dioxide, methane, nitrous oxide, perfluorocarbon, hydrofluorocarbon, and sulfur hexafluoride emissions, were 55.54 Mt CO_2 equivalents in the year 2010, which amounts to 0.1% of the global total.

Cuba signed the Montreal Protocol, an international treaty related to protection of the ozone layer, and the Kyoto protocol, an international treaty of the United Nations regarding climate change that started to be effective in 2005. It is the first international law that gives compulsory limits for the emission of greenhouse gases in industrial countries. Until 2011, 191 countries and the European Union have ratified the Kyoto protocol. The US never joined, and Canada left in 2011.

Cuban countermeasures for climate change in the energy sector are termed "The energy revolution" and concentrate on energy efficiency and savings as well as the development and use of renewable energy sources. The national electric system was substantially reformed in 2004/2005, by replacing inefficient old devices such as nine million incandescent bulbs (replaced for free), one million fans and two millions refrigerators with efficient ones, and a progressive tariff structure so that high consumers pay substantially more (the first 100 kW per household and month are very cheap, beyond that the price skyrockets stepwisely). Social loans were given to the public for the purchase of efficient new household devices. Further countermeasures are reforestation programs (the forest cover in Cuba increased from 14% in 1959 to 29% in 2015), management of water, soil and droughts, agricultural and industrial waste management and urban planning. The energy revolution resulted in annual total savings of 1.5 billion MWh, and total savings of 20 billion MWh. In 2006 the World Wide Fund for Nature (WWF) stated that in this way Cuba became the most sustainable country on the planet; due to the low energy consumption it has a small ecological footprint, lower than the 1.8 global hectares per head that denote sustainability according to the WWF 2006 Living Planet report. The “new energy revolution” in Cuba started in 2012. It aims at shifting electricity production from non-renewable to renewable sources. In 2014 a new law of foreign investment was approved, with investments in the renewable energy industry among its priorities.

Cuba has diverse topography and a large number of species of fauna and flora (about 10 000 insect species, about 8000 plant species, with nearly 6000 of them being native flowering species). The Northern coast is rocky, the Southern coast rather flat and swampy. The country has seven national parks and various other protected areas. In 2001, Cuba had 31 mammal species and 86 bird species (amongst them the rare Cuban crocodile, manatees, the smallest frog - the pygmy frog - and the smallest bird in the world - the bee elf). The national tree of Cuba is the silvery Royal Palm, which reaches a height of 15-23 meters (50-75 ft); their number is estimated as 20 millions. The national bird of Cuba is the Tocororo, the Cuban trogon, whose feathers show the colors of the Cuban flag (red, blue, white). About one fourth of the island is covered with pine and mahogany trees. According to a 2006 International Union for Conservation of Nature and Natural Resources (IUCN) report, 11 mammal species, 18 bird species, 7 reptile species, 47 amphibian species, 23 fish species, 3 invertebrate species, and 163 plant species were threatened.

Below, we introduce three Cuban national parks, to give a flavor of the fauna and flora of the island.

The national park Alejandro de Humboldt is located in the East of Cuba. Since 2001, it has been UNESCO world cultural heritage. The park is important water storage. It is the most well preserved mountainous ecosystem in the Caribbean (95% is forested), and according to UNESCO one of the biologically most diverse island places on Earth, with 1800-2000 species, 70-80% of them endemic (which means they live only there). Its area is 706.8 square kilometers; the park is surrounded by a 500-meter wide buffer zone. It has a unique variety of ecosystems, with riffs and mangrove forests on the coast, the largest not fragmented tropical rainforest in the Caribbean (50% of the park), mountain cloud forest, and a 1175 m high peak, the El Toldo. The park faces threats such as poachers, illegal logging and forest fires.

The national park Vinales on the Western end of Cuba is much smaller, only 132 square kilometers. The Vinales valley is one of the most beautiful areas in Cuba, a karstic depression encircled by mountains, the landscape flat with up to 300 meter high green dome-like limestone outcrops (mogotes), with spectacular caves and various endemic plants and animals. Traditional methods of tobacco growing on the reddish-brown soil and rich vernacular architecture, crafts and music have not changed substantially for several centuries. In 1999, it was declared UNESCO World Cultural and Landscape Site.

The Guanahacabibes national park is located in the westernmost point of Cuba; it covers an area of 400 square kilometers. On the land, amphibians, reptiles and (between November and March) migratory birds are plentiful. Vast coral reefs with huge cave systems and large fish swarms as well as four species of turtles contribute to a diverse and beautiful marine ecosystem. The Guanahacabibes Peninsula was declared UNESCO Biosphere Reserve in 1987.

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See also: Electricity; Energy; Energy Conversion; Oil/Petroleum; Oil/Peroleum Reserves (Global); Sustainability; United Nations Development Group; United Nations Environment Programme; Water Consumption and Withdrawal; Water Quality Impacts; Watts.

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Daylighting

Daylighting systems are constructions for lighting that guide daylight into buildings and allow for uniform illumination with natural light. They can prevent direct sunlight and glare, and allow for proper uniform illumination of computer workplaces; they furthermore they help to save energy costs for electric lighting and can even be used for heating cool rooms, by making use of the infrared part of the sunlight. Most people clearly prefer natural light to electric light, at home, at school and at work, as it enhances happiness, as do plants and strong colors. There are passive and active daylighting systems. Active daylighting systems trace the sun, and thereby maximize light collection; for passive systems the building orientation is of paramount importance. Famous buildings with daylighting are the HSBC main building by Sir Norman Foster in Hong Kong and the California College of Arts San Francisco Campus by Skidmore Owings and Merrill. Noteworthy historical examples of daylighting are the colorful windows in Gothic churches that transform strong sunlight with sharp shades and glare into a soft play of beautiful colors indoors.

Architecture follows the possibilities. The atria of the past, such as the Roman atrium, are based on the absence of a proper artificial light source. With the introduction of electric light the building density was enhanced, with known consequences. Modern daylighting tries to minimize such consequences, passively, via less building density and changed building structure, and actively, via dynamical light guidance. In the future, for which a 24 hour usage of key facilities and/or operating cycles that are independent of the time of the day can be envisaged, sunlight pipelines or related storage devices might provide the needed daylight. Also dynamic room clusters, changing orientation and position with usage, are conceivable. Premises without people possibly do not need any daylight. Another aspect is the social context. The usage frequency of certain rooms changes depending on the type of use, the resident structure and the social norm. The tasks for daylighting systems are easier when one central room is used 90% of the time, as opposed to various rooms in similar proportions.

The available daylight changes throughout the day between sunrise and sunset. In non-equatorial areas of the Earth, i.e., areas north and south of the tropics, also seasonal changes must be considered and observed. Maximum and minimum values of available daylight are important in planning the orientation of facades. The varying angle of the sunlight allows to determine the distance of the sun from the horizon at a certain time and the depth of the building that is reached by the light. Many people do want daylight, but not direct sunlight at their workplaces. Diffusers, curtains, blinds or tinted glass are used in some cases; however, the price is that the view out from the window, which allows the eyes to relax and adds to our wellbeing, is lost.

Daylighting systems are strongly dependent on latitude (the angular distance North or South of the equator), climate and weather. In most cases various different lighting approaches are combined in one system, such as combining actively sun-tracking systems (that need clear skies) with with backup lighting.

Daylight is important for our natural biorhythms such as the 24-hour circadian rhythm and hormone production. Too little daylight exposure may generate or intensify sleep problems and/or seasonal affective disorder and diseases such as vitamin D deficiency, bone and heart diseases, multiple sclerosis, obesity, diabetes and cancer. Seeing the weather and the changing times of the day contribute to our wellbeing. The natural changes in daylight illuminance levels and color temperature have biological effect on humans. Daylighting provides health and psychological benefits additional to energy savings.

Providing natural daylight to offices, schools or private dwellings can also contribute to prevent the Sick-Building-Syndrome. This is a syndrome where diseases and feelings of uneasiness are directly correlated to the time spent in certain buildings, and its influence on the person via heating, air condition, lack of ventilation, accumulation of gases, too little oxygen supply, etc. In electric lighting systems, low frequency electromagnetic fields can cause discomfort such as headaches, eye strain and attention deficit problems in some people. Daylighting systems can prevent such discomfort, since it does not flicker at all.

Simple daylighting systems are windows on the façade or roof. Lightly colored interior walls, floors and ceilings next to windows more evenly distribute the light, and reduce sharp contrasts. The sawtooth clerestory roof of factories is a simple and highly efficient way to increase the amount of daylight inside. Clerestories are vertically or nearly vertically oriented windows. In sawtooth roofs clerestories can be inserted in any possible compass direction, since no direct sunlight can enter, but in other buildings, difficulties to shade the low sun during certain times of the day or of the year need to be considered.

Windows, skylights and light tubes belong to passive daylighting systems. The inside of light tubes is covered with a highly reflective material. For passive daylighting systems, the orientation of the building is important, as are the building depth and shading objects around the building. On the Northern hemisphere, southwards oriented rooms get most direct light, whereas northwards oriented rooms tend to be dark and cooler. The light coming to North facing rooms is diffuse and therefore might be used more easily than in the southwards oriented rooms were the direct light might cause glare. On the Southern hemisphere the opposite holds. Windows can be coated in various ways, e.g., to selectively reflect unwanted heat or to diffuse direct sunlight.

