D

2,4-D 2,4-dichlorophenoxyacetic acid (2,4-dichlorophenoxyethanoic acid): a synthetic *auxin used as a weedkiller of broad-leaved weeds. *See* PESTICIDE.

D'Alembertian Symbol $\Box$ (sometimes printed $\Box^2$). An operator that is the analogue of the Laplace operator in four-dimensional Minkowski space–time, i.e.

$$\Box = \partial^2/\partial x^2 + \partial^2/\partial y^2 + \partial^2/\partial z^2 - (1/c^2)\,\partial^2/\partial t^2,$$

where c is the speed of light. The D'Alembertian is very useful in the special theory of relativity.

D'Alembert's principle A formulation of Newtonian mechanics that reduces dynamics to an equilibrium condition like statics by extending Newton's third law to the case of forces acting on bodies rather than just bodies in static equilibrium, i.e. it postulates that bodies are always in equilibrium even when they are acted on by a force because the force applied to the body minus the rate of change of the momentum with respect to time is always zero. It was proposed by the French mathematician Jean le Rond D'Alembert (1717–83) in 1743.

dalton *See* ATOMIC MASS UNIT.

Dalton, John (1766–1844) British chemist and physicist. In 1801 he formulated his law of partial pressures (*see* DALTON'S LAW), but he is best remembered for *Dalton's atomic theory, which he announced in 1803. Dalton also studied colour blindness (a condition, once called Daltonism, that he shared with his brother).

Dalton's atomic theory A theory of *chemical combination, first stated by John Dalton in 1803. It involves the following postulates:
(1) Elements consist of indivisible small particles (atoms).
(2) All atoms of the same element are identical; different elements have different types of atom.
(3) Atoms can neither be created nor destroyed.
(4) 'Compound elements' (i.e. compounds) are formed when atoms of different elements join in simple ratios to form 'compound atoms' (i.e. molecules).

Dalton also proposed symbols for atoms of different elements (later replaced by the present notation using letters).

Dalton's law The total pressure of a mixture of gases or vapours is equal to the sum of the partial pressures of its components, i.e. the sum of the pressures that each component would exert if it were present alone and occupied the same volume as the mixture of gases. Strictly speaking, the principle is true only for ideal gases.

dam A structure built across a river to impound or divert the flow of water. A dam may be constructed for one or a number of purposes. It may raise the water level to increase the depth for navigation purposes; divert water; provide a head of water for the generation of hydroelectric power; or store water for industrial or domestic use, irrigation, flood control, or power production. In addition, water stored by dams is often used for recreational purposes. Most dams are constructed of either concrete or of earth and rock. **Gravity dams** depend on the weight of their bulk for stability and usually have a flat vertical face upstream. **Arch dams** are curved concrete structures with a convex curve upstream. Pressure is transmitted to the sides of the dam.

damping A decrease in the amplitude of an oscillation as a result of energy being drained from the oscillating system to overcome frictional or other resistive forces. For example, a pendulum soon comes to rest unless it is supplied with energy from an outside source; in a pendulum clock, energy is supplied through an *escapement from a wound spring or a falling mass to compensate for the energy lost through friction. Damping is introduced intentionally in measuring instruments of various kinds to overcome the problem of taking a reading from an oscillating needle. A measuring instrument is said to be **critically damped** if the system just fails to oscillate and the system comes to rest in the shortest possible time. If it is **underdamped** it will oscillate re-

peatedly before coming to rest; if it is **overdamped** it will not oscillate but it will take longer to come to rest than it would if it was critically damped. An instrument, such as a galvanometer, that is critically damped is often called a **deadbeat** instrument.

dance of the bees A celebrated example of *communication in animals, first investigated by Karl von Frisch (1886–1982). Honeybee workers on returning to the hive after a successful foraging expedition perform a 'dance' on the comb that contains coded information about the distance and direction of the food source. For example the **waggle dance**, characterized by tail-wagging movements, indicates the direction of a food source at a distance of more than 100 metres. Other workers, sensing vibrations from the dance, follow the instructions to find the food source.

Daniell cell A type of primary *voltaic cell with a copper positive electrode and a negative electrode of a zinc amalgam. The zinc-amalgam electrode is placed in an electrolyte of dilute sulphuric acid or zinc sulphate solution in a porous pot, which stands in a solution of copper sulphate in which the copper electrode is immersed. While the reaction takes place ions move through the porous pot, but when it is not in use the cell should be dismantled to prevent the diffusion of one electrolyte into the other. The e.m.f. of the cell is 1.08 volts with sulphuric acid and 1.10 volts with zinc sulphate. It was invented in 1836 by the British chemist John Daniell (1790–1845).

Daphnia A genus of crustaceans belonging to the class Branchiopoda and order Cladocera (water fleas). *Daphnia* species have a transparent carapace and a protruding head with a pair of highly branched antennae for swimming and a single median compound eye. The five pairs of thoracic appendages form an efficient filter-feeding mechanism. Reproduction can take place without mating, i.e. by *parthenogenesis.

dark energy Energy in the universe associated with the fact that the expansion of the universe is accelerating and the *cosmological constant could have a non-zero value. Analysis of data from *WMAP indicates that about 70% of the energy of the universe is in the form of dark energy. The nature of dark energy is not known.

dark galaxy A galaxy that is composed largely of dark matter. There is some evidence for the existence of such galaxies. It is thought that they should be very common, particularly since theories of large-scale structure work much better if the existence of plentiful dark galaxies is assumed.

dark matter *See* MISSING MASS.

SEE WEB LINKS

- The home page of the Cryogenic Dark Matter Search Experiment

dark period (in botany) The period considered to be critical in the responses of plants to changes in day length (*see* PHOTOPERIODISM). It is believed that such responses, which include the onset of flowering, are determined by the length of the period of darkness that occurs between two periods of light.

dark reaction *See* PHOTOSYNTHESIS.

darmstadtium Symbol Ds. A radioactive transactinide element; a.n. 110. It has several isotopes; the most stable being ^{281}Ds, with a half-life of about 1.6 minutes. It can be produced by bombarding a plutonium target with sulphur nuclei or by bombarding a lead target with nickel nuclei. Darmstadtium was named after the German city of Darmstadt, the location of the Institute for Heavy Ion Research where it was first produced.

SEE WEB LINKS

- Information from the WebElements site

Darwin, Charles (1809–82) British naturalist, who studied medicine in Edinburgh followed by theology at Cambridge University, intending a career in the Church. However, his interest in natural history led him to accept an invitation in 1831 to join HMS *Beagle* as naturalist on a round-the-world voyage. After his return five years later he published works on the geology he had observed. He was also formulating his theory of *evolution by means of *natural selection, but it was to be 20 years before he published *On the Origin of Species* (1859), prompted by similar views expressed by Alfred Russel *Wallace. Among his later works was *The Descent of Man* (1871). *See also* DARWINISM.

SEE WEB LINKS

- The complete works of Charles Darwin online

Darwinism The theory of *evolution proposed by Charles Darwin in *On the Origin of Species* (1859), which postulated that present-day species have evolved from simpler ancestral types by the process of *natural se-

lection acting on the variability found within populations. *On the Origin of Species* caused a furore when it was first published because it suggested that species are not immutable nor were they specially created – a view directly opposed to the doctrine of *special creation. However the wealth of evidence presented by Darwin gradually convinced most people and the only major unresolved problem was to explain how the variations in populations arose and were maintained from one generation to the next. This became clear with the rediscovery of Mendel's work on classical genetics in the 1900s and led to the present theory known as *neo-Darwinism.

Darwin's finches (Galapagos finches) The 14 species of finch, unique to the Galapagos Islands, that Charles Darwin studied during his journey on HMS *Beagle*. Each is adapted to exploit a different food source. They are not found on the mainland because competition there for these food sources from other birds is fiercer. Darwin believed all the Galapagos finches – basically similar but differing in bill shape – to be descendants of a few that strayed from the mainland, and this provided important evidence for his theory of evolution. *See also* ADAPTIVE RADIATION.

DAT (digital audio tape) A type of magnetic tape originally designed for audio recording but now adapted for computer storage and backup use. The recording method allows a capacity of about 1 gigabyte.

database A large collection of information that has been coded and stored in a computer in such a way that it can be extracted under a number of different category headings.

date-rape drugs Drugs that are used to render the victim unable to resist a sexual assault. Particular drugs used for this purpose are flunitrazepam and gammahydroxybutyric acid (GHB).

dating techniques Methods of estimating the age of rocks, palaeontological specimens, archaeological sites, etc. **Relative dating techniques** date specimens in relation to one another; for example, *stratigraphy is used to establish the succession of fossils. **Absolute** (or **chronometric**) **techniques** give an absolute estimate of the age and fall into two main groups. The first depends on the existence of something that develops at a seasonally varying rate, as in *dendrochronology and *varve dating. The other uses some measurable change that occurs at a known rate, as in *chemical dating, **radioactive** (or **radiometric**) **dating** (*see* CARBON DATING; FISSION-TRACK DATING; POTASSIUM–ARGON DATING; RUBIDIUM–STRONTIUM DATING; URANIUM–LEAD DATING), and *thermoluminescence.

dative bond *See* CHEMICAL BOND.

daughter **1.** A nuclide produced by radioactive *decay of some other nuclide (the **parent**). **2.** An ion or free radical produced by dissociation or reaction of some other (**parent**) ion or radical.

Davy, Sir Humphry (1778–1829) British chemist, who studied gases at the Pneumatic Institute in Bristol, where he discovered the anaesthetic properties of *dinitrogen oxide (nitrous oxide). He moved to the Royal Institution, London, in 1801 and five years later isolated potassium and sodium by electrolysis. He also prepared barium, boron, calcium, and strontium as well as proving that chlorine and iodine are elements. In 1816 he invented the *Davy lamp.

Davy lamp An oil-burning miner's safety lamp invented by Sir Humphry Davy in 1816 when investigating firedamp (methane) explosions in coal mines. The lamp has a metal gauze surrounding the flame, which cools the hot gases by conduction and prevents ignition of gas outside the gauze. If firedamp is present it burns within the gauze cage, and lamps of this type are still used for testing for gas.

day The time taken for the earth to complete one rotation on its axis. The **solar day** is the interval between two successive returns of the sun to the *meridian. The **mean solar day** of 24 hours is the average value of the solar day for one year. The **sidereal day** is measured with respect to the fixed stars and is 4.09 minutes shorter than the mean solar day as a result of the imposition of the earth's orbital motion on its rotational motion.

day-neutral plant A plant in which flowering can occur irrespective of the day length. Examples are cucumber and maize. *See* PHOTOPERIODISM. *Compare* LONG-DAY PLANT; SHORT-DAY PLANT.

***d*-block elements** The block of elements

in the *periodic table consisting of scandium, yttrium, and lanthanum together with the three periods of transition elements: titanium to zinc, zirconium to cadmium, and hafnium to mercury. These elements all have two outer *s*-electrons and have *d*-electrons in their penultimate shell; i.e. an outer electron configuration of the form $(n–1)d^x ns^2$, where x is 1 to 10. *See also* TRANSITION ELEMENTS.

d.c. *See* DIRECT CURRENT.