Normal windows transmit light and heat. Windows, sunroofs, doors or skylights made from smart glass provide daylight tuned to the needs of the people inside. In smart glass installations the amount of light, the glare and the heat can be controlled via external stimuli from the environment or from control systems, resulting in energy savings for lighting and heating/cooling. Passive smart glass systems react to stimuli such as light and heat, whereas active smart glass systems can be controlled by electrical stimuli and integrated with building intelligence systems.

In active daylighting systems, light gathering is optimized via actively tracking the sun with solar collecting and tracking systems. This can be done via heliostats, computer controlled mirrors that reflect the light and warmth into otherwise dark and cold rooms. The transmitted sunrays can be used for lighting and heating. A heliostat is a mirror that continuously reflects sunlight on one specific area. It is for example used to reflect sunlight into windows or light tubes. If only lighting is needed, a cold mirror (i.e., a mirror that only reflects visible light, but no infrared radiation) can be used, and the infrared rays that pass through the cold mirror (instead of being reflected) can be converted to electricity in solar panels.

The most common fancy current daylighting systems consist of optical fibers or tubular light ducts that guide the light into the building. Some of them have active collectors (on the façade, on the rooftop) that track the sun. Fresnel lenses or parabolic reflectors are used to collect the light and focus it onto the end of glass fibers. A Fresnel lens is much thinner than conventional lenses. A parabolic reflector is a curved surface that can collect light, sound or radio waves: examples for parabolic reflectors are satellite dishes, solar cookers and radio telescopes.

There are various other ways to guide light into a building. Adequately arranged reflecting panels are for example used to bring more daylight into office buildings in Hong Kong. For this method, windows need to be present in close proximity. In tropical and temperate regions, anidolic light guides are often the method of choice to bring daylight into a building. Anidolic optics transport light that is collected by protruding façade elements deep into the building, where another anidolic element transfers the light into the room. Anidolic optics means non-imaging optics. Luminaires (light fixtures, light fittings) are structures in the inside of the building that release the light. The daylight can be combined with artificial light.

In fiber-optic concrete systems, optical fibers are embedded into the concrete of the wall or the ceiling, turning the wall translucent, allowing daylight to enter. Such a systems is preferred in countries where no additional thermal insulation of walls and/or ceilings is necessary. An interesting alternative to commercial systems has been suggested from the biomimetics community: sponge spicules, which are made from hydrated silica and can grow up the three meters in length. They have demonstrated light guiding capabilities, however, to grow to that length takes 3,000 years.

Already the Pantheon in Rome had a round skylight in the dome, resulting in impressive effects from natural lighting in the building. Another historical example for daylighting is the Johnson Wax building in Racine, Wisconsin, by Frank Lloyd Wright (1867-1959). The main room has lily-pad columns made of large concrete circles, and daylighting in between, and glass tube daylighting in the interior corridors. The German art movement Bauhaus, which operated from 1919 to 1933, explicitly stated to build with space and light as opposed to bricks. For the Bauhaus movement, daylighting and fresh air were chief design principles. In old Japan, sliding panel doors with translucent screens made of paper separated rooms and provided daylight even deep in the house.

The companies SL Rasch, Bartenbach LichtLabor and Dian Kreatif installed a revolutionary new daylighting system in the Wilayah Persekutuan mosque in Kuala Lumpur, Malaysia. The 3600 square meter large prayer hall is illuminated by bright daylight collected from 12 heliostats, each one meter in diameter. A mirror prism in the zenith of the dome focuses the collected light into the building and onto a single huge central chandelier made from a large glass panel covered with lenses. Optical effects on the lenses spread some of the light into rainbow colors. On days with less favorable light conditions, the heliostats are turned into lamps.

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See also: Compact Fluorescent Bulb; Energy Efficiency; LED; Work.

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Joule

Joule is the derived SI unit of energy, work and amount of heat in physics: $1\ \mathrm{J} = 1\ \mathrm{kg \cdot m^2/s^2}$. SI refers to the International System of Units. Energy, work and the amount of heat are akin to each other. Work in physics is defined as the transmission of energy via a force. A force is considered doing work on a body if the contact point of the force moves a certain nonzero distance. If a body is only held, without moving it, no work is performed. Work is a scalar quantity that can be positive, negative or zero. Scalar means that work has only a magnitude, not a direction. In SI and SI derived units, 1 J can for example be expressed as follows: $1\ \mathrm{J} = 1\ \mathrm{N \cdot m} = 1\ \mathrm{Pa \cdot m^3} = 1\ \mathrm{W \cdot s} = 1\ \mathrm{C \cdot V}$, with N (Newton), Pa (Pascal), W (Watt), C

(Coulomb) and V (Volt) being the derived SI unit for force, pressure, power, electric charge and electric potential, respectively, and m (meter) and s (second) being fundamental SI units for length and time. SI refers to the international systems of units. In atomic and nuclear physics, because of the small forces involved, the electron Volt is often used, with 1 eV = $1.602 \cdot 10^{-19}$ J. The relation between the previously used unit calorie and the derived SI unit J is as follows: 1 cal = 4.184 J. In an old definition by Nicolas Clément from 1824, one calorie is the amount of thermal energy that is needed to heat one gram of water by one Kelvin (named after Irish born physicist Lord Kelvin). Kelvin is the SI basic unit of thermodynamic temperature (also known as absolute temperature). When the combustion energy of foods is given in calories (e.g. on labels of foodstuff), in fact always kilocalories are meant, also known as large calories or nutritionist's calories (Cal). 1 kcal = 1000 cal = 1 Cal.

Thermodynamics is the study of processes in which energy transfer takes place as heat or work. Heat and temperature are two different concepts. Heat is the energy that is transferred from one body to another in case of a temperature difference, from the location of higher temperature to the location of lower temperature. The amount of heat is quantitatively given in Joule. Temperature is a comparative, objective measure of how hot or cold an object is. The Kelvin, the basic SI unit of thermodynamic temperature, is defined as the fraction 1/273.16 of the thermodynamic temperature of the triple point of water. At the triple point of water all its three states, solid, fluid and gaseous, are in thermal equilibrium. The triple point of water is at a pressure of 611.657 Pa (about 6 mbar) and (per definition) 273.16 K. Pascal (Pa) is the derived SI unit for pressure, mechanical stress, Young's modulus and tensile strength: 1 Pa = 1 $kg/(m \cdot s^2)$ = 1 N/m^2. Temperature given in degree Celsius (also known as degree centigrade) is equivalent to temperature given in Kelvin, plus 273.15. A temperature difference of a certain amount of K is equivalent to the same temperature difference in degrees centigrade. The (absolute) temperature in Kelvin starts at absolute zero, at 0 K = -273.15 degrees centigrade. At the standard pressure of 101 325 Pa, water freezes at 273.15 K.

An early theory in physics of heat (stated 1667 by Johann Joachim Becher), deals with an invisible, fluid, fire-like "heat matter" (phlogiston) that can neither be generated nor destroyed. However, the fact that rubbing two bodies against each other can be used to generate any amount of heat destroyed the theory of a "heat matter" with always the same amount. The modern theory of heat was formed in the 1840s. English physicist and brewer James Prescott Joule (1818–1889) showed that when a viscous fluid is intensely stirred, increase or decrease of heat energy correlates with decrease or increase of a related amount of performed mechanical energy. In this way it became clear that heat energy is not subject to a principle of conservation, but rather a form of inner energy. Only the total energy is conserved, and subject to a principle of conservation. Joule was a student of John Dalton (see entry on Atomic Mass Unit).

Heat, like work, represents a transfer of energy. In his famous 1840s experiment on the mechanical equivalent of heat, Joule showed that work, like heat, is a transfer of energy. In this experiment, a weight that was falling to the ground (in air) was connected to paddles in a pot of water, which started to spin when the weight was falling. When the weight falls, the paddle wheels turn and the water heats up. Joule showed in this way that a certain amount of work is always equivalent to a certain amount of heat. In another famous set of experiments conducted between 1840 and 1843, James P. Joule showed the relationship between electrical current flowing through a conductor, electrical resistance, time and the generated heat. In his experimental setup, electrical current was flowing through a wire that was immersed in water. Joule measured the temperature increase of the water after the current was flowing through the water for a certain amount of time, and correlated it with the length and electrical resistance of the wire and the amount of electrical current. The heat produced is proportional to the square of the current, the electrical resistance and the time. In this way, he showed that the power, which is the energy per time, converted from electrical to thermal energy is the same as the electrical current travelling through the resistor multiplied with the voltage. Potential difference is another word for voltage. This relationship is now known as Joule heating, or Joule's first law. Examples for Joule heating are electric heaters and fuses, electronic cigarettes, ironing solders and incandescent light bulbs.

Thus the first law of thermodynamics, which states that the inner energy of a system can only be changed by the transport of energy in form of work and/or heat, is simply a different formulation of the law of the conservation of energy, which says that the total energy of an isolated system is constant. This means that energy cannot be created or destroyed; it can only be transformed from one form to another. The term "energy creation" is wrong in the strict physics sense, rather, the term "energy conversion" shall be used when relating e.g. to power plants.

The specific heat capacitance of a substance is the energy that is needed to heat one kilogram of this substance by one Kelvin. It is temperature dependent, and varies for water by about 1% in the 0-100 degrees centigrade range, which is one of the reasons why the old definition by Clément from 1824 for the unit of energy, work and amount of heat is not used anymore. Instead, Joule is defined as a derived SI unit, by using the three basic SI units kg, m and s.

The pre-fixes k (kilo), M (mega), G (giga) denote 1000, 1 million (10^6 = 1 000 000) and 1 billion (10^9 = 1 000 000 000). 1 kWh = 1000 Wh, 1 MWh = 1000 kWh = 10^6 Wh = 1 000 000 Wh. In electricity-related aspects, often rather than Joules, kWh or MWh are used. In electrical utility bills, kWh are used. Since 1 J = 1 W·s, 1 hour = 60 minutes = 3600 seconds and 1000 W = 1 kW, 1 kWh = 1*1000W*3600s = 3.6*10^6 Ws = 3 600 000 Ws = 3 600 000 J = 3.6 MJ, which are 3.6 megajoules. 1 MWh = 1000 kWh = 3.6 GJ, which are 3.6 gigajoules. A microwave household oven with 1000 W = 1 kW that runs for one hour uses 1 kWh.

The energy content of a battery (power supply) is usually given by its capacity in A·h (Ampere hours). A·h can mathematically be converted to W·h and thereby to W·s = J. For this conversion, the value in W·h must be divided by the voltage of the power source, a value that is approximate since the voltage is not constant during discharge of a battery. The equation for determining battery energy is $E = P \cdot t = V \cdot I \cdot t$, with I being the current (in amperes), V being the electromotive force expressed in volts, P the power expressed in watts, t the time expressed in seconds and E the energy expressed in joules. Energy equals voltage times charge, which is the same as voltage times current times time (since current is charge per time). 1 J = 1 W·s = 1 C·V = 1 A·s·V, with C = A·s, charge C (in Coulomb) equals current (in Ampere) times time (in seconds). 1 Ampere = 1 Watt per Volt. One AA battery has a nominal voltage of 1.5 V and a capacity of 2850 A·h; one AAA battery has a nominal voltage of 1.5 V and a capacity of 1150 A·h. Therefore, a AA battery can supply 4275 W·h = 4.275 kWh, since 1.5 V * 2850 A·h = 4275 W·h = 15.39 MJ; and a AAA battery can supply 6.21 MJ.

It is important to note that the unit for torque is N·m, which is not equivalent to Joule, because torque has a vectorial unit with a direction. The amount of torque describes how much something is turned or twisted. 1 J is the product of a vector force and a vector displacement, and is a scalar unit, whereas torque is the cross product of a distance vector and a force vector, so its unit is a vectorial unit. The institutions of standards and technology therefore discourage the use of the unit N·m for energy, work or the amount of heat, and recommend the use of the N·m for torque only.

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See also: Batteries; Chemical Energy Storage; Compressed Air Energy Storage; Energy; Energy Conversion; Energy Density; Energy Flow (in the earth system); Energy Transitions; Energy Transport; Energy Use, History of (Overview); Work.

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Kyshtym Disaster (Soviet Union)

The Kysthym disaster was a radiological contamination accident that took place in a closed city now known as Ozyorsk on September 29, 1957 in the Chelyabinsk Region of the former Soviet Union, about 1000 miles east of Moscow. It is also known as the Mayak Nuclear Waste Explosion, since it took place in the Mayak Plant, a Plutonium processing site that was part of the Soviet Union atomic bomb project, which is still processing radioactive material. It was the third most serious nuclear accident releasing radioactive substances ever recorded. The Kysthym disaster was the only Level 6 serious accident that ever happened, according to the International Nuclear and Radiological Event Scale INES. Fukushima Daiichi and Chernobyl nuclear disasters are classified as even more serious: both are rated as major accidents - Level 7 on the logarithmic INES scale. Each increasing level represents an accident approximately ten times more severe than the previous level. The number of deaths resulting from the disaster varies according to the sources between 200 and more than 8,000. 10,000 people were evacuated; several villages disappeared from the maps. Russian dissident Zhores Aleksandrovich Medvedev reported the catastrophe to the general public in the West only in 1976. The site contaminated by nuclear fallout was closed to the public in 1968, by erecting the East-Ural Nature Reserve, where any unauthorized access is strictly forbidden.

In 1945, nuclear bombings of the cities of Hiroshima and Nagasaki were conducted by the United States, in the first and only use of nuclear weapons in a war. The Soviet Union started in 1945 with great haste and disregard for safety to erect the Mayak plant in the extreme Southwestern corner of Siberia, in a closed city called Chelyabinsk-65 (earlier called Chelyabinsk-40, now known as Ozyorsk) for highly classified research on and development of nuclear weapons. Six nuclear reactors were operated with an open cycle cooling system, releasing contaminated water into Lake Kyzyltash. Major nuclear safety issues resulted in various accidents at the Mayak Plant, with the Kysthym disaster being the largest. An underground tank storing tens of tons of fluid nuclear waste, results from the production of Plutonium for nuclear weapons, detonated in a chemical, non-nuclear explosion. Reason for the explosion was a spark from an internal control device that ignited crystallized nitrate salts and acetates which formed due to a failing water cooling system. The explosion set free the equivalent of an estimated 310 Gigajoules, and released a total of 740 Petabequerels (PBq) of radioactive fission products. 90% of the products remained on site, and 74 PBq were carried by the wind up to 400 kilometers in Northeastern direction. The resulting radioactive fallout contaminated a region of 15,000 to 20,000 square kilometers, an area that is now known as the East Urals Radioactive Trace. One Gigajoule denotes one billion Joules. Joule is the SI derived unit for energy, work or the amount of heat. In terms of other SI units, 1 J = 1 kg * m^2/s^2. One PBq denotes 10^{15} Bq. Bequerel is the SI derived unit for radioactivity. 1 Bq is defined as the activity of a quantity of radioactive material in which one nucleus decays per second. In terms of other SI units, 1 Bq = 1/s.

The mean equivalent ionizing dose affecting the red bone marrow of the more than 1000 people in the closest villages was about 570 Millisieverts. One Millisievert is one thousandth of a Sievert. Sievert is the SI unit for effective dose, measuring the biological damage produced by radiation. It is given in Joule per kilogram, and results from the absorbed dose in Gray (1 Gy = 1 J/kg) multiplied by a quality factor. This quality factor is necessary to describe the different effects of the same amount of radiation on different body parts: The same beam of radiation passing through a human body deposits a greater dose in denser body parts than in less dense parts, causing different amounts of damage. Since bone is denser than soft tissue such as muscles, ionizing collisions occur more frequently in bone, more irreparable damage occurs in bones, and therefore the quality factor for bone is larger than the one for muscles.

It is not known how many deaths resulted from the fallout. Numbers vary between 200 and 8,000. The explosion was visible hundreds of kilometers away and was explained by the local newspapers that time as aurora borealis (Northern lights).

Since 1951, and during the following decades, Lake Karachay was used by the Mayak facility as nuclear waste dumping site. The Washington DC based Worldwatch Institute on nuclear waste describes Lake Karachay as the most polluted spot on Earth. The top 3.4 meters of lake sediments are almost entirely composed of high level, still lethal, radioactive waste that remains a serious problem. Polluted water from the lake spreads to the North and the South. The Mayak plant is still in operation; about 15,000 employees process and recycle nuclear waste from submarines, icebreakers and nuclear power plants there and commercially produce various radioactive isotopes.

Russian dissident Zhores Aleksandrovich Medvedev made the event known to the Western public in 1976. He published journal articles and books on the incident. 470,000 people were exposed to radiation, 270,000 of them to dangerous levels, and around 10,000 were evacuated. The villages Berdyanish, Satlykovo and Galikayevo, the populated areas with highest contamination, were cleared within about two weeks (without telling the reason for the evacuation); they disappeared from the maps. In further concerned villages, the evacuation took place only hundreds of days after the accident.

The disaster contributed to the formation of the Kyshtym-57 Foundation, which has since 1990 provided support to 15,000 people with chronic radiation sickness, with 200,000 in the region still remaining in need for social protection, medical aid and decontamination of heavily polluted areas. The cancer rate in the region is higher than average.

The contaminated site was closed to the general public in 1968, through erection of the East-Ural Nature Reserve, where any unauthorized access is strictly forbidden. An area of 300 square miles is still heavily contaminated with radioactive Caesium-137 (half life 30 years), Plutonium-239 (half life 24.11 years) and Strontium-90 (half life 29 years). The half life denotes the time after which 50% of the respective substance undergoes radioactive decay. The full extent of the disaster was made public in 1989, 32 years after the accident, three years after the Chernobyl catastrophe, by declassifying documents concerning the accident.

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See also: Fukushima Nuclear Disaster; Joule; Mayak Nuclear Waste Explosion (Soviet Union, 1957); Nuclear Accidents; Radiation (nuclear, coal, gas); Radioactivity.