DDT Dichlorodiphenyltrichloroethane; a colourless organic crystalline compound, $(ClC_6H_4)_2CH(CCl_3)$, made by the reaction of trichloromethanal with chlorobenzene. DDT is the best known of a number of chlorine-containing pesticides used extensively in agriculture in the 1940s and 1950s. The compound is stable, accumulates in the soil, and concentrates in fatty tissue, reaching dangerous levels in carnivores high in the food chain. Restrictions are now placed on the use of DDT and similar pesticides.

Deacon process A former process for making chlorine by oxidizing hydrogen chloride in air at 450°C using a copper chloride catalyst. It was patented in 1870 by Henry Deacon (1822–76).

deactivation A partial or complete reduction in the reactivity of a substance, as in the poisoning of a catalyst.

deadbeat *See* DAMPING.

deamination The removal of an amino group ($–NH_2$) from a compound. Enzymatic deamination occurs in the liver and is important in amino-acid metabolism, especially in their degradation and subsequent oxidation. The amino group is removed as ammonia and excreted, either unchanged or as urea or uric acid.

death The point at which the processes that maintain an organism alive no longer function. In humans it is diagnosed by permanent cessation of the heartbeat; however, the heart can continue beating after a large part of the brain ceases to function (*see* BRAIN DEATH). The death of a cell due to external damage or the action of toxic substances is known as **necrosis**. This must be distinguished from programmed cell death (*see* APOPTOSIS), which is a normal part of the developmental process.

death phase *See* BACTERIAL GROWTH CURVE.

death rate (mortality) The rate at which a particular species or population dies, whatever the cause. The death rate is an important factor in controlling the size of a population. *Compare* BIRTH RATE.

de Broglie, Louis-Victor Pierre Raymond (1892–1987) French physicist, who taught at the Sorbonne in Paris for 34 years. He is best known for his 1923 theory of *wave–particle duality (*see also* DE BROGLIE WAVELENGTH), which reconciled the corpuscular and wave theories of *light and proved important in *quantum theory. For this work he was awarded the 1929 Nobel Prize.

de Broglie wavelength The wavelength of the wave associated with a moving particle. The wavelength (λ) is given by $\lambda = h/mv$, where h is the Planck constant, m is the mass of the particle, and v its velocity. The **de Broglie wave** was first suggested by Louis de Broglie in 1923 on the grounds that electromagnetic waves can be treated as particles (*photons) and one could therefore expect particles to behave in some circumstances like waves (*see* COMPLEMENTARITY). The subsequent observation of *electron diffraction substantiated this argument and the de Broglie wave became the basis of *wave mechanics.

debye A unit of electric *dipole moment in the electrostatic system, used to express dipole moments of molecules. It is the dipole moment produced by two charges of opposite sign, each of 1 statcoulomb and placed 10^{-18} cm apart, and has the value $3.335\,64 \times 10^{-30}$ coulomb metre.

Debye–Hückel theory A theory to explain the nonideal behaviour of electrolytes, published in 1923 by Peter Debye (1884–1966) and Erich Hückel (1896–). It assumes that electrolytes in solution are fully dissociated and that nonideal behaviour arises because of electrostatic interactions between the ions. The theory shows how to calculate the extra free energy per ion resulting from such interactions, and consequently the activity coefficient. It gives a good description of nonideal electrolyte behaviour for very dilute solutions, but cannot be used for more concentrated electrolytes.

Debye–Scherrer method A method of X-ray diffraction in which a beam of X-rays is diffracted by material in the form of powder. Since the powder consists of very small crystals of the material in all possible orienta-

tions, the diffraction pattern is a series of concentric circles. This type of pattern allows the unit cell to be found with great precision. This method was first used by Peter Debye and Paul Scherrer in 1916 and independently by Albert Hull in 1917.

deca- Symbol da. A prefix used in the metric system to denote ten times. For example, 10 coulombs = 1 decacoulomb (daC).

decahydrate A crystalline hydrate containing ten molecules of water per molecule of compound.

decalescence *See* RECALESCENCE.

decanedioic acid (sebacic acid) A white crystalline dicarboxylic acid, $HOOC(CH_2)_8COOH$; r.d. 1.12; m.p. 131–134.5°C; b.p. 294.4°C (100 mmHG). Obtained from castor oil, it is used in plasticizers, lubricants, and cosmetics and in the production of other organic chemicals.

decanoic acid (capric acid) A white crystalline straight-chain saturated *carboxylic acid, $CH_3(CH_2)_8COOH$; m.p. 31.5°C. Its esters are used in perfumes and flavourings.

decantation The process of separating a liquid from a settled solid suspension or from a heavier immiscible liquid by carefully pouring it into a different container.

Decapoda An order of crustaceans of the class Malacostraca that are distributed worldwide, mainly in marine habitats. Decapods comprise swimming forms (shrimps and prawns) and crawling forms (crabs, lobsters, and crayfish). All are characterized by five pairs of walking legs, the first pair of which are highly modified in crawling forms to form powerful grasping pincers. The carapace is fused with the thorax and head forming a *cephalothorax. The antennae are especially long in shrimps and prawns, which also possess several pairs of well-developed swimming appendages (**pleopods**) posterior to the walking legs. Following fertilization by the male, females usually carry the eggs until they hatch. The larvae undergo several transformations before attaining adult form.

decarboxylation The removal of carbon dioxide from a molecule. Decarboxylation is an important reaction in many biochemical processes, such as the *Krebs cycle and the synthesis of *fatty acids. *See also* OXIDATIVE DECARBOXYLATION.

decay **1.** *See* DECOMPOSITION. **2.** The spontaneous transformation of one radioactive nuclide into a daughter nuclide, which may be radioactive or may not, with the emission of one or more particles or photons. The decay of N_0 nuclides to give N nuclides after time t is given by $N = N_0\exp(-\gamma t)$, where γ is called the **decay constant** or the **disintegration constant**. The reciprocal of the decay constant is the **mean life**. The time required for half the original nuclides to decay (i.e. $N = \frac{1}{2}N_0$) is called the **half-life** of the nuclide. The same terms are applied to elementary particles that spontaneously transform into other particles. For example, a free neutron decays into a proton and an electron (*see* BETA DECAY). *See also* ALPHA PARTICLE.

SEE WEB LINKS

- Values of radionuclide half-lives at the NIST website

deci- Symbol d. A prefix used in the metric system to denote one tenth. For example, 0.1 coulomb = 1 decicoulomb (dC); 0.1 metre = 1 decimetre (dm).

decibel A unit used to compare two power levels, usually applied to sound or electrical signals. Although the decibel is one tenth of a **bel**, it is the decibel, not the bel, that is invariably used. Two power levels P and P_0 differ by n decibels when $n = 10\log_{10}P/P_0$. If P is the level of sound intensity to be measured, P_0 is a reference level, usually the intensity of a note of the same frequency at the threshold of audibility.

The logarithmic scale is convenient as human audibility has a range of 1 (just audible) to 10^{12} (just causing pain) and one decibel, representing an increase of some 26%, is about the smallest change the ear can detect.

deciduous Describing plants in which all the leaves are shed at the end of each growing season, usually the autumn in temperate regions or at the beginning of a dry season in the tropics. This seasonal leaf fall helps the plant retain water that would otherwise be lost by transpiration from the leaves. Examples of deciduous plants are rose and horse chestnut. *Compare* EVERGREEN.

deciduous teeth (milk teeth) The first of two sets of teeth of a mammal. These teeth are smaller than those that replace them (the *permanent teeth) and fewer in number, since there are no deciduous *molars. *See also* DIPHYODONT.

decimal system A number system based

on the number 10; the number system in common use. All rational numbers can be written as a **finite decimal** (e.g. ¼ = 0.25) or a **repeating decimal** (e.g. 5/27 = 0.185 185 185…). An *irrational number can be written to any number of decimal places, but can never be given exactly (e.g. √3 = 1.732 050 8…).

declination **1.** The angle between the magnetic meridian and the geographic meridian at a point on the surface of the earth. *See* GEOMAGNETISM. **2.** The angular distance of a celestial body north (positive) or south (negative) of the celestial *equator.

decoction A solution made by boiling material (e.g. plant substances) in water, followed by filtration.

decoherence A process in which a quantum mechanical state of a system is altered by the interaction between the system and its environment. The process of decoherence has been detected experimentally. Decoherence was postulated in the 1980s and has been used to clarify discussions of the foundations of quantum mechanics.

decomposer An organism that obtains energy from the chemical breakdown of dead organisms or animal or plant wastes. Decomposers, most of which are bacteria and fungi, secrete enzymes onto dead matter and then absorb the breakdown products (*see* SAPROTROPH). Many decomposers (e.g. nitrifying bacteria) are specialized to break down organic materials that are difficult for other organisms to digest. Decomposers fulfil a vital role in the *ecosystem, returning the constituents of organic matter to the environment in inorganic form so that they can again be assimilated by plants. *Compare* DETRITIVORE. *See also* CARBON CYCLE; NITROGEN CYCLE.

decomposition **1. (decay)** The chemical breakdown of organic matter into its constituents by the action of *decomposers. **2.** A chemical reaction in which a compound breaks down into simpler compounds or into elements.

deconfinement temperature *See* QUARK CONFINEMENT.

decrepitation A crackling noise produced when certain crystals are heated, caused by changes in structure resulting from loss of water of crystallization.

deep-sky object Any object located outside our solar system that is of interest to an astronomical observer. The term usually applies to a *star cluster, *nebula, *galaxy, or *galaxy cluster, but not a star.

defecation The expulsion of faeces from the rectum due to contractions of muscles in the rectal wall. A sphincter muscle, which is under voluntary control, is situated at the end of the rectum (the anus); relaxation of this muscle allows defecation to occur. In babies control of the anal sphincter muscle has not been developed and defecation occurs automatically as a reflex response to the presence of faeces in the rectum.

defect **1.** *See* CRYSTAL DEFECT. **2.** *See* MASS DEFECT. **3.** *See* TOPOLOGICAL DEFECT.

deficiency disease Any disease caused by an inadequate intake of an essential nutrient in the diet, primarily vitamins, minerals, and amino acids. Examples are scurvy (lack of vitamin C), rickets (lack of vitamin D), and iron-deficiency anaemia.

definite inflorescence *See* CYMOSE INFLORESCENCE.

definite integral *See* INTEGRATION.

definite proportions *See* CHEMICAL COMBINATION.

deflagration A type of explosion in which the shock wave arrives before the reaction is complete (because the reaction front moves more slowly than the speed of sound in the medium).

deforestation The extensive cutting down of forests for the purpose of extracting timber or fuel wood or to clear the land for mining or agriculture. Forests are often situated in upland areas and are important in trapping rainwater. Deforestation in these areas, particularly in India and Bangladesh, has resulted in the flooding of low-lying plains; it has also led to an increase in soil erosion and hence desert formation (*see* DESERTIFICATION), resulting in crop loss and economic problems for local communities. The felling and burning of trees releases large amounts of carbon dioxide, thereby increasing global carbon dioxide levels and contributing to the *greenhouse effect. Rainforests, particularly those of South America, are rich in both fauna and flora; their removal leads to an overall decrease in *biodiversity and the loss of plant species that have potentially beneficial pharmaceutical effects. Despite movements to reduce deforestation,

economic pressures ensure that the process still continues.

degassing The removal of dissolved, absorbed, or adsorbed gases from a liquid or solid. Degassing is important in vacuum systems, where gas absorbed in the walls of the vacuum vessel starts to desorb as the pressure is lowered.

degaussing The process of neutralizing the magnetization in an object that has inadvertently become magnetized. For example, ferromagnetic components of TV sets may become magnetized and misdirect the electron beams. A degaussing coil is often provided and fed with a diminishing alternating current each time the set is switched on. Ships can be degaussed by surrounding them with current-carrying cables that set up an equal and opposite field. This prevents the ships from detonating magnetic mines. Degaussing is used to protect scientific and other electronic devices from strong magnetic fields; usually a system of coils is designed to neutralize such fields over the important region or the equipment is surrounded by a shield of suitable alloy (e.g. Mumetal).

degeneracy pressure The pressure in a *degenerate gas of fermions caused by the Pauli exclusion principle and the Heisenberg uncertainty principle. Because of the exclusion principle, fermions at a high density, with small interparticle spacing, must have different momenta. Because of the uncertainty principle, the momentum difference must be inversely proportional to the spacing. Consequently, in a high-density gas (small spacing) the particles have high relative momenta, which leads to a degeneracy pressure much greater than the thermal pressure. *White dwarfs and *neutron stars are supported against collapse under their own gravitational fields by the degeneracy pressure of electrons and neutrons respectively.

degenerate **1.** Having quantum states with the same energy. For example, the five *d*-orbitals in an isolated transition-metal atom have the same energy (although they have different spatial arrangements) and are thus **degenerate levels**. The application of a magnetic or electric field may cause the quantum states to have different energies (*see* CRYSTAL-FIELD THEORY). In this case, the degeneracy is said to be 'lifted'. **2.** Having a high particle concentration such that the *Maxwell–Boltzmann distribution does not apply and the behaviour of the particles is governed by *quantum statistics. Systems in which the particles are degenerate are called **degenerate gases**; examples are the conduction electrons in a metal (or *degenerate semiconductor), the electrons in a *white dwarf, and the neutrons in a *neutron star. *See also* DEGENERACY PRESSURE.

degenerate semiconductor A heavily doped *semiconductor in which the *Fermi level is located in either the valence band or the conduction band (*see* ENERGY BANDS) causing the material to behave as a metal.

degenerate states *Quantum states of a system that have the same energy.

degeneration **1.** Changes in cells, tissues, or organs due to disease, etc., that result in an impairment or loss of function and possibly death and breakdown of the affected part. **2.** The reduction in size or complete loss of organs during evolution. The human appendix has undergone this process and performs no obvious function in man. Degeneration of external organs may cause animals to appear to be more primitive than they really are; for example, early zoologists believed whales were fish rather than mammals because of the degeneration of their limbs. *See also* VESTIGIAL ORGAN.

deglutition (swallowing) A reflex action initiated by the presence of food in the pharynx. During deglutition, the soft *palate is raised, which prevents food from entering the nasal cavity; the *epiglottis closes, which blocks the entrance to the windpipe; and the oesophagus starts to contract (*see* PERISTALSIS), which ensures that food is conveyed to the stomach.

degradation A type of organic chemical reaction in which a compound is converted into a simpler compound. An example is the *Barbier–Wieland degradation.

degree **1.** A unit of plane angle equal to 1/360th of a complete revolution. **2.** A division on a *temperature scale. **3.** The power to which a variable is raised. If one expression contains several variables the overall degree of the expression is the sum of the powers. For example, the expression $p^2q^3r^4$ has a degree of 9 overall (it is a second-degree expression in p). The degree of a polynomial is the degree of the variable with the highest power, e.g. $ax^5 + bx^4 + c$ has a degree of 5. **4.** The highest power to which the

derivative of the highest order is raised in a *differential equation. For example, $(d^2y/dx^2)^3 + dy/dx = c$ is a differential equation of the third degree (but second order).

degrees of freedom **1.** The number of independent parameters required to specify the configuration of a system. This concept is applied in the *kinetic theory to specify the number of independent ways in which an atom or molecule can take up energy. There are however various sets of parameters that may be chosen, and the details of the consequent theory vary with the choice. For example, in a monatomic gas each atom may be allotted three degrees of freedom, corresponding to the three coordinates in space required to specify its position. The mean energy per atom for each degree of freedom is the same, according to the principle of the *equipartition of energy, and is equal to $kT/2$ for each degree of freedom (where k is the *Boltzmann constant and T is the thermodynamic temperature). Thus for a monatomic gas the total molar energy is $3LkT/2$, where L is the Avogadro constant (the number of atoms per mole). As $k = R/L$, where R is the molar gas constant, the total molar energy is $3RT/2$.

In a diatomic gas the two atoms require six coordinates between them, giving six degrees of freedom. Commonly these are interpreted as six independent ways of storing energy: on this basis the molecule has three degrees of freedom for different directions of translational motion, and in addition there are two degrees of freedom for rotation of the molecular axis and one vibrational degree of freedom along the bond between the atoms. The rotational degrees of freedom each contribute $kT/2$, to the total energy; similarly the vibrational degree of freedom has an equal share of kinetic energy and must on average have as much potential energy (*see* SIMPLE HARMONIC MOTION). The total energy per molecule for a diatomic gas is therefore $3kT/2$ (for translational energy of the whole molecule) plus $2kT/2$ (for rotational energy of each atom) plus $2kT/2$ (for vibrational energy), i.e. a total of $7kT/2$.
2. The least number of independent variables required to define the state of a system in the *phase rule. In this sense a gas has two degrees of freedom (e.g. temperature and pressure).

dehiscence The spontaneous and often violent opening of a fruit, seed pod, or anther to release and disperse the seeds or pollen. Examples are the splitting of laburnum pods and primrose capsules; such structures are described as **dehiscent** (*compare* INDEHISCENT).

dehydration **1.** Removal of water from a substance. **2.** A chemical reaction in which a compound loses hydrogen and oxygen in the ratio 2:1. For instance, ethanol passed over hot pumice undergoes dehydration to ethene:

$$C_2H_5OH - H_2O \rightarrow CH_2{:}CH_2$$

Substances such as concentrated sulphuric acid, which can remove H_2O in this way, are known as **dehydrating agents**. For example, with sulphuric acid, methanoic acid gives carbon monoxide:

$$HCOOH - H_2O \rightarrow CO$$

dehydrogenase Any enzyme that catalyses the removal of hydrogen atoms (**dehydrogenation**) in biological reactions. Dehydrogenases occur in many biochemical pathways but are particularly important in driving the reactions of the *electron-transport chain in cell respiration. They work in conjunction with the hydrogen-accepting coenzymes *NAD and *FAD.

dehydrogenation A chemical reaction in which hydrogen is removed from a compound. Dehydrogenation of organic compounds converts single carbon–carbon bonds into double bonds. It is usually effected by means of a metal catalyst.

dehydrohalogenation A type of chemical reaction in which a hydrogen halide is removed from a molecule with formation of a double bond. A simple example is the formation of ethene from chloroethane using alcoholic potassium hydroxide:

$$CH_3CH_2Cl + KOH \rightarrow CH_2{=}CH_2 + KCl + H_2O.$$

deionized water Water from which dissolved ionic salts have been removed by *ion-exchange techniques. It is used for many purposes as an alternative to distilled water.

dekatron A neon-filled tube with a central anode surrounded by ten cathodes and associated transfer electrodes. As voltage pulses are received by the tube a glow discharge moves from one set of electrodes to the next, enabling the device to be used as a visual counting tube in the decimal system. The tube can also be used for switching.

delayed neutrons The small proportion of neutrons that are emitted with a measurable time delay in a nuclear fission process. *Compare* PROMPT NEUTRONS.

delay line A component in an electronic circuit that is introduced to provide a specified delay in transmitting the signal. Coaxial cable or inductor-capacitor networks can be used to provide a short delay but for longer delays an **acoustic delay line** is required. In this device the signal is converted by the *piezoelectric effect into an acoustic wave, which is passed through a liquid or solid medium, before reconversion to an electronic signal.

deletion (in genetics) **1.** A *point mutation involving the removal of one or more base pairs in the DNA sequence. **2.** A frequently lethal *chromosome mutation that arises from an inequality in *crossing over during meiosis such that one of the chromatids loses more genetic information than it receives.

deliquescence The absorption of water from the atmosphere by a hygroscopic solid to such an extent that a concentrated solution of the solid eventually forms.

delocalization In certain chemical compounds the valence electrons cannot be regarded as restricted to definite bonds between the atoms but are 'spread' over several atoms in the molecule. Such electrons are said to be **delocalized**. Delocalization occurs particularly when the compound contains alternating (conjugated) double or triple bonds, the delocalized electrons being those in the pi *orbitals. The molecule is then more stable than it would be if the electrons were localized, an effect accounting for the properties of benzene and other aromatic compounds. Another example is in the ions of carboxylic acids, containing the carboxylate group $-COO^-$. In terms of a simple model of chemical bonding, this group would have the carbon joined to one oxygen by a double bond (i.e. C=O) and the other joined to O^- by a single bond (C–O^-). In fact, the two C–O bonds are identical because the extra electron on the O^- and the electrons in the pi bond of C=O are delocalized over the three atoms.

delta A fan-shaped area of sediment deposited at the mouth of a river, where it enters a lake or the sea. Usually the river divides and subdivides into many smaller channels (distributaries), sometimes depositing bars and building up levees. Marshes may border the delta. The sediment may range in particle size, consisting of gravel, sand, silt, or clay. The larger material is deposited first as the load-carrying capacity of the river diminishes, with the clay being deposited last.

delta-brass A strong hard type of *brass that contains, in addition to copper and zinc, a small percentage of iron. It is mainly used for making cartridge cases.

deltahedron A polyhedron that has triangular faces. *See* WADE'S RULES.

delta-iron *See* IRON.

demagnetization The removal of the ferromagnetic properties of a body by disordering the domain structure (*see* MAGNETISM). One method of achieving this is to insert the body within a coil through which an alternating current is flowing; as the magnitude of the current is reduced to zero, the domains are left with no predominant direction of magnetization.

deme A group of organisms in the same *taxon. The term is used with various prefixes that denote how the group differs from other groups. For example, an **ecodeme** occurs in a particular ecological habitat, **cytodemes** differ from each other cytologically, and **genodemes** differ genetically.