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Malaysia

Malaysia is a federal constitutional monarchy in South East Asia. It consists of the Malay peninsula (which is located South of Thailand) and part of the island of Borneo (which is shared between Indonesia, Brunei and Malaysia). Malaysia is a multiethnic, multireligious country, with a population of 30.12 million people (2014 data) and tropical climate. It is a founding member of ASEAN, the Association of Southeast Asian Nations, of which it has been member since 1967. Malaysia has an area of 330,290 square kilometers; its capital and largest city is Kuala Lumpur, with 1.6 million inhabitants. Malaysia's GDP (2013) is 312.4 billion USD (2013), with a growth rate of 1.28% (2000-2014). The inflation rate is 3% (2014); the unemployment rate is 3%. Malaysia's exports in the year 2013 were 227.7 billion USD, its imports 192.9 billion USD. Its GDP (PPP) per capita is 22,555 USD (2013); its human development index is high, 0.773. Malaysia is a newly industrialized, developing country, with a fast growing service sector and important agriculture and forestry. Major export goods are electrical and electronic products, petroleum products, liquid natural gas, chemicals and chemical products, palm oil, crude petroleum, machinery, metal manufactures and scientific equipment. Major import goods are electrical and electronic products, refined petroleum products, chemicals and chemical products, machinery, transport equipment, metal manufactures, iron and steel products, crude petroleum and scientific equipment. Malaysia's energy sources are oil, natural gas, coal and renewable energies such as hydropower electricity, biomass, and solar energy. Natural gas as fuel source makes up 75% of its energy mix. 8% of the country is protected area; and further 8% is set aside as forest reserves. The country still has undisturbed virgin rainforests, and rare animals such as tapirs, orangutans, sunbears, rhinoceroses and tigers. However, Malaysia is the country with the highest deforestation rate in the world, and its large biodiversity is threatened.

Malaysia's CO_2 emissions per capita in the year 2010 were 7.63 metric tons, the electricity consumption per capita in the year 2011 was 3 953 kWh. Malaysia's total primary energy production in the year 2010 was 3.7 quadrillion British Thermal Units (BTU) = $3.7*10^{15}$ BTU. With 1 BTU = 1055 J, this can be converted to Joule: $3.7*10^{15}$ BTU = 3 903.7 PJ. 1 PJ = 10^{15} J = 277.78 million kWh. The outputs/shares per energy carrier were: crude oil (513.72 thousand barrels per day), distillate fuel oil (172.11 thousand barrels per day), motor gasoline (108.9 thousand barrels per day), liquefied petroleum gas (100.77 thousand barrels per day), other petroleum products (98.85 thousand barrels per day), jet fuel (63 thousand barrels per day), residual fuel oil (19.22 thousand barrels per day), kerosene (9.91 thousand barrels per day), biodiesel (4.5 thousand barrels per day), hydroelectric power (5.95 billion kWh), coal (3 132.77 short tons), dry natural gas (2 180 billion cubic feet) and natural liquid gas (90.31 billion cubic feet). Malaysia's shares of the total primary energy supplies are as follows: gas 44.3%, oil 38.7%, coal/peat 12%, renewable energy and energy from waste 4.1% and hydroelectric energy 0.9% (2008 data). In terms of electricity production, the share of natural gas dominates with 62%, followed by coal (29.5%), hydroelectricity (6.4%) and oil (2.1%, 2010 data). The main electricity consumers in Malaysia are industry (45%), commercial (33%) and residential (21%, 2012 data).

The fossil fuels oil, gas and coal still dominate electricity production in Malaysia: 86% of the electricity comes from thermal power plants, and 13% from hydropower plants. This is a major change compared to 2006, when still 95.5% came from fossil fuels. The country recently committed to increase the amount of renewable energy in its energy portfolio; this concerns especially hydropower, solar and wind energy as well as biomass (waste from palm oil plantations – Malaysia is one of the World's largest palm oil producers). Malaysia is planning to have 30% of electricity over the next decade generated through hydropower to reduce the adverse effects of fossil fuel use, however, this would in many cases mean the flooding of forested areas for dams. There is no nuclear power plant in the country.

Haze is one of the major pollution problems in Malaysia, and in South East Asia in general. Haze obscures visibility, and causes eye inflammations, asthma, headache, fatigue, nasal and throat irritations, as well as lung tissue inflammation and scarring. In the long run, it leads to cardiovascular diseases and birth defects. Haze in South East Asia mainly comes from burning rainforest and peat swamp areas in their conversion to oil palm plantations, not just in the country itself, but also in Indonesia, from where the haze travels through the atmosphere to Malaysia. In 2002 the ASEAN Agreement on Transboundary Haze Pollution was signed, however, Indonesia is the only ASEAN country that never ratified this document.

Malaysia signed the Kyoto protocol. The Kyoto protocol is an international treaty of the United Nations regarding climate change that started to be effective in 2005. It is the first international law that gives compulsory limits for the emission of greenhouse gases in industrial countries. The pillar of its climate strategy is environmental protection. Until 2011, 191 countries and the European Union have ratified the Kyoto protocol. The US never joined, and Canada left in 2011. The country established a National Steering Committee on Climate Change in 1994 and formulated its National Policy on Climate Change in 2009.

Malaysia committed to a voluntary reduction of 40% in terms of greenhouse gas emissions compared to 2005 levels by the year 2020. The three pillars to reach this goal are energy efficiency, renewable energy and solid waste management. In the MYCarbon program, a national corporate greenhouse gas program for the country, corporations and the general public are encouraged to report their related emissions. In the year 2010, Malaysia had greenhouse gas emissions of 0.2 Gt CO_2e. CO_2e stands for carbon dioxide equivalent; it gives the effect of different greenhouse gases in terms of the effect an equivalent amount of CO_2 would have on warming. CO_2 emissions are steadily increasing in the country, with energy conversion having an increasingly larger share (in 2009, they were at 28.2%). Other contributors are transportation (17.2%, with 85% of this number from transportation on roads and 13 % from transportation by ships), industry, commerce and construction (12.6%), landfills (11.8%), forest and grassland conversion (11.7%), fugitive emissions from fuel (10.6%), mineral products (4.7%), emissions from soil (2.2%) and commercial sources (1%, 2009 data). Important policies are the “National Energy Efficiency & Conservation Master Plan” and the renewable energy capacity target of the country (goal: reaching 2 GW installed renewable capacity in 2020).

Malaysia has diverse topography (lowland forests, highland forests, marine environment, mangrove forest, peat swamps) and is a biodiversity hotspot with a large number of species of fauna and flora. The tropical country has two UNESCO biosphere reserves (Tasik Chini, Crocker Range), two UNESCO natural world heritage sites (Gunung Mulu and Kinabalu Park), five national parks (Taman Negara, Endau Rompin, Islands of Mersing, Gunung Ledang and Penang National Park) and various further protected areas such as nature parks, state parks, wildlife sanctuaries, wildlife reserves and marine parks.

The national flower of Malaysia is the *Hibiscus rosa-sinensis*, the national butterfly is the Rajah Brooke Birdwing *Trogonoptera brookiana*. Malaysia is a country with high species diversity. However, logging (legal and illegal), poaching, burning of forest, the building of highways and the conversion of land that was forested to oil palm plantations and housing areas for the fast growing population reduces the available area for wildlife very fast. Remaining forested areas are at the moment fragmented, and therefore not sustainable. Plans exist to establish wildlife corridors, on the peninsula and in Sabah and Sarawak, the two Malaysian states in Borneo. In 1990, 68% of the country was forested. Between 1990 and 2010 Malaysia lost 8.6% of its forest cover. If the current rate of deforestation continues, there would be no forests left in Malaysia by 2020.

Major anthropogenic influences on biogeochemical cycles have begun with the industrial revolution at the end of the 19th century. Since then, emissions of greenhouse gasses from industry (the major emitter), the transport sector and the burning of fossil fuels and other human activities that influence our global radiation balance affected the average global temperature. It has increased by almost one degree centigrade. Between 1951 and 1996 Malaysia experienced a warming trend of 0.18 degrees centigrade per decade.

Major Malaysian environmental organizations are the Borneo Resources Institute Malaysia, the Centre for Environment, Technology & Development, Malaysia, the Environmental Protection Society Malaysia, the Global Environment Centre, the Malaysian Karst Society, the Malaysian Nature Society, the Malaysian Society of Marine Sciences, Partners of Community Organizations, the Sabah Wetlands Conservation Society, the Socio-Economic & Environmental Research Institute, the Sustainable Development Network Malaysia, TRAFFIC (the wildlife trade monitoring network), Treat Every Environment Special, Wetlands International (Malaysia), World Wide Fund for Nature (WWF) Malaysia, Water Watch Penang, Consumers' Association of Penang, Sahabat Alam Malaysia and the Third World Network (Malaysia Office). The Malaysian Nature Society (MNS) is the oldest environmental NGO in Malaysia; it was founded in 1940. Its main activities are concerned with forest and marine habitat conservation, outreach activities and policy advocacy. TRAFFIC works internationally on conservation issues related to illegal and unsustainable trade of wild animals and plants. Its Southeast Asia office was opened in 1991.

Although Malaysia is still one of the least polluted countries in Asia, especially in urban environments, the fast rate of industrialization brings various environmental problems, such as forest destruction, pollution of fresh water bodies and the ocean, soil erosion, coast erosion (due to the removal of mangrove forests), overfishing and coral reef destruction, air pollution and a major waste disposal problem.

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See also: Electricity; Energy; Joule; Rainforest Foundation Fund; Southeast Asian Haze (1997, 2006); Oil/Petroleum; Oil/Petroleum Reserves (Global); United Nations Development Group; United Nations Environment Programme; Water Consumption and Withdrawal; Water Quality Impacts; Watts.