demodulation The process of extracting the information from a modulated carrier wave (*see* MODULATION; RADIO). The device used is called a **demodulator** or a **detector**.

de Moivre's theorem For *complex numbers in polar form, the equation

$$(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta.$$

It is true for all integer values of n. There is at least one value of the left-hand side of the equation that makes it also true for non-integer values of n. It was named after the French mathematician Abraham de Moivre (1667–1754).

denature **1.** To add a poisonous or unpleasant substance to ethanol to make it unsuitable for human consumption (*see* METHYLATED SPIRITS). **2.** To produce a structural change in a protein or nucleic acid that results in the reduction or loss of its biological properties. Denaturation is caused by heat, chemicals, and extremes of pH. The

differences between raw and boiled eggs are largely a result of denaturation. **3.** To add another isotope to a fissile material to make it unsuitable for use in a nuclear weapon.

dendrimer (dendritic polymer) A type of macromolecule in which a number of chains radiate out from a central atom or cluster of atoms. Dendritic polymers have a number of possible applications. *See also* SUPRAMOLECULAR CHEMISTRY.

dendrite **1.** (in chemistry) A crystal that has branched in growth into two parts. Crystals that grow in this way (**dendritic growth**) have a branching treelike appearance. **2.** (in neurology) Any of the slender branching processes that arise from the *dendrons of the cell body of a motor *neuron. It forms connections (*see* SYNAPSE) with the axons of other neurons and transmits nerve impulses from these to the cell body.

dendrochronology An absolute *dating technique using the *growth rings of trees. It depends on the fact that trees in the same locality show a characteristic pattern of growth rings resulting from climatic conditions. Thus it is possible to assign a definite date for each growth ring in living trees, and to use the ring patterns to date fossil trees or specimens of wood (e.g. used for buildings or objects on archaeological sites) with lifespans that overlap those of living trees. The bristlecone pine (*Pinus aristata*), which lives for up to 5000 years, has been used to date specimens over 8000 years old. Fossil specimens accurately dated by dendrochronology have been used to make corrections to the *carbon-dating technique. Dendrochronology is also helpful in studying past climatic conditions. Analysis of trace elements in sections of rings can also provide information on past atmospheric pollution.

dendron Any of the major cytoplasmic processes that arise from the cell body of a motor neuron. A dendron usually branches into *dendrites.

denitrification A chemical process in which nitrates in the soil are reduced to molecular nitrogen, which is released into the atmosphere. This process is effected by denitrifying bacteria (e.g. *Pseudomonas denitrificans*), which use nitrates as a source of energy for other chemical reactions in a manner similar to respiration in other organisms. *Compare* NITRIFICATION. *See* NITROGEN CYCLE.

densitometer An instrument used to measure the *photographic density of an image on a film or photographic print. Densitometers work by letting the specimen transmit or reflect a beam of light and monitoring the transmitted or reflected intensity. They originally consisted of visual *photometers but most instruments are now photoelectric. The simplest transmission densitometer consists of a light source, a photosensitive cell, and a microammeter: the density is measured in terms of the meter readings with and without the sample in place. They have a variety of uses, including detecting the sound track on a cinematic film, measuring intensities in spectrographic records, and checking photographic prints.

density **1.** The mass of a substance per unit of volume. In *SI units it is measured in kg m^{-3}. *See also* RELATIVE DENSITY; VAPOUR DENSITY. **2.** *See* CHARGE DENSITY. **3.** *See* PHOTOGRAPHIC DENSITY.

SEE WEB LINKS

- Values of densities of commonly used materials at the NPL website

density functional theory A theory used to describe many-fermion systems in which the energy is a *functional of the density of fermions. Density functional theory has been used extensively in the theory of electrons in atoms, molecules, and solids, and the theory of nucleons in nuclei.

dental caries Tooth decay, which involves the destruction of the enamel layer of the tooth by acids produced by the action of bacteria on sugar. Bacteria can bind to teeth on **dextran**, a sticky substance derived from sucrose. The bacterial cells and other waste attached to dextran gives rise to *plaque. If dental caries is not treated it can spread to the dentine and pulp of the tooth, which leads to infection and death of the tooth.

dental formula A representation of the dentition of an animal. A dental formula consists of eight numbers, four above and four below a horizontal line. The numbers represent (from left to right) the numbers of incisors, canines, premolars, and molars in either half of the upper and lower jaws. The total number of teeth in both jaws is therefore obtained by adding up all the numbers in the dental formula and multiplying by 2. Representative dental formulas are shown in the illustration overleaf. *See also* PERMANENT TEETH.

2	1	2	3	human	2	0	3	3	rabbit	3	1	4	2	bear
2	1	2	3	(32 teeth)	1	0	2	3	(28 teeth)	3	1	4	3	(42 teeth)

Representive dental formulas.

denticle (placoid scale) *See* SCALES.

dentine The bony material that forms the bulk of a *tooth. Dentine is similar in composition to bone but is perforated with many tiny canals for nerve fibres, blood capillaries, and processes of the dentine-forming cells (*odontoblasts). Ivory, the material that forms elephant tusks, is made of dentine.

dentition The type, number, and arrangement of teeth in a species. This can be represented concisely by a *dental formula. *See also* PERMANENT TEETH; DIPHYODONT; MONOPHYODONT; POLYPHYODONT; HETERODONT; HOMODONT.

deoxyribonuclease *See* DNASE.

deoxyribonucleic acid *See* DNA.

deoxyribose (2-deoxyribose) A pentose (five-carbon) sugar, a derivative of *ribose, that is a component of the nucleotides (deoxyribonucleotides) that form the building blocks of *DNA.

depleted Denoting a material that contains less of a particular isotope than it normally contains, especially a residue from a nuclear reactor or isotope-separation plant.

depleted uranium Uranium mostly consisting of uranium–238, obtained as a by-product of enriching natural uranium or obtained from reprocessing plants. It has a high density and is used in armour-piercing shells.

depletion layer A region in a *semiconductor that has a lower-than-usual number of mobile charge carriers. A depletion layer forms at the interface between two dissimilar regions of conductivity (e.g. a *p*–*n* junction). *See* DIODE.

depolarization **1.** (in physics) The prevention of *polarization in a *primary cell. For example, maganese(IV) oxide (the **depolarizer**) is placed around the positive electrode of a *Leclanché cell to oxidize the hydrogen released at this electrode. **2.** (in neurophysiology) A reduction in the difference of electrical potential that exists across the plasma membrane of a nerve or muscle cell. Depolarization of a nerve-cell membrane occurs during the passage of an *action potential along the axon when the nerve is transmitting an impulse.

deposition The laying down of material on the earth's surface. This includes materials that have been eroded elsewhere and transported by natural agents, such as rivers, wind, ice (e.g. glaciers), and the tides and currents in the sea. It also includes the deposition of materials resulting from chemical precipitation, the formation of crusts on the earth's surface through evaporation, and the growth, accumulation, and decay of natural organisms.

depression (low; disturbance) An area of low atmospheric pressure in the mid- and high-latitudes that is shown on a synoptic chart (weather map) surrounded by several closed isobars. Depressions generally move towards the northeast in the northern hemisphere and towards the southeast in the southern hemisphere. Unsettled weather conditions are associated with depressions and they form the main source of precipitation in most lowland parts of the mid-latitudes.

depression of freezing point The reduction in the freezing point of a pure liquid when another substance is dissolved in it. It is a *colligative property – i.e. the lowering of the freezing point is proportional to the number of dissolved particles (molecules or ions), and does not depend on their nature. It is given by $\Delta t = K_f C_m$, where C_m is the molar concentration of dissolved solute and K_f is a constant (the **cryoscopic constant**) for the solvent used. Measurements of freezing-point depression (using a Beckmann thermometer) can be used for finding relative molecular masses of unknown substances.

SEE WEB LINKS

- Raoult's original paper

depsides A class of compounds formed by condensation of a phenolic carboxylic acid (such as gallic acid) with a similar compound, the reaction being between the carboxylic acid group on one molecule and a phenolic –OH group on the other. Depsides are similar to esters, except that the –OH group is linked directly to an aromatic ring. In such compounds, the –O–CO– group is

called a **depside linkage**. Depsides are found in tannins and other natural products.

depth of field The range of distance in front of and behind an object that is being focused by an optical instrument, such as a microscope or camera, within which other objects will be in focus. The **depth of focus** is the amount by which the distance between the camera and the film can be changed without upsetting the sharpness of the image.

derivative **1.** (in chemistry) A compound that is derived from some other compound and usually maintains its general structure, e.g. trichloromethane (chloroform) is a derivative of methane. **2.** (in mathematics) *See* DIFFERENTIATION; CALCULUS.

derived unit *See* BASE UNIT.

dermal bone *See* MEMBRANE BONE.

Dermaptera An order of insects comprising the earwigs. Earwigs typically have long thin cylindrical bodies with biting mouthparts and a stout pair of curved forceps at the tip of the abdomen, used for catching prey and in courtship. Some species have a single pair of wings, which at rest are folded back over the abdomen like a fan; others are wingless. Most earwigs are nocturnal and omnivorous.

dermis (corium; cutis) The thicker and innermost layer of the *skin of vertebrates, the other layer being the *epidermis. The dermis consists of fibrous connective tissue in which are embedded blood vessels, sensory nerve endings, and (in mammals) hair follicles, sebaceous glands, and sweat ducts. Beneath the dermis lies the *subcutaneous tissue.

desalination The removal of salt from sea water for irrigation of the land or to provide drinking water. The process is normally only economic if a cheap source of energy, such as the waste heat from a nuclear power station, can be used. Desalination using solar energy has the greatest economic potential since shortage of fresh water is most acute in hot regions. The methods employed include evaporation, often under reduced pressure (flash evaporation); freezing (pure ice forms from freezing brine); *reverse osmosis; *electrodialysis; and *ion exchange.

desert A major terrestrial *biome characterized by low rainfall. Hot deserts, such as the Sahara and Kalahari deserts of Africa, have a rainfall of less than 25 cm a year and extremely high daytime temperatures (up to 36°C). Vegetation is sparse, and desert plants are adapted to conserve water and take advantage of the rain when it falls. The perennials include xerophytic trees and shrubs (*see* XEROPHYTE) and *succulents, such as cacti. Annual plants are *ephemerals, lying dormant as seeds for most of the year and completing their life cycle in the brief rainy periods. Desert animals are typically nocturnal or active at dawn and dusk, thus avoiding the extreme daytime temperatures.

desertification The gradual conversion of fertile land into desert, usually as a result of human activities. Loss of topsoil leads to further soil erosion until the land can no longer be used to grow crops or support livestock. A major factor contributing to desertification is bad management of farmland. Overgrazing of livestock removes the plant cover and exposes the soil, making it vulnerable to erosion. Overintensive cultivation of crop plants, especially monoculture (*see* AGRICULTURE), depletes the soil of nutrients and organic matter, resulting in loss of fertility and increasing its susceptibility to erosion. In many Third World countries it is difficult to control the process of desertification as the livelihood of the people often depends on practices that contribute to soil erosion. Another major cause of desertification is *deforestation. Loss of vegetation also results from reductions in rainfall resulting from climate change.