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Pareidolia

The term pareidolia denotes a cognitive bias that makes people perceive patterns where there are none. The roots of the word pareidolia are the Greek παρά (para, meaning "wrong") and εἴδωλον (eidolon, meaning "figure, representation"). Random auditory, visual, tactile or other stimuli are perceived as significant. One example would be that subjects correlate the content of spam emails or randomly overheard conversations of strangers to current questions and issues in their lives. In most cases, however, the random things that are perceived as patterns are visual signals that are perceived as faces. People tend to see faces in cloud formations, in inkblots (such as the famous Rorschach inkblots), in stone formations, in trees, in caves, on houses, in coffee stains, in everyday environments. Especially in face recognition, perception is highly controlled, filtered and selected by top-down processes. Face recognition centers in the brain more often interpret something that is no face as a face than miss a face. Reason for this might be in the history of the human species, where it has always been of utmost importance to recognize faces as early and fast as possible, and from which results the misconception of faces in purely random patterns and in environments where there are no faces. In contrast to a hallucination, a pareidolia effect can be shared with other people and does not disappear even when the subject is watching (or listening) intensively. Various simple cognitive strategies and intuitive heuristics (rules of the thumb) are based on pareidolia phenomena, especially in situations with large uncertainties or under pressure.

Cognitive Basis of Pareidolia

Sensations are colored by mood, expectations and attention. The human brain tends to complete diffuse and seemingly uncomplete images and structures and to align them with known pattern and forms, predominantly dependent on a subject's expectations. People systematically underestimate that things can happen by chance. It makes them feel better, and gives them a sense of comfort, home and known environment. Their bias to interpret randomness as patterns is the basis for the contribution of randomness to belief systems and behavior.

In human interactions pareidolia might let subjects see patterns and structures in interpersonal relationships that allow them to predict reaction chains between these people for the future, and thereby bring them social advantages. These structures and pattern need not really be (such they would be for empathic people) but in course of self-fulfilling prophecies can become. The term self-fulfilling prophecy describes the phenomenon that the expectations of one person of another person urge this other person to behave like the first person expects it, via positive feedback between belief and behavior: the more the other person behaves as we want/foresee, the more we reward him/her. In the beginning, the self-fulfilling prophecy is a wrong or just random assumption, but becomes true with time and feedback.

Face Pareidolia

Face pareidolia is much more common than any other type of pareidolia. Reason for the preferred perception of faces might be a natural alarm function that is based on an early cortical mechanism for top-down facilitation of face recognition that limits the numbers of object representations that need to be considered in the analysis of visual stimuli. Already babies show a clear preference for faces over all other visual stimuli.

In human face perception, type I errors (false positives) outweigh type II errors (false negatives): more patterns that are in fact no faces are perceived as faces than faces are missed. This points towards the importance of face recognition in social interactions.

Of specific interest is the ability of people to fast see emotions in human faces, even in ones that consist of nothing more than a few quickly drawn circles and lines – there might be paramount evolutionary advantage in the ability to quickly discriminate friends from enemies. The hands of clocks in shops and in advertisements rather show "ten past ten", which is attributed to a smiling face, than "twenty past eight", which is attributed to a sad face.

Religious, Auditory and Tactile Pareidolia

Religious pareidolia refers to the phenomenon that subjects tend to see religious phenomena such as faces of religious figures or the word Allah are perceived on toasts, grilled cheese sandwiches, mold covered windows and others. People who describe themselves as highly religiously faithful tend to experience this type of pareidolia more frequently than subjects who describe themselves as less faithful or not faithful at all.

Auditory pareidolia include the hearing of words and sentences spoken in one's own language in noise (which is sometimes interpreted as the voices of spirits), in people speaking another language or in records that are being played backwards. In this type of pareidolia, the perception can be drastically increased when repetitively listening to the recording with a person pointing out the messages, showing also the power of suggestion. Parapsychologists sometimes use recording devices to capture audio signals that are then interpreted as paranormal messages; this type of auditory pareidolia is known as electronic voice phenomena, EVP, or instrumental transcommunication.

Tactile pareidolia for example arises in the perception and interpretation of palpatory findings in osteopathy, in the course of diagnostic palpation. Palpation is the feeling with fingers or hands during a physical examination. Osteopathy is a system of complementary medicine involving the treatment of medical disorders through the manipulation and massage of the skeleton and musculature. Palpation is a complex process that is influenced by previous experiences, the information the patient gave and the context of the action. Massage therapists might over-interpret "messages from the body" because of tactile pareidolia.

Similar, but Different: Hallucinations, Clustering Illusions, Apophenia, Selective Perception and Hierophany

In pareidolia there is always a sensory stimulus that is interpreted by the subject. In hallucinations, on the contrary, there are no underlying sensory stimuli; the whole perception is internal. Pareidolia is therefore communicable to other people, who might even see the same in the respective pattern, such as the man in the moon or animals in clouds (with or without aid from others).

Pareidolia, the clustering illusion and apophenia are cognitive biases, exemplifying the tendency to perceive connections or meaningful pattern where there are none. In the clustering illusion subjects see a pattern in a random sequence of numbers or events. In apophenia people see "something" in random pattern, and this something disappears when the subject is watching intensively. There is also a link between apophenia and creativity: Leornardo da Vinci (1452-1519) used his ability to see patterns where there are none to fire up his imagination: "*I will not refrain from setting among these precepts a new device for consideration which, although it may appear trivial and almost ludicrous, is nevertheless of great utility in arousing the mind to various inventions. And this is, that if you look at any walls spotted with various stains or with a mixture of different kinds of stones, if you are about to invent some scene you will be able to see in it a resemblance to various different landscapes adorned with mountains, rivers, rocks, trees, plains, wide valleys, and various groups of hills. You will also be able to see divers combats and figures in quick movement, and strange expressions of faces, and outlandish costumes, and an infinite number of things which you can then reduce into separate and well conceived forms. With such walls and blends of different stones it comes about as it does with the sound of bells, in whose clanging you may discover every name and word that you can imagine*".

Patterns need to be recognized as early as possible, enabling proper meeting of the requirements and adequate actions. The human brain is always looking for known patterns, which can be assigned to already known information in an easier and faster way. Selective perception, apophenia, pareidolia and hierophany (the manifestation of the sacred) are examples of protective mechanism that prevent people from information overflow and that help to sort things and bring order into chaos.

Pareidolia Relating to Judgment and Decisions

The human tendency to see pattern in random information (i.e. mainly to see something one wants to see) is generally not seen as beneficial. However, in uncertain situations it can be helpful. An apophenia that serves via complexity reduction as heuristic in a judgment or decision is termed illusory correlation: one sees relations between phenomena that have nothing to do with each other. As opposed to an inference, that is a conclusion reached on the basis of evidence and reasoning, most judgments are not reached by inference, but are strongly influenced by social factors and cognitive processes influenced by experience, history, motivations, goals and expectations. Judgmental heuristics are rules of the thumb that allow fast and economic judgments in situations with various uncertainties. Judgmental heuristics are automatic, involuntary and unconscious thinking processes that happen without attention and effort. Judgmental heuristics are also used by subjects who want to think in a controlled, not automatic, voluntary and conscious way, but cannot, because of fatigue, disturbance, distraction or similar factors. Pareidolia can accelerate judgment and decision-making.

In decision engineering reduction of complexity is an important aspect in optimization. As the fast face recognition in pareidolia demonstrates, such optimizations also take place in human cognition and can serve as valuable inspiration for decision engineering and related fields.

Figure 1: Photo of an *Abrus precatorius* seedpod. Various subjects report to see this image of a seedpod as a human face, a mask or a dragon. Image source: http://pixdaus.com/abrus-seed-pod-one-of-the-components-of-this-seed-is-one-of/items/view/35487/. Permission requested.

Figure 2. Photo of some books, a box with tea, a first-aid box and the brush part of a broom. People are especially good at perceiving emotions of faces. This photo is interpreted by many as a happy face, as opposed to the seedpod in Figure 1, which is rather interpreted as angry face.

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See also: Clustering Illusion; Cognitive Biases (Overview); Conscious and Unconscious Thought; Mental Models; Selective Perception.

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Rainforest Foundation Fund

The Rainforest Foundation Fund is a New York based nonprofit organization that was initially founded in 1989 as the Rainforest Foundation International, by the Belgian filmmaker Jean-Pierre Dutilleux, the musician Sting and his wife Trudie Styler. The mission of the Rainforest Foundation Fund is to protect and support indigenous and traditional populations of the world's rainforests in their efforts to conserve their environment and fulfill their rights to land, life and livelihood. Today, the fund supports three autonomous organizations: Rainforest Foundation US, Rainforest Foundation Norway and Rainforest Foundation UK, which together have projects in more than 20 countries on three continents (South America, Africa, Asia). Further monetary sources come from grants, events and donations from individuals and companies.

The Earth's area covered by rainforests is shrinking at a rate of 5-10% per decade. The current rate of rainforest destruction is the equivalent of two football fields every second. Countries with the highest deforestation rate are Brazil, Indonesia, the Democratic Republic of Congo and Malaysia.

The main causes for rainforest destruction are human activities: such as logging for timber, burning (burning Indonesian forests which causes haze at alarming levels that is hazardous to human health in Malaysia and Singapore) to clear the land for monocultures such as oil palm plantations (for biofuels and food) or to provide grazing land for cattle or land for housing estates, and for mining. Also drying because of less rain due to climate change threatens rainforests.

Burning the rainforests also contributes to increased carbon dioxide concentrations in the air. carbon dioxide is a greenhouse gas that substantially contributes to climate change. Although rainforests currently only cover less than two percent of the Earth's surface, they are home to 50% of all plant and animal species.

When Sting and Trudie were flying over the Amazon rainforest in the 1980s, they realized its beauty and vulnerability, and were shocked by the deforestation they spotted. They met with a tribesman, the Kayapo leader Raoni, who had gained internationally renown in the film documentation that Dutilleux presented at the 1977 Cannes Film Festival, and is arguably the most famous Amazonian Indian. Sting, Trudie and Raoni have since since met with various heads of state and have discussed deforestation issues and threats with them. The Kayapo are a nomadic indigenous people who live along the Xingu River in the Eastern part of the Amazon rainforest; they have been in contact with outside society only since the 1960s. Sting and his wife decided to found an initiative protecting rainforests. Their approach is focused around a rights-based approach for peoples living in rainforests. Such peoples have a close relationship with their environment and its sustainable management. Nowadays, it is increasingly hard for most of them to solely live off the rainforest. Because modern civilization takes out large and precious timber such as gaharu (eaglewood), poaches the large mammals, and pollutes air and soil and water with a middle age technology that harms more than it helps. The indigenous population of the Amazon drastically reduced, from over 6 million in 1500 B.C. to just 250.000 in the early 1990s.

The way of life and view of the world of indigenous peoples is very different to our representation of modern society. Protection of the natural environment (on which we all utterly depend) inherently belongs to their grand concepts. Indigenous peoples are marginalized in various aspects. Many of them are culturally, economically and physically threatened.

Rainforests in the tropics are an important carbon storage. Reduced deforestation (logging, peat fires, forest burning) could decrease carbon emissions by 20%, additionally to the almost two billion tons of Carbon that are stored annually in rainforests (tree bark, leaves, soil).

Current projects of the Rainforest Foundation Fund UK comprise drafting a new law for Congo, providing access to education in Cameroon, training community lawyers in Cameroon, implementing community mapping in the Democratic Republic of Congo, protecting land rights for Ashaninka people in Peru, lobbying for forest laws in the Democratic Republic of Congo, reducing logging and increasing forests in the Central African Republic, monitoring Gabon's forest policy, monitoring rainforests and climate change, obtaining protection rights for the Baka, Bakola and Bagyeli (three hunter gatherer peoples in Cameroon), supporting Congo non governmental organizations and the Pakitzapango dam campaign (this planned dam in the Peruvian amazon would flood 73,000 ha of forest, and result in the displacement of more than 10,000 members of the Ashaninka people).

Current projects of the Rainforest Foundation Fund US comprise support of the Yanomami people in Northern Brazil in defense against Gold mining activities and the illegal establishment of cattle grazing grounds, as well as the provision of health care, outreach and awareness programs for indigenous peoples in Guyana (where rainforests still cover about 80% of the country), educating the Kuna people in Panama on climate change and the United Nations collaborative program on reducing emissions from deforestation and forest degradation in developing countries (UN-REDD Programme), helping the Wounaan people of Panama to obtain legal title to their lands (covering significant portions of untouched rainforest which are threatened by clearing for, e.g., agriculture and the provision of grazing land for cattle), and collaboration with organizations in Peru regarding the provision of healthcare, which is a public good and legal right of all Peruvian citizens, to the Kandozi and Shapra peoples who live in Peru's Northern Amazon.

Current projects of the Rainforest Foundation Fund Norway are focused on increasing awareness in the country on rainforest issues, on the grass root, policy and business levels. In their palm oil campaign they informed citizens on rainforest destruction and social conflicts in Indonesia and Malaysia (the two major producers of palm oil) related to the creation of palm oil plantations. This campaign was successful as within one year, the consumption of palm oil containing products in Norway decreased by 64%, from 15,000 tons in 2011 to 5,400 tons in 2012. The Rainforest Foundation Fund Norway also runs, with partners, projects in the Amazon, in Central Africa and in South East Asia (Indonesia, Malaysia, Papua New Guinea) and Oceania. The Norwegian Ministry of Foreign Affairs supports their initiative "Sustainable Management of Amazon Territories Across National Boundaries and Founded on Legal Rights" in the Amazon.

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See also: 2030 Frame for Climate and Energy Policies (EU); Amazon Watch; Americas Energy and Climate Symposium; Biodiesel; Biogeochemical Cycles (water cycle, carbon cycle, nitrogen cycle, etc.); Brazil; Carbon Footprint; Climate Action Network; Climate Action Plan; Climate Change: Coal; Coal Mining; Costa Rica; Economic Costs of Climate Change; Energy and Climate Partnership of the Americas; Framework Convention on Climate Change; Indonesia; Intergovernmental Panel of Climate Change; Malaysia; Mountain Top Removal Mining; Peru; Water; Water Quality Impacts.

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Selective perception

Selective perception is a cognitive bias that influences a person's decisions and judgments. This psychological phenomenon denotes that only selected aspects of the environment are perceived, whereas others are filtered out. Selective perception is a consequence of the mostly unconscious search for certain patterns in sensory stimuli. This search is influenced by personal ideals, experiences, expectations, interests, attitudes and moral concepts. The mind is always looking for patterns, to be able to cope with the huge amount of information and to better integrate new information in already existing one. Patterns with a complexity between perfect symmetry and noise without any structure are perceived most likely. In selective perception, information that reinforces the own position is perceived preferably; whereas information that weakens the own position is not perceived. Information is sought, selected and interpreted in a highly subjective way, fulfilling one's own expectations.

Perception

The understanding and definition of the concept of perception are different in psychology and physiology as opposed to philosophy. In psychology and physiology, perception is the basis for learning processes. It is defined as the processing chain of sensory information that helps the individual to adapt to the environment or gives him/her feedback on the effects of his/her behavior.

The perception chain goes from measuring the sensory stimuli (e.g., in receptor cells such as the inner hair cells in the inner ear) via transduction and processing to perception, recognition and acting, with important steps of selection, processing and interpretation. In the processing phase, signals are balanced with previous knowledge. Thereby, in psychology and physiology not all sensory stimuli are called perceptions, but just the ones that are cognitively processed and serve the orientation of a subject. Perception allows for meaningful actions and – in higher organisms – for the construction of mental models of the world, allowing for anticipatory and planning thinking.

The two controlling processes during perception are termed *selection* and *inference*. Selection acts as a filter, only a small part of the whole sensory spectrum is perceived and processed. Inference denotes that one transcends the available information and unconsciously draws conclusions about not perceived and/or not perceivable properties, to complete the image.

Philosophy, on the other hand, discriminates perception from cognition. Cognition denotes the mental processing of matters that are perceived. Perception denotes the sensual image of the outside world in the central nervous system of organisms and relations between the perceived objects.

Psychological basis of selective perception

The evolutionary advantage of humans as a species is based on enormous adaptability. Selective perception denotes the phenomenon that only certain contents are perceived. These contents are determined by a subject's wishes and experiences. Selective perception has a goal and a function. Subjects perceive the world in a highly subjective and individual way that is constructed by interpreting certain parts of the environment.

Confirmation bias is a concept from cognition psychology that describes the tendency of subjects to search, select and choose information in a way that they confirm their own expectations. Further concepts that are related to selective perception are the law of attraction, cognitive dissonance and distortion and self-fulfilling prophecies.

What a subject sees a stimulus as depends on what he/she knows. The phenomenon of selective perception is not just a visual one, but a cognitive one. Perception is shaped by higher centers in the brain. The brain filters the environment and obviously shows the subject the world as he/she wants to see it at the moment. Visual perceptions for example are guided by feelings, memories and expectations, and what people see depends on their worldview.

People selectively perceive what complies with their current task, goal and requirements. Selective perception might also be called blindness due to inattentiveness, and is an impressive example for people's ability to concentrate.

Similar to a person's body, a person's brain adapts its way of working to environmental conditions. Patterns need to be recognized as early as possible, enabling proper meeting of the requirements and adequate actions. Therefore, only things (pleasant or unpleasant) are consciously perceived that fit already experienced situations or existing expectations; everything else is suppressed and filtered out. The main goal of the perception is successful actions.

Selective perception is a result of one of the strongest aspects of our brains, and allows for the discrimination of matters of importance from matters of no importance. The human brain is always looking for known patterns, which can be assigned to already known information in an easier and faster way. Selective perception, which might also be called attentional blindness, is a protective mechanism that prevents people from information overflow.

Important experiments in selective perception

The US American researchers Dan Simons and Christopher Chabris published a famous video in which, unnoticed by about 50% of first time viewers, a woman dressed as a gorilla walks through a group of people playing a ball game. Reason for this is that the attention of the viewers is focused on a task, namely counting the number of passes of the ball with the white team. In the 50% of people who do see the gorilla, attention is distracted from the original task, allowing focusing on the unexpected. When people view the video a second time, many are surprised on how such an obvious stimulus can have passed the scene unnoticed.