desiccation A method of preserving organic material by the removal of its water content. Cells and tissues can be preserved by desiccation after lowering the samples to freezing temperatures; thereafter they can be stored at room temperature.

desiccator A container for drying substances or for keeping them free from moisture. Simple laboratory desiccators are glass vessels containing a drying agent, such as silica gel. They can be evacuated through a tap in the lid.

desmids Unicellular mainly freshwater green algae that belong to the class Desmidioideae. Like *Spirogyra*, they have an elaborate chloroplast. The cells of desmids are characteristically split into two halves joined by a narrow neck, each half being a mirror image of the other. The outer wall of the cell is patterned with various protuberances and

covered with a mucilaginous sheath, which may function in the cell's gliding movement.

desmotubule *See* PLASMODESMATA.

desorption The removal of adsorbed atoms, molecules, or ions from a surface.

destructive distillation The process of heating complex organic substances in the absence of air so that they break down into a mixture of volatile products, which are condensed and collected. At one time the destructive distillation of coal (to give coke, coal tar, and coal gas) was the principal source of industrial organic chemicals.

detailed balance The cancellation of the effect of one process by another process that operates at the same time with the opposite effect. An example of detailed balance is provided by a chemical reaction between two molecular species A and B, which results in the formation of the molecular species C and D. Detailed balance for this chemical reaction occurs if the rate at which the reaction A + B → C + D occurs is equal to the rate at which the reaction C + D → A + B occurs. The equilibrium state in thermodynamics is characterized by detailed balance. When there is detailed balance in a system, the *self-organization far from equilibrium associated with *non-equilibrium statistical mechanics cannot occur.

detector **1.** *See* DEMODULATION. **2.** *See* COUNTER.

detergent A substance added to water to improve its cleaning properties. Although water is a powerful solvent for many compounds, it will not dissolve grease and natural oils. Detergents are compounds that cause such nonpolar substances to go into solution in water. *Soap is the original example, owing its action to the presence of ions formed from long-chain fatty acids (e.g. the octadecanoate (stearate) ion, $CH_3(CH_2)_{16}COO^-$). These have two parts: a nonpolar part (the hydrocarbon chain), which attaches to the grease; and a polar part (the $–COO^-$ group), which is attracted to the water. A disadvantage of soap is that it forms a scum with hard water (*see* HARDNESS OF WATER) and is relatively expensive to make. Various synthetic ('soapless') detergents have been developed from petrochemicals. The commonest, used in washing powders, is sodium dodecylbenzenesulphonate, which contains $CH_3(CH_2)_{11}C_6H_4SO_2O^-$ ions. This, like soap, is an example of an **anionic detergent**, i.e. one in which the active part is a negative ion. **Cationic detergents** have a long hydrocarbon chain connected to a positive ion. Usually they are amine salts, as in $CH_3(CH_2)_{15}N(CH_3)_3^+Br^-$, in which the polar part is the $–N(CH_3)_3^+$ group. **Nonionic detergents** have nonionic polar groups of the type $–C_2H_4–O–C_2H_4–OH$, which form hydrogen bonds with the water. Synthetic detergents are also used as wetting agents, emulsifiers, and stabilizers for foam.

determinant A *scalar quantity written |A| or det A. It represents a particular defined sum of products of a square *matrix. The determinant |A| expands as

$$\begin{vmatrix} a & b \\ c & d \end{vmatrix} = ad - bc.$$

determined Describing embryonic tissue at a stage when it can develop only as a certain kind of tissue (rather than as any kind).

detonating gas A mixture of hydrogen and oxygen in the ratio two parts hydrogen to one part oxygen by volume, produced by electrolysis of water. When sparked or ignited it explodes to produce water.

detoxification (detoxication) The process by which harmful compounds, such as drugs and poisons, are converted to less toxic compounds in the body. Detoxification is an important function of the *liver. *See also* PHASE I METABOLISM; PHASE II METABOLISM.

detritivore An animal that feeds on *detritus. Examples of detritivores are earthworms, blowflies, maggots, and woodlice. Detritivores play an important role in the breakdown of organic matter from decomposing animals and plants (*see* DECOMPOSER).

detritus Particles of organic material derived from dead and decomposing organisms, resulting from the activities of the *decomposers. Detritus is the source of food for *detritivores, which can themselves be eaten by carnivores in a **detritus food chain**:

detritus → detritivore → carnivore.

deuterated compound A compound in which some or all of the hydrogen–1 atoms have been replaced by deuterium atoms.

deuterium (heavy hydrogen) Symbol D. The isotope of hydrogen that has a mass number 2 (r.a.m. 2.0144). Its nucleus contains one proton and one neutron. The abundance of deuterium in natural hydro-

gen is about 0.015%. It is present in water as the oxide HDO (*see also* HEAVY WATER), from which it is usually obtained by electrolysis or fractional distillation. Its chemical behaviour is almost identical to hydrogen although deuterium compounds tend to react rather more slowly than the corresponding hydrogen compounds. Its physical properties are slightly different from those of hydrogen, e.g. b.p. 23.6 K (hydrogen 20.4 K).

deuterium oxide *See* HEAVY WATER.

Deuteromycota A phylum formerly used in some classifications to include all fungi in which sexual reproduction is absent. Also known as Fungi Imperfecti ('imperfect fungi'). They are now regarded as ascomycetes or basidiomycetes that have lost the ability to produce asci or basidia, respectively. Examples of these fungi are the *Penicillium* moulds.

deuteron A nucleus of a deuterium atom, consisting of a proton and a neutron bound together.

Devarda's alloy An alloy of copper (50%), aluminium (45%) and zinc (5%), used in chemical tests for the nitrate ion (in alkaline solutions it reduces a nitrate to ammonia).

development (in biology) The complex process of growth and maturation that occurs in living organisms. Cell division and differentiation are important processes in development. In vertebrate animals there are three developmental stages: (1) *cleavage, in which the zygote divides to form a ball of cells, the *blastula; (2) gastrulation, in which the cells become arranged in three primary *germ layers (*see* GASTRULA); (3) **organogenesis** (or **organogeny**), in which further cell division and differentiation results in the formation of organs. The development of many invertebrates (e.g. insects) and amphibians involves the process of *metamorphosis. *See also* MORPHOGENESIS; PRIMARY GROWTH.

deviation **1. (angle of deviation)** The angle formed between a ray of light falling on a surface or transparent body and the ray leaving it. **2.** The difference between one of an observed set of values and the true value, usually represented by the mean of all the observed values. The **mean deviation** is the mean of all the individual deviations of the set. *See* STANDARD DEVIATION.

devitrification Loss of the amorphous nature of glass as a result of crystallization.

Devonian A geological period in the Palaeozoic era that extended from the end of the Silurian (about 416 million years ago) to the beginning of the Carboniferous (about 360 million years ago). It was named by Adam Sedgwick (1785–1873) and Roderick Murchison (1792–1871) in 1839. The Devonian is divided into seven stages based on invertebrate fossil remains, such as corals, brachiopods, ammonoids, and crinoids, found in marine deposits. There were also extensive continental deposits consisting of conglomerates, red silts, and sandstones, forming the Old Red Sandstone facies. Fossils in the Old Red Sandstone include fishes and the earliest land plants. Graptolites became extinct early in the Devonian and the trilobites declined.

de Vries, Hugo *See* MENDEL, JOHANN GREGOR.

dew *See* PRECIPITATION.

Dewar, Sir James (1842–1923) British chemist and physicist, born in Scotland. In 1875 he became a professor at Cambridge University, while carrying out much of his experimental work at the Royal Institution in London. He began studying gases at low temperatures and in 1872 invented the *Dewar flask. In 1891, together with Frederick Abel (1827–1902), he developed the smokeless propellant explosive *cordite, and in 1898 was the first to liquefy hydrogen.

Dewar benzene An isomer of benzene, C_6H_6. Dewar benzene has the systematic name bicyclo[2,2,0]hexa-2,5-diene, and is a nonplanar bicyclic molecule. It has a high bond strain and will spontaneously slowly convert to benzene. The unsubstituted compound was first synthesized in 1963.

Dewar flask A vessel for storing hot or cold liquids so that they maintain their temperature independently of the surroundings. Heat transfer to the surroundings is reduced to a minimum: the walls of the vessel consist of two thin layers of glass (or, in large vessels, steel) separated by a vacuum to reduce conduction and convection; the inner surface of a glass vessel is silvered to reduce radiation; and the vessel is stoppered to prevent evaporation. It was devised around 1872 by Sir James Dewar and is also known by its first trade name **Thermos flask**. *See also* CRYOSTAT.

Dewar structure A proposed structure of *benzene, having a hexagonal ring of six carbon atoms with two opposite atoms joined by a long single bond across the ring and with two double C–C bonds, one on each side of the hexagon. Dewar structures contribute to the resonance hybrid of benzene.

d

dew point The temperature at which the water vapour in the air is saturated. As the temperature falls the dew point is the point at which the vapour begins to condense as droplets of water.

dew-point hygrometer *See* HYGROMETER.

dextrin An intermediate polysaccharide compound resulting from the hydrolysis of starch to maltose by amylase enzymes.

dextrorotatory Denoting a chemical compound that rotates the plane of polarization of plane-polarized light to the right (clockwise as observed by someone facing the oncoming radiation). *See* OPTICAL ACTIVITY.

dextrose *See* GLUCOSE.

diabetes *See* ANTIDIURETIC HORMONE; INSULIN.

diacylglycerol *See* INOSITOL.

diagenesis The processes, both chemical and physical, that modify a sediment once it has become buried. A material, such as calcite or silica, may crystallize and form a cement that binds together the particles of a sedimentary rock. Changes in temperature and pressure may convert one type of clay into another. New minerals may be deposited or formed by recrystallization, such as the formation of calcite from aragonite.

diagonal relationship A relationship within the periodic table by which certain elements in the second period have a close chemical similarity to their diagonal neighbours in the next group of the third period. This is particularly noticeable with the following pairs.

Lithium and magnesium:
(1) both form chlorides and bromides that hydrolyse slowly and are soluble in ethanol;
(2) both form colourless or slightly coloured crystalline nitrides by direct reaction with nitrogen at high temperatures;
(3) both burn in air to give the normal oxide only;
(4) both form carbonates that decompose on heating.

Beryllium and aluminium:
(1) both form highly refractory oxides with polymorphs;
(2) both form crystalline nitrides that are hydrolysed in water;
(3) addition of hydroxide ion to solutions of the salts gives an amphoteric hydroxide, which is soluble in excess hydroxide giving beryllate or aluminate ions $[Be(OH)_4]^{2-}$ and $[Al(OH)_4]^-$;
(4) both form covalent halides and covalent alkyl compounds that display bridging structures;
(5) both metals dissolve in alkalis.