In a second experiment by the same authors, another video (video II) is played to the viewers. They know about the gorilla, have seen the first video, and expect (and see) the gorilla in video II. Only 17% of the people in this group notice the change in color of the prominent background curtain and the disappearance of one person in video II. These changes are noticed by about double as many people (29%) from the control group, who do not know about the gorilla. These experiments show the power of selective perception; even when the unexpected is expected, perception is not improved – rather the reverse takes place, it is impoverished.

Filters in selective perception

Various filters such as expectations, emotions, experiences, attention, motivation, interests, context, ideologies, goals, interests, beliefs, prejudices and attitudes unconsciously influence a subject's perceptions in everyday life. Education, media and social environment influence these filters. Expectations are of specific importance in selective perception – they act similar to templates. Subjects tend to evaluate actions of people they like more positively than actions of people they do not like. Selective perception focuses attention to stimuli that serve to achieve conscious or unconscious goals, wishes, needs and tendencies.

Dangers of selective perception

Selective perception can be dangerous since it stays active even outside of situations already known to the subject. Selective perception is not objective; it rather complies with *a reality of the subject* than an *objective reality*.

The more a subject concentrates on one aspect only, the easier other, potentially important aspects in the environment can slip their attention. Blindness due to inattentiveness is the reason for various car accidents, after which people report that they did not see the other car at all. In some subjects, predominantly negative things are perceived, and continue to be selectively perceived. This leads to a negative worldview, where in the long run only negative things dominate the perception of the person, which can lead to mental disorders.

Especially environments where it is impossible for the subject to detect any patterns tend to irritate subjects, and they start to see patterns (such as faces of friends, or words in one's own language although people are speaking a language the person does not understand) where there are none – such as in clouds, stone formations, spam emails or inkblots. This phenomenon is called pareidolia.

Cognitive dissonance and related phenomena in selected perception

The concept of cognitive dissonance in social psychology denotes an uncomfortable emotional state that is generated by cognitions such as perceptions, thoughts, opinions, attitudes, wishes and intentions that are not compatible with each other in a subject, and that are therefore avoided. Rather, subjects actively search for cognitive consonance, which is perceived as comfortable. One consequence of this phenomenon, which is termed seeing-and-avoidance hypothesis, is selective perception of information, such as visual stimuli. Strong emotions such as fear or being over nervous can change perception in two ways, either by sharpening the senses or by inducing distortions in perception of various potencies.

Subjects tend to stick to their decisions or justify them (confirmation bias), by downgrading new dissonant information that is in conflict with their decisions, and upgrading consonant information that confirms it. Decisions are changed only after a certain individual tolerance threshold is crossed, to bring experience and decision into consonance again. The amount of felt dissonance by dissonant information is dependent on the tolerance and readiness for change in the respective subject.

If indeed something is perceived that is in contrast to learnt things or that contradicts something already learnt, cognitive dissonance arises. With this phenomenon, the firm image that a subject has made from the world to be able to cope with it shatters. This means uncertainty and danger, since the strategies that helped this subject to survive in the past prove to be not safe anymore. Either the subject integrates the new experiences, or denies them. Selective perception prevents cognitive dissonance. Life might be confortable or not, most important is that the subject copes with it. Selective perception is therefore an adaptation of perception to the environment, to ensure optimal actions.

The brain continuously tries to process perceptions according to past experiences. This gives a sense of safety. Things that might challenge this feeling of safety are often not perceived. In this way, selective perception not only contributes to refine and improve already learnt things, but also prevents that disturbing information gets through to the subject. Without selective perception the subject would need to make accessible and analyze each already known situation anew.

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See also: Choice Supportive Bias; Cognitive Biases (Overview); Confirmation Bias; Decision

Model; Experience-Weighted Attraction (EWA); Mental Models; Pareidolia.

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Time Perception

Time perception denotes the perception of the passing of time, temporal sequences, time intervals and the presence. Chronobiological timers can be exogenous (i.e., coming from outside the body) or endogenous (i.e., coming from inside the body). In all organisms inner clock and endogenous timers regulate periodic physiological processes and repetitive behavioral patterns with period durations from milliseconds to years. Examples for such periodic patterns are sleep patterns and leaf movements in plants, which both are circadian rhythms, meaning they have a 24 hour rhythm. Further examples for patterns that occur periodically in time are menstrual cycles, winter rest and cell division. Many of these cycles are interdependent, and have, with time, become endogenous cycles that also occur if the organisms are not subject to external timers, such as on a spacecraft. There is no specific organ for time perception in humans. Time perception can easily be manipulated. Experiencing the change of day and night is important, not to generate temporal rhythms in people, but to synchronize them. Experiments with people who lived in conditions with no natural light for a long time showed an inherent day-night cycle, although, without external natural light stimuli, most people revert to a 25-hour rhythm. The circadian rhythm is sensed by a small region in the hypothalamus of the brain, above the visual nerve, called suprachiasmatic nucleus. From brain imaging studies, it is concluded that especially the basal ganglia and the right parietal lobe are important for the development of the human feeling for time. In decision sciences, time is seen as resource, influencing judgment and decisions under time pressure and with limited time budget.

Neural basis of time perception

Nearly all organisms have an inner clock. Spending too much time in indoor low light conditions can lead to disturbance of the inner clock in humans, causing sleep and eating disorders as well as depressions. Also single celled organisms have an inner clock – which tells us that no network of cells needs to be present for such a phenomenon.

Central pattern generators, possibly in the form of coupled oscillators, serve as timers in the central nervous system of animals. Clock genes are genes that control temporal rhythms. Pacemaker neurons and neuronal networks such as the cardiac pacemakers in the heart give rise to rhythmic motor activities by the generation of bursts of activity depending on complex cellular and intercellular activities.

Economic, social and cultural dimensions of time perception

Time is an object of value in economy. Social time is mainly coupled to working rhythms. Societal perception of time only appears in cultures with division of labor, coupled with planning, and not yet in hunter-gatherer cultures.

Comparative cultural studies and their philosophical reflection increasingly reveal that there is no time as anthropological constant for each and everybody. What rather exists are culturally specific concepts with diverse structures such as the cyclic one of peoples which live close to nature (who believe in the eternal recurrence of the same), the eschatological one (concentrating on the end of ordinary reality and reunion with the divine), the straight and continuous one, on which most traditional physics is based, and that is the basis of the western culture (but often seen as universal) and the dilating one, that may branch any moment, causing multiple universes and that might be able to explain the time concept of quantum theory.

Modern technological cultures have a linear concept of the flow of time, coupled with the concept of progress, whereas traditional cultures know periodic flows of time, with the concept of progress being unfamiliar to them. In Western societies, time is seen as an important resource. With this concept come phenomena such as time distress and time pressure, being generated from the need for coordination in a society.

Personal perception of time is in stark contrast to the concept of time in economy-dominated structures that are based on a linear model of time with economic growth, established economical structures and the beat of the finance system and machine production. Time management and multitasking can be misleading when viewed as simple effectiveness increase and cause burnout and depression – which is the reason why various researchers currently recommend a deceleration of current society.

Relativity of time perception

Interesting aspects of time perception in humans is that life seems to accelerate with age, that internal time seems to pass in a different way than external physical time as measured by a mechanical clock, that time in dreams, daydreams and fantasies seems to pass in different ways, and that, especially in dangerous situations such as a critical situation when driving of when falling off a fast running horse, time seems to stretch and allow a person to plan actions and realize them in a very rational way.

Perception of time durations is variable. If a person experiences something interesting, time flies and passes by very fast. However, if this person remembers this time of his/her life, it seems to stretch, since so many interesting. The opposite is true if the person goes through a boring time, during which time seems to pass very slowly. However, if this person remembers this time, it seems to occupy only a small stretch, since nothing interesting happened. Experiencing and remembering the same time duration result in different perceptions of the length of its duration.

Perception of the presence and simultaneity in time

The perception of simultaneity of sensory signals is complicated and interesting. Signal conduction in nerves has a certain velocity, and visual and auditory signals travel with different velocities in air (for example, the flash of a lightning that happens far away can be seen much earlier than the corresponding thunder can be heard, the closer to the person the lightning takes place, the closer the thunder and lightning are perceived together in time, and if they happen very closely, they are perceived as concurrent). Simultaneity of visual stimuli is perceived when the signals are at maximum 20 to 30 milliseconds apart (a millisecond, ms, is one thousandth of a second, 30 ms are equivalent to 0.03 s); simultaneity of auditory stimuli is perceived when the signals are at maximum 3 milliseconds apart. Consecutive visual signals can be ordered in time when they are at least 40 ms from each other. Reaction times are dependent on the attention of a person, and vary between 0.3 and 1.5 seconds.

The presence is the time in which everything happens. The perceived duration of the presence in humans is three seconds.

The duration of the presence seems to be 2.7 seconds, according to neurological and psychological studies. This duration is similar to the German wording *Augenblick* (blink of an eye) that denotes an instant. This approximately three second time interval is also of importance in lyrics and music, especially in the perception of rhythm and rime. For the manufacturing of a present given the inputs from various senses, the human mind has to integrate stimuli that arrive faster and slower. Generally, the organism waits for the slowest overall information until the present is generated. In this way, it may well be that large animals (and perhaps also people) that need to integrate stimuli that come from various parts of their bodies live further in the past than smaller animals.

Human time perception can be the subject to temporal illusions. In a famous example published in 2008, the US American neuroscientist David M. Eagleman showed that when a light is flashed one tenth of a second after a person presses a button, for the person the pressing and the flash appear simultaneously, because the time between these two events is so small that they become concurrent in the mind of the person. If now after some time the time delay is removed, and the light flashes when the person pushes the button, for the person something magic happens: the light flashes before (s)he hits the button. Independent of when the person pushes the button. All this because people can discriminate visual events that are 0.04 seconds apart, but sometimes the brain waits for visual and other stimuli for 0.1 seconds to integrate them into one present.

Time and qualia

Various physicists and philosophers see the seeming flow of time as a subjective phenomenon or even as illusion. It is assumed that it is closely connected to consciousness, which is another phenomenon that cannot be explained or described in physical terms. Time perception would in this case be comparable to the qualia known from the philosophy of consciousness (qualia are subjective contents of experience) and would have as little to do with reality as the conscious perception of the color green has to do with the respective wavelength of light (different colors correspond to different wavelengths, animals and people have receptors with varying bandwidths in their eyes, and in the receptors in the eye the stimuli are encoded as electrical signals that travel to the brain and are processed in vision centers – the brain itself lies in total darkness, and does not actually see the respective wavelengths).

Time in physics

The Christian theologian Augustinus von Hippo (354 – 430) was the first to discriminate between physical time, which can be measured exactly, and subjective time related to experience. The concept of time is closely correlated to the concept of causality, the relationship between cause and effect. Only things that happened in the past or happen in the presence can influence things that will happen in the future, not *vice versa*.

Time and its inverse, frequency (time is measured in seconds, frequency is measured in Hz, the inverse of seconds, 1 Hz = 1/s), are the physical quantities that can be measured with the highest precision. Even the current definition of length, via the meter, is made via time: it is the time that the light in vacuum covers in 1/ 299792458 seconds.

The flow of time in the natural sciences has a unique, irreversible direction, resulting the concept of the arrow of time, and can be determined via the direction of the increase in entropy (entropy is a measure for disorder – the flow of time in closed systems goes from order to disorder; a teacup for example is first whole and functional, and then shatters into pieces – we never see pieces of a shattered teacup reorganizing into a function teacup again, without the help of external energy, e.g. a person gluing the parts together). The phenomenon of simultaneity in time for different observers who move at different speeds becomes relative in Einstein's relativity theory.

Modern physics proposes for the phenomenon of time a so-called Planck time of 10^{-43} s below which time looses its properties as continuum. Time in general relativity theory is not necessarily unlimited. Modern physics assumes that the Big Bang was not just the beginning of the existence matter, but also of space and time.

Time in philosophy

There are many open questions with relation to time. Time in philosophy refers to changes and the succession of events that are perceived by the conscious human mind. Question dealt with in the philosophy of time are: What is time? Does time exist when nothing else is changing? How is time related to the mind? Why does time have an arrow? Was there a time before the Big Bang? Is there a timeless substratum from which time emerges?

Large time scales are important in tactical and strategic decision-making. In decision sciences time is seen as a resource and as a contextual factor –time resources and horizons influence decision-making processes and performance.

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See also: Long Time Horizons; Risk Perception; Selective Perception; Time Pressure; Timeless Decision Theory.

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Watts

Watt is the derived SI unit of electrical or mechanical power in physics: 1 W = 1 kg·m^2/s^3. SI refers to the International System of Units. Energy and power are different concepts in physics. Power in physics is defined as the rate of doing work, which is equivalent to the rate at which energy is transformed. Power is a scalar quantity that can be positive, negative or zero. Scalar means that power has only a magnitude, not a direction. In SI and SI derived units, 1 W can for example be expressed as follows: 1 W = 1 J/s = 1 N·m/s = 1 Pa·m^3/s = 1 A·V, with J (Joule), N (Newton), Pa (Pascal), A (Ampere) and V (Volt) being the derived SI unit for work, force, pressure, electric current and electric potential, respectively, and m (meter) and s (second) being fundamental SI units for length and time. The relation between the previously used units calories per second, British Thermal Unit per second (BTU/s) and horsepower and the derived SI unit Watt is as follows: 1 cal/s = 4.184 W, 1 BTU/s = 1055 W and 1 hp = 746 W. The pre-fixes k (kilo), M (mega), G (giga) denote 1000, 1 million (10^6 = 1 000 000) and 1 billion (10^9 = 1 000 000 000). 1 kW = 1000 W, 1 MW = 1000 kW = 10^6 W = 1 000 000 W.

Watt, the unit of electrical and mechanical power, is named after the Scottish engineer

James Watt (1736-1819). Contrary to popular belief, Watt was not the inventor of the steam engine. The Newcomen steam engine had been patented already in the year 1698, and was used to pump water out of mines (it was only capable of up and down pumping). In 1781, Watt made his revolutionary invention: the rotary-motion steam engine that, opposed to the Newcomen engine, could be used for different kinds of machinery. This allowed for the mechanization of weaving, spinning and transport. Within short time, this engine was used in factories producing textiles, paper, flour and cotton; by 1800 already 500 of Watt's machines were installed in mines and factories all over the United Kingdom. The machines were also used in iron mills, distilleries, canals and waterworks. Watt also invented the steam locomotive.

When Watt and his business partner Matthew Boulton started to produce and sell steam engines, for which they had a near monopoly, they needed a measure to specify the power of the engines, so to justify the premium that they charged their customers for using them. As premium they set one third of the savings when the motor does the work compared to when a herd of horses does the work, for 25 years). Watt decided to compare engine and horse powers. In this way, he invented the physical concept of horsepower, describing how much work his motors can do per unit of time. A good horse can work all day at an average rate of about 2/3 of what he defined as a horsepower. Not to be accused of exaggeration when describing his motors with words such as "this is a 50 horsepower engine", Watt decided to multiply this number by 3/2. One horsepower is equivalent to 746 W.

The increased use of machinery and factories ignited the industrial revolution at the end of the 18^{th} century and lead humankind into the era of the anthropocene, which is the era when the human influence on the living environments of Earth became paramount. Mass production provided many people with goods or services, but also resulted in the development of various environmental hazards. The detrimental effects on ecologies would in many cases only be realized decades later.

If a mechanical force is acting in parallel to the direction of movement, mechanical power P can be expressed as $P = F \cdot v$, with F being force, and v being velocity. The related vector equation $P = \mathbf{F} \cdot \mathbf{v}$ is valid without limitations, since the angle dependency is taken into consideration in the scalar product of the vectors **F** and **v**. For rotational movement against torque **M**, $P = \mathbf{M} \cdot \boldsymbol{\omega}$, with $\boldsymbol{\omega}$ being the angular velocity around an axis that is parallel to the direction vector. For a spindle with torque M, the power of the spindle (e.g. in an engine) is $P = 2\pi \cdot M \cdot n$, with M being the angular moment and n the number of rotations, with $n = \omega/(2\pi)$. The power of an engine describes how much chemical or electrical energy can be transformed to mechanical energy per unit of time. In most cars, nearly 85% of the converted energy is wasted as thermal energy that goes out the exhaust pipe, plus friction in the moving parts. This means that most car engines are only 15% efficient. The power of a car is limited by the rate at which it can do work, such as accelerate, drive up a hill, overcome air resistance and the forces of internal friction. The power of a car is most frequently given in horsepower.

Hydraulics deals with liquids moving in confined spaces under pressure. Hydraulic power P via work of a volume is the product of the pressure difference Δp and the flow $Q = \Delta v/\Delta t$: P

$= \Delta p \cdot Q$.

Power of a light bulb or heater describes how much electric energy is transformed to light and thermal energy per unit of time. Incandescent light bulbs for example are very inefficient in the conversion of electric energy to light energy: 90% of the converted energy is thermal waste energy, and only 10% is light energy! The electric power P describes the rate at which electric energy is transferred by an electric circuit: $P = U \cdot I$, with U being the voltage (potential difference) and I being the current. The average power of a lightning bolt in a thunderstorm is 5 GW; its average duration is 30 microseconds (which is 30 millionth of a second).

Power stations produce power that is measured in watts (or kW, or MW). Energy is sold as Wh (or kWh, or MWh) to households and the industry, which is the power in watts multiplied by the running time in hours. Electric energy can easily be converted to other forms of energy; however, the efficiency of the conversion is in many cases less than 100%.

The typical power consumption of commonly used electrical household components are: LCD television set 30-300 W, LCD monitor 30-45 W, PC 300-400 W, laptop computer 40-60 W, refrigerator 150-300 W, incandescent light bulb 25-100 W, fluorescent light 15-60 W, halogen light 30-80 W, speaker 10-300 W, microwave 100-1000 W and air conditioner 1000-2000 W. If for example an air conditioner with 1000 watts runs for 1 hour, 1000 Wh = 1 kWh are consumed.

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See also: Batteries; Biogeochemical Cycles (water cycle, carbon cycle, nitrogen cycle, etc.); Cogeneration Power Plant; Combined Cycle Power Plant; Energy; Hydroelectric Power; Hydropower; Joule; Power; Power Density; Solar Power; Wave Power; Wind Power; Work.

Further Reading

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