Boron and silicon:
(1) both display semiconductor properties;
(2) both form hydrides that are unstable in air and chlorides that hydrolyse in moist air;
(3) both form acidic oxides with covalent crystal structures, which are readily incorporated along with other oxides into a wide range of glassy materials.

The reason for this relationship is a combination of the trends to increase size down a group and to decrease size along a period, and a similar, but reversed, effect in electronegativity, i.e. decrease down a group and increase along a period.

diakinesis The period at the end of the first prophase of *meiosis when the separation of *homologous chromosomes is almost complete and *crossing over has occurred.

dialysis A method by which large molecules (such as starch or protein) and small molecules (such as glucose or amino acids) in solution may be separated by selective diffusion through a semipermeable membrane. For example, if a mixed solution of starch and glucose is placed in a closed container made of a semipermeable substance (such as Cellophane), which is then immersed in a beaker of water, the smaller glucose molecules will pass through the membrane into the water while the starch molecules remain behind. The plasma membranes of living organisms are semipermeable, and dialysis takes place naturally in the kidneys for the excretion of nitrogenous waste. An artificial kidney (**dialyser**) utilizes the principle of dialysis by taking over the functions of diseased kidneys.

diamagnetism *See* MAGNETISM.

1,6-diaminohexane (hexamethylenediamine) A solid colourless amine,

$H_2N(CH_2)_6NH_2$; m.p. 41°C; b.p. 204°C. It is made by oxidizing cyclohexane to hexanedioic acid, reacting this with ammonia to give the ammonium salt, and dehydrating the salt to give hexanedionitrile ($NC(CH_2)_6CN$). This is reduced with hydrogen to the diamine. The compound is used, with hexanedioic acid, for producing *nylon 6,6.

diamond The hardest known mineral (with a hardness of 10 on Mohs' scale). It is an allotropic form of pure *carbon that has crystallized in the cubic system, usually as octahedra or cubes, under great pressure. Diamond crystals may be colourless and transparent or yellow, brown, or black. They are highly prized as gemstones but also have extensive uses in industry, mainly for cutting and grinding tools. Diamonds occur in ancient volcanic pipes of kimberlite; the most important deposits are in South Africa but others are found in Tanzania, the USA, Russia, and Australia. Diamonds also occur in river deposits that have been derived from weathered kimberlite, notably in Brazil, Democratic Republic of Congo, Sierra Leone, and India. Industrial diamonds are increasingly being produced synthetically.

diapause A period of suspended development or growth occurring in many insects and other invertebrates during which metabolism is greatly decreased. It is often triggered by seasonal changes and regulated by an inborn rhythm and enables the animal to survive unfavourable environmental conditions so that its offspring may be produced in more favourable ones. The egg is the most common diapausal stage.

diaphragm **1.** (in optics) An opaque disc with a circular aperture at its centre. Diaphragms of different sizes are used to control the total light flux passing through an optical system or to reduce aberration by restricting the light passing through a system to the central portion. An **iris diaphragm** consists of a number of overlapping crescent-shaped discs arranged so that the central aperture can be continuously varied in diameter. **2.** (in anatomy) The muscular membrane that divides the thorax (chest) from the abdomen in mammals. It plays an essential role in breathing (*see* RESPIRATORY MOVEMENT), being depressed during inhalation and raised during exhalation.

diaphysis The shaft of a mammalian limb bone, which in immature animals is separated from the ends of the bone (*see* EPIPHYSIS) by cartilage.

diaspore A mineral form of a mixed aluminium oxide and hydroxide, AlO.OH. *See* ALUMINIUM HYDROXIDE.

diastase *See* AMYLASE.

diastema The gap that separates the biting teeth from the grinding teeth in herbivores. It creates a space in which food can be held in readiness for the grinding action of the teeth. This space is filled by large canine teeth in carnivores.

diastereoisomers Stereoisomers that are not identical and yet not mirror images. For instance, the *d*-isomer of tartaric acid and the meso-isomer constitute a pair of diastereoisomers. *See* OPTICAL ACTIVITY.

diastole The phase of a heart beat that occurs between two contractions of the heart, during which the heart muscles relax and the ventricles fill with blood. *Compare* SYSTOLE. *See* BLOOD PRESSURE.

diatomic molecule A molecule formed from two atoms (e.g. H_2 or HCl).

diatoms *See* BACILLARIOPHYTA.

diazepam A *benzodiazepine used medically to treat anxiety, convulsions, insomnia, and alcohol withdrawal. It is widely used, and often known under its tradename **Valium**.

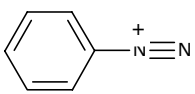
diazine *See* AZINE.

diazo compounds Organic compounds containing two linked nitrogen compounds. The term includes *azo compounds, diazonium compounds, and also such compounds as diazomethane, CH_2N_2.

SEE WEB LINKS

- Information about IUPAC nomenclature

diazonium salts Unstable salts containing the ion $C_6H_5N_2^+$ (the **diazonium ion**: see formula). They are formed by *diazotization reactions.



Diazonium salts. Structure of diazonium ion $C_6H_5N_2^+$.

diazotization The formation of a *diazonium salt by reaction of an aromatic amine

with nitrous acid at low temperature (below 5°C). The nitrous acid is produced in the reaction mixture from sodium nitrite and hydrochloric acid:

$$ArNH_2 + NaNO_2 + HCl \rightarrow ArN^+N + Cl^- + Na^+ + OH^- + H_2O$$

dibasic acid An *acid that has two acidic hydrogen atoms in its molecules. Sulphuric (H_2SO_4) and carbonic (H_2CO_3) acids are common examples.

1,2-dibromoethane A colourless liquid *haloalkane, $BrCH_2CH_2Br$; r.d. 2.2; m.p. 9.79°C; b.p. 131.36°C. It is made by addition of bromine to ethene and used as an additive in petrol to remove lead during combustion as the volatile lead bromide.

dicarbide *See* CARBIDE.

dicarboxylic acid A *carboxylic acid having two carboxyl groups in its molecules. In systematic chemical nomenclature, dicarboxylic acids are denoted by the suffix *-dioic*; e.g. hexanedioic acid, $HOOC(CH_2)_4COOH$.

dichasium *See* CYMOSE INFLORESCENCE.

dichlorine oxide (chlorine monoxide) A strongly oxidizing orange gas, Cl_2O, made by oxidation of chlorine using mercury(II) oxide. It is the acid anhydride of chloric(I) acid.

dichloroethanoic acid *See* CHLOROETHANOIC ACIDS.

dichloromethane (methylene chloride) A colourless, slightly toxic liquid, CH_2Cl_2, b.p. 41°C. It has a characteristic odour similar to that of trichloromethane (chloroform), from which it is made by heating with zinc and hydrochloric acid. It is used as a refrigerant and solvent (for paint stripping and degreasing).

2,4-dichlorophenoxyacetic acid *See* 2,4-D.

dichogamy The condition in which the male and female reproductive organs of a flower mature at different times, thereby ensuring that self-fertilization does not occur. *Compare* HOMOGAMY. *See also* PROTANDRY; PROTOGYNY.

dichotomous Describing the type of branching in plants that results when the growing point (apical bud) divides into two equal growing points, which in turn divide in a similar manner after a period of growth, and so on. Dichotomous branching is common is ferns and mosses.

dichroism The property of some crystals, such as tourmaline, of selectively absorbing light vibrations in one plane while allowing light vibrations at right angles to this plane to pass through. Polaroid is a synthetic dichroic material. *See* POLARIZATION.

dichromate(VI) A salt containing the ion $Cr_2O_7^-$. Solutions containing dichromate(VI) ions are strongly oxidizing.

Dicotyledoneae In traditional classifications, one of the two classes of flowering plants (*see* ANTHOPHYTA), distinguished by having two seed leaves (*cotyledons) within the seed. The dicotyledons usually have leaf veins in the form of a net, a ring of vascular bundles in the stem, and flower parts in fours or fives or multiples of these. They include many food plants (e.g. potatoes, peas, beans), ornamentals (e.g. roses, ivies, honeysuckles), and hardwood trees (e.g. oaks, limes, beeches). Dicots are no longer considered a taxonomically valid group. *See* EUDICOT. *Compare* MONOCOTYLEDONEAE.

Dictyoptera An order of insects (sometimes classified as *Orthoptera) comprising the cockroaches (suborder Blattaria) and the mantids (suborder Mantodea), occurring mainly in tropical regions. Cockroaches are oval and flattened in shape; some have a single well-developed pair of wings, folded back over the abdomen at rest, while in others the wings may be reduced or absent. They are usually found in forest litter, feeding on dead organic matter, but some species, e.g. the American cockroach (*Periplaneta americana*), are major household pests, scavenging on starchy foods, fruits, etc. In most species the females produce capsules (**oothecae**) containing 16–40 eggs. These are either deposited or carried by the female during incubation.

dielectric A nonconductor of electric charge in which an applied electric field causes a *displacement of charge but not a flow of charge. Electrons within the atoms of a dielectric are, on average, displaced by an applied field with respect to the nucleus, giving rise to a dipole that has an electric moment in the direction of the field. The resulting stress within the dielectric is known as the **electric polarization** (P) and is defined by $P = D - E\varepsilon_0$, where D is the dis-

placement, E is the electric field strength, and ε_0 is the electric constant.

The **dielectric constant** is now called the relative *permittivity. The **dielectric strength** is the maximum potential gradient that can be applied to a material without causing it to break down. It is usually expressed in volts per millimetre. *See also* CAPACITOR.

dielectric constant *See* PERMITTIVITY.

dielectric heating The heating of a dielectric material, such as a plastic, by applying a radio-frequency electric field to it. The most common method is to treat the material as the dielectric between the plates of a capacitor. The heat produced is proportional to $V^2 f A \phi / t$, where V is the applied potential difference, f its frequency, A is the area of the dielectric, t its thickness, and ϕ is the loss factor of the material (related to its *permittivity).

Diels–Alder reaction A type of chemical reaction in which a compound containing two double bonds separated by a single bond (i.e. a conjugated *diene) adds to a suitable compound containing one double bond (known as the **dienophile**) to give a ring compound. In the dienophile, the double bond must have a carbonyl group on each side. It is named after the German chemists Otto Diels (1876–1954) and Kurt Alder (1902–58), who discovered it in 1928.

diene An *alkene that has two double bonds in its molecule. If the two bonds are separated by one single bond, as in buta-1,3-diene CH_2:CHCH:CH_2, the compound is a **conjugated diene**.

dienophile *See* DIELS–ALDER REACTION.

Diesel engine *See* INTERNAL-COMBUSTION ENGINE.

diet The food requirements of an organism. The foods that constitute the human diet should contain vitamins, mineral salts (*see* ESSENTIAL ELEMENT), and dietary *fibre as well as water, carbohydrates and fats (which provide energy), and proteins (required for growth and maintenance). A balanced diet contains of the correct proportions of these *nutrients, which will vary depending on the age, sex, body size, and the level of activity of the individual. An inadequate supply of different food types in the diet can lead to *malnutrition.

dietary fibre *See* FIBRE.

diethyl ether *See* ETHOXYETHANE.

differential calculus *See* CALCULUS.

differential equation An equation in which a derivative of y with respect to x appears as well as the variables x and y. The **order** of a differential equation is the order of its highest derivative. The **degree** of the equation is the highest power present of the highest-order derivative. There are many types of differential equation, each having its own method of solution. The simplest type has separable variables, enabling each side of the equation to be integrated separately.

differential scanning calorimetry (DSC) *See* THERMAL ANALYSIS.

differential thermal analysis (DTA) *See* THERMAL ANALYSIS.

differentiation **1.** (in mathematics) The process of finding the **derivative** of a function in differential *calculus. If $y = f(x)$, the derivative of y, written dy/dx or $f'(x)$, is equal to the limit as $\Delta x \to 0$ of $[f(x + \Delta x) - f(x)]/\Delta x$. In general, if $y = x^n$, then $dy/dx = nx^{n-1}$. On a graph of $y = f(x)$, the derivative dy/dx is the gradient of the tangent to the curve at the point x. **2.** (in biology) The changes from simple to more complex forms undergone by developing tissues and organs so that they become specialized for particular functions. Differentiation occurs during embryonic development, *regeneration, and (in plants) meristematic activity (*see* MERISTEM). *See also* HOMEOTIC GENES.

diffraction The spreading or bending of waves as they pass through an aperture or round the edge of a barrier. The diffracted waves subsequently interfere with each other (*see* INTERFERENCE) producing regions of reinforcement and weakening. First noticed as occurring with light by Francesco Grimaldi (1618–63), the phenomenon gave considerable support to the wave theory of light. Diffraction also occurs with streams of particles such as electrons because of the quantum-mechanical wave nature of such particles. *See also* FRESNEL DIFFRACTION; FRAUNHOFER DIFFRACTION; ELECTRON DIFFRACTION.

diffraction grating A device for producing spectra by diffraction and interference. The usual grating consists of a glass or speculum-metal sheet with a very large number of equidistant parallel lines ruled on it (usually of the order of 1000 per mm). Dif-

fracted light after transmission through the glass or reflection by the speculum produces maxima of illumination (spectral lines) according to the equation $m\lambda = d(\sin i + \sin\theta)$, where d is the distance between grating lines, λ is the wavelength of the light, i is the angle of incidence, θ the direction of the diffracted maximum, and m is the 'order' of the spectral line. Reflection gratings are also used to produce spectra in the ultraviolet region of the electromagnetic spectrum.

diffusion **1.** The process by which different substances mix as a result of the random motions of their component atoms, molecules, and ions. In gases, all the components are perfectly miscible with each other and mixing ultimately becomes nearly uniform, though slightly affected by gravity. The diffusion of a solute through a solvent to produce a solution of uniform concentration is slower, but otherwise very similar to the process of gaseous diffusion. Diffusion of small molecules and ions across a *cell membrane is known as **passive transport**. In solids, diffusion occurs very slowly at normal temperatures. *See also* FICK'S LAW; GRAHAM'S LAW. **2.** The scattering of a beam of light by reflection at a rough surface or by transmission through a translucent (rather than transparent) medium, such as frosted glass. **3.** The passage of elementary particles through matter when there is a high probability of scattering and a low probability of capture.

diffusion cloud chamber *See* CLOUD CHAMBER.

diffusion gradient *See* CONCENTRATION GRADIENT.

diffusion pump (condensation pump) A *vacuum pump in which oil or mercury vapour is diffused through a jet, which entrains the gas molecules from the container in which the pressure is to be reduced. The diffused vapour and entrained gas molecules are condensed on the cooled walls of the pump. Pressures down to 10^{-7} Pa can be reached by sophisticated forms of the diffusion pump.

digestion The breakdown by a living organism of ingested food material into chemically simpler forms that can be readily absorbed and assimilated by the body. This process requires the action of digestive enzymes and may take place extracellularly (i.e. in the *alimentary canal), as is the case in most animals; or intracellularly (e.g. by engulfing phagocytic cells), as occurs in protozoans and cnidarians.

digestive system The system of organs that are involved in the process of *digestion. The digestive system of mammals is divided into the **gastrointestinal tract** (*see* ALIMENTARY CANAL) and accessory structures, such as teeth, tongue, liver, pancreas, and gall bladder.

digit **1.** (in mathematics) A symbol used to represent a single number. For example, the number 479 consists of three digits. **2.** (in anatomy) A finger or toe. In the basic limb structure of terrestrial vertebrates there are five digits (*see* PENTADACTYL LIMB). This number is retained in man and other primates, but in some other species the number of digits is reduced. Frogs, for example, have four fingers and five toes, and in ungulate (hooved) mammals, the digits are reduced and their tips are enclosed in horn, forming hooves.

digital audio tape *See* DAT.

digital camera *see* CAMERA.

digital certificate *See* CERTIFICATE.

digital computer *See* COMPUTER.

digital display A method of indicating a reading of a measuring instrument, clock, etc., in which the appropriate numbers are generated on a fixed display unit by the varying parameter being measured rather than fixed numbers on a scale being indicated by a moving pointer or hand. *See* DIGITRON; LCD; LIGHT-EMITTING DIODE.

digital recording A method of recording or transmitting sound in which the sound itself is not transmitted or recorded. Instead the pressure in the sound wave is sampled at least 30 000 times per second and the successive values represented by numbers, which are then transmitted or recorded. Afterwards they are restored to analogue form in the receiver or player. This method is used for very high fidelity recordings as no distortion or interference occurs during transmission or in the recording process.

digitigrade Describing the gait of most fast-running animals, such as dogs and cats, in which only the toes are on the ground and the rest of the foot is raised off the ground. *Compare* PLANTIGRADE; UNGULIGRADE.

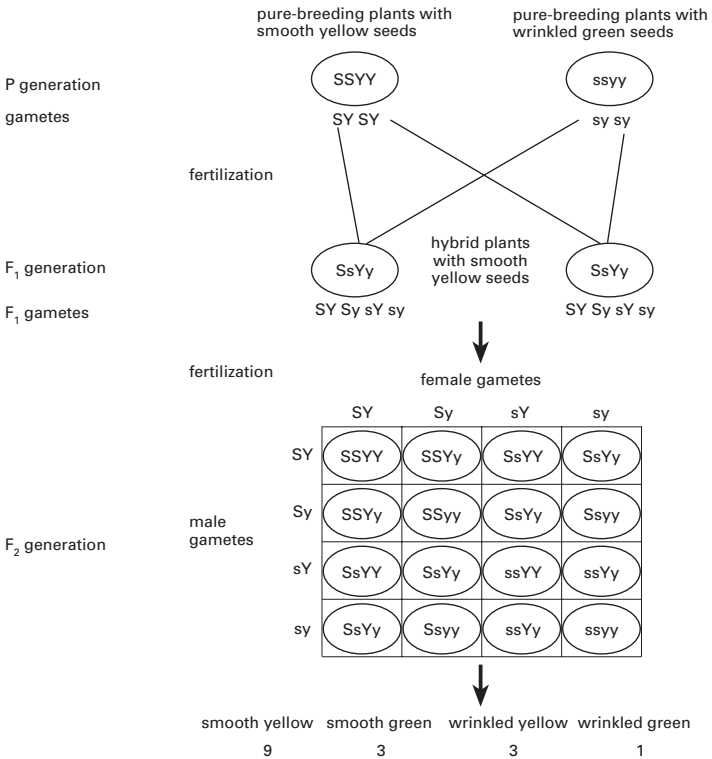
digitron An electronic gas-discharge tube

that provides a *digital display in calculators, counters, etc. It usually has 10 cold cathodes shaped into the form of the digits 0–9. The cathode selected receives a voltage pulse causing a glow discharge to illuminate the digit. It has now largely been superseded by *light-emitting diodes and liquid-crystal displays (*see* LCD).

dihedral (dihedron) An angle formed by the intersection of two planes (e.g. two faces of a polyhedron). The **dihedral angle** is the angle formed by taking a point on the line of intersection and drawing two lines from this point, one in each plane, perpendicular to the line of intersection.

dihybrid cross A genetic cross between parents that differ in two characteristics, controlled by genes at different loci. Mendel performed a dihybrid cross using pea plants and the characteristics of seed colour and texture: the parental plants had either smooth yellow seeds (SSYY) – the dominant characteristics – or wrinkled green seeds (ssyy) – the recessive characteristics. All the offspring had smooth yellow seeds, being heterozygous (SsYy) for the two alleles. Crossing between these offspring produced an F_2 generation of plants with smooth yellow, smooth green, wrinkled yellow, and wrinkled green seeds in the ratio 9:3:3:1 (see illustration). Mendel used these results as the basis for his Law of Independent Assortment (*see* MENDEL'S LAWS). *Compare* MONOHYBRID CROSS.

dihydrate A crystalline hydrate containing two moles of water per mole of compound.



Dihybrid cross.

dihydric alcohol *See* DIOL.

dihydrogen The normal form of molecular hydrogen, H_2, used to distinguish it from hydrogen atoms.

1,2-dihydroxybenzene (catechol) A colourless crystalline phenol, $C_6H_4(OH)_2$; r.d. 1.15; m.p. 105°C; b.p. 245°C. It is used as a photographic developer.

2,3-dihydroxybutanedioic acid *See* TARTARIC ACID.

dikaryon A cell of a fungal hypha or mycelium containing two haploid nuclei of different strains. The nuclei associate in pairs but do not fuse, therefore the cell is not truly diploid. Dikaryosis occurs in the Basidiomycota and Ascomycota.

dilatancy *See* NEWTONIAN FLUID.

dilation (dilatation) **1.** An increase in volume. *See also* VASODILATION. **2.** *See* TIME DILATION.

dilatometer A device for measuring the cubic *expansivities of liquids. It consists of a bulb of known volume joined to a graduated capillary tube, which is closed at the top to prevent evaporation. A known mass of liquid is introduced into the device, which is submerged in a bath maintained at different temperatures t_1 and t_2. The two volumes corresponding to these temperatures, V_1 and V_2, are read off the calibrated stem. The value of the cubic expansivity (γ) is then given by

$$\gamma = (V_2 - V_1)/V_1(t_2 - t_1).$$

dilead(II) lead(IV) oxide A red amorphous powder, Pb_3O_4; r.d. 9.1; decomposes at 500°C to lead(II) oxide. It is prepared by heating lead(II) oxide to 400°C and has the unusual property of being black when hot and red-orange when cold. The compound is nonstoichiometric, generally containing less oxygen than implied by the formula. It is largely covalent and has $Pb(IV)O_6$ octahedral groups linked together by Pb(II) atoms, each joined to three oxygen atoms. It is used in glass making but its use in the paint industry has largely been discontinued because of the toxicity of lead. Dilead(II) lead(IV) oxide is commonly called **red lead** or, more accurately, **red lead oxide**.

Dillie–Koppanyi test A presumptive test for barbituates. The **Dillie–Koppanyi test reagent** has two solutions: a 1% solution of cobalt acetate in methanol, followed by a 5% solution of isopropylamine ($CH_3CH(CH_3)NH_2$) in methanol. Barbiturates give a reddish-violet colour.

diluent A substance added to dilute a solution or mixture (e.g. a *filler).

dilute Describing a solution that has a relatively low concentration of solute.

dilution The volume of solvent in which a given amount of solute is dissolved.

dilution law *See* OSTWALD'S DILUTION LAW.

dimensional analysis A method of checking an equation or a solution to a problem by analysing the dimensions in which it is expressed. It is also useful for establishing the form, but not the numerical coefficients, of an empirical relationship. If the two sides of an equation do not have the same dimensions, the equation is wrong. If they do have the same dimensions, the equation may still be wrong, but the error is likely to be in the arithmetic rather than the method of solution.

dimensionless units *See* SI UNITS.

dimensions The product or quotient of the basic physical quantities, raised to the appropriate powers, in a derived physical quantity. The basic physical quantities of a mechanical system are usually taken to be mass (M), length (L), and time (T). Using these dimensions, the derived physical quantity velocity will have the dimensions L/T and acceleration will have the dimensions L/T^2. As force is the product of a mass and an acceleration (*see* NEWTON'S LAWS OF MOTION), force has the dimensions MLT^{-2}. In electrical work in *SI units, current, I, can be regarded as dimensionally independent and the dimensions of other electrical units can be found from standard relationships. Charge, for example, is measured as the product of current and time. It therefore has the dimension IT. Potential difference is given by the relationship $P = VI$, where P is power. As power is force × distance ÷ time ($MLT^{-2} \times L \times T^{-1} = ML^2T^{-3}$), voltage V is given by $V = ML^2T^{-3}I^{-1}$.

dimer An association of two identical molecules linked together. The molecules may react to form a larger molecule, as in the formation of dinitrogen tetroxide (N_2O_4) from nitrogen dioxide (NO_2), or the formation of an *aluminium chloride dimer (Al_2Cl_6) in the vapour. Alternatively, they may be held by hydrogen bonds. For example, carboxylic

acids form dimers in organic solvents, in which hydrogen bonds exist between the O of the C=O group and the H of the –O–H group.

dimethylbenzenes (xylenes) Three compounds with the formula $(CH_3)_2C_6H_4$, each having two methyl groups substituted on the benzene ring. 1,2-dimethylbenzene is ortho-xylene, etc. A mixture of the isomers (b.p. 135–145°C) is obtained from petroleum and is used as a clearing agent in preparing specimens for optical microscopy.

dimethylformamide (DMF) A colourless liquid compound, $(CH_3)_2NCHO$; r.d. 0.944; m.p. –61°C; b.p. 153°C. The systematic name is N,N-dimethylmethanamide. It can be made from methanoic acid (formic acid) and dimethylamine, and is widely used as a solvent.

dimethylglyoxime (DMG) A colourless solid, $(CH_3CNOH)_2$, m.p. 234°C. It sublimes at 215°C and slowly polymerizes if left to stand. It is used in chemical tests for nickel, with which it forms a dark-red complex.

dimethyl sulphoxide (DMSO) A colourless solid, $(CH_3)_2SO$; m.p. 18°C; b.p. 189°C. It is used as a solvent and as a reagent in organic synthesis.

1,3-dimethylxanthine *See* THEOPHYLLINE.

3,7-dimethylxanthine *See* THEOBROMINE.

dimictic lake A lake that is stratified by a *thermocline that is not permanent but is turned over twice during one year. The thermocline is disrupted due to seasonal changes in the climate. A **meromictic lake** is one in which there is a permanent stratification.

dimorphism **1.** (in biology) The existence of two distinctly different types of individual within a species. An obvious example is **sexual dimorphism** in certain animals, in which the two sexes differ in colouring, size, etc. Dimorphism also occurs in some lower plants, such as mosses and ferns, that show an *alternation of generations. **2.** (in chemistry) *See* POLYMORPHISM.

dinitrogen The normal form of molecular nitrogen, N_2, used to distinguish it from nitrogen atoms.

dinitrogen oxide (nitrous oxide) A colourless gas, N_2O, d. 1.97 g dm^{-3}; m.p. –90.8°C; b.p. –88.5°C. It is soluble in water, ethanol, and sulphuric acid. It may be prepared by the controlled heating of ammonium nitrate (chloride free) to 250°C and passing the gas produced through solutions of iron(II) sulphate to remove impurities of nitrogen monoxide. It is relatively unreactive, being inert to halogens, alkali metals, and ozone at normal temperatures. It is decomposed on heating above 520°C to nitrogen and oxygen and will support the combustion of many compounds. Dinitrogen oxide is used as an anaesthetic gas ('laughing gas') and as an aerosol propellant.

dinitrogen tetroxide A colourless to pale yellow liquid or a brown gas, N_2O_4; r.d. 1.45 (liquid); m.p. –11.2°C; b.p. 21.2°C. It dissolves in water with reaction to give a mixture of nitric acid and nitrous acid. It may be readily prepared in the laboratory by the reaction of copper with concentrated nitric acid; mixed nitrogen oxides containing dinitrogen oxide may also be produced by heating metal nitrates. The solid compound is wholly N_2O_4 and the liquid is about 99% N_2O_4 at the boiling point; N_2O_4 is diamagnetic. In the gas phase it dissociates to give **nitrogen dioxide**

$$N_2O_4 \rightleftharpoons 2NO_2$$

Because of the unpaired electron this is paramagnetic and brown. Liquid N_2O_4 has been widely studied as a nonaqueous solvent (self-ionizes to NO^+ and NO_3^-). Dinitrogen tetroxide, along with other nitrogen oxides, is a product of combustion engines and is thought to be involved in the depletion of stratospheric ozone.

Dinomastigota (Dinoflagellata) A phylum of mostly single-celled protists. They are abundant in the marine plankton; many are *photoautotrophs, containing brown xanthophyll pigments in addition to chlorophyll. Dinoflagellates characteristically have two undulipodia (flagella) for locomotion and most have a rigid cell wall of cellulose encrusted with silica. Some species (e.g. *Noctiluca miliaris*) are bioluminescent.

dinosaur An extinct terrestrial reptile belonging to a group that constituted the dominant land animals of the Jurassic and Cretaceous periods, 190–65 million years ago. There were two orders. The Ornithischia were typically quadrupedal herbivores, many with heavily armoured bodies, and included *Stegosaurus*, *Triceratops*, and *Iguanodon*. They were all characterized by birdlike pelvic girdles. The Saurischia included many

bipedal carnivorous forms, such as *Tyrannosaurus* (the largest known carnivore), and some quadrupedal herbivorous forms, such as *Apatosaurus* (*Brontosaurus*) and *Diplodocus*. They all had lizard-like pelvic girdles. Many of the herbivorous dinosaurs were amphibious or semiaquatic.

d

SEE WEB LINKS

- A Dino Directory produced by the Natural History Museum, London; contains a wealth of information and images

dinucleotide A compound consisting of two *nucleotides.

diode An electronic device with two electrodes. In the obsolescent **thermionic diode** a heated cathode emits electrons, which flow across the intervening vacuum to the anode when a positive potential is applied to it. The device permits flow of current in one direction only as a negative potential applied to the anode repels the electrons. This property of diodes was made use of in the first thermionic radios, in which the diode was used to demodulate the transmitted signal (*see* MODULATION). In the **semiconductor diode**, a *p*–*n* junction performs a similar function. The forward current increases with increasing potential difference whereas the reverse current is very small indeed. *See* SEMICONDUCTOR; TRANSISTOR.

dioecious Describing plant species that have male and female flowers on separate plants. Examples of dioecious plants are willows. *Compare* MONOECIOUS.

diol (dihydric alcohol) An *alcohol containing two hydroxyl groups per molecule.

dioptre A unit for expressing the power of a lens or mirror equal to the reciprocal of its focal length in metres. Thus a lens with a focal length of 0.5 metre has a power of 1/0.5 = 2 dioptres. The power of a converging lens is usually taken to be positive and that of a diverging lens negative. Because the power of a lens is a measure of its ability to cause a beam to converge, the dioptre is now sometimes called the radian per metre.

dioxan A colourless toxic liquid, $C_4H_8O_2$; r.d. 1.03; m.p. 11°C; b.p. 101.5°C. The molecule has a six-membered ring containing four CH_2 groups and two oxygen atoms at opposite corners. It can be made from ethane-1,2-diol and is used as a solvent.

dioxin (2,4,7,8-tetrachlorodibenzo-*p*-dioxin) A toxic solid, formed in the manufacture of the herbicide *2,4,5-T; it was present as an impurity in Agent Orange, used as a defoliant during the Vietnam War. It is the most toxic member of a group of compounds (called **dioxins**) that occur widely as environmental pollutants, being produced during combustion processes and as byproducts in various industrial manufacturing processes. Dioxins decompose very slowly and may be concentrated in the food chain; in animals they are stored in fat. Exposure to high levels of dioxins can cause skin disfigurement (chloracne) and may result in fetal defects. Because of their toxicity, many countries have imposed strict controls to reduce industrial emissions of dioxins.

dioxonitric(III) acid *See* NITROUS ACID.

dioxygen The normal form of molecular oxygen, O_2, used to distinguish it from oxygen atoms or from ozone (O_3).

dioxygenyl compounds Compounds containing the positive ion O_2^+, as in dioxygenyl hexafluoroplatinate O_2PtF_6 – an orange solid that sublimes in vacuum at 100°C. Other ionic compounds of the type $O_2^+[MF_6]^-$ can be prepared, where M is P, As, or Sb.

dip *See* GEOMAGNETISM.

dipeptide A compound consisting of two amino acid units joined at the amino ($-NH_2$) end of one and the carboxyl (–COOH) end of the other. This peptide bond (*see* PEPTIDE) is formed by a condensation reaction that involves the removal of one molecule of water.

diphenylmethanone (benzophenone) A colourless solid, $C_6H_5COC_6H_5$, m.p. 49°C. It has a characteristic smell and is used in making perfumes. It is made from benzene and benzoyl chloride using the *Friedel–Crafts reaction with aluminium chloride as catalyst.

diphosgene A colourless liquid, $ClCO.O.CCl_3$, originally used in 1916 by Germany in World War I as a chemical warfare agent. It is now used as a reagent in organic synthesis. *See also* CARBONYL CHLORIDE.

diphosphane (diphosphine) A yellow liquid, P_2H_4, which is spontaneously flammable in air. It is obtained by hydrolysis of calcium phosphide. Many of the references to the spontaneous flammability of phosphine (PH_3) are in fact due to traces of P_2H_4 as impurities.

diphosphine *See* DIPHOSPHANE.

diphosphonates *See* BISPHOSPHONATES.

diphyodont Describing a type of dentition that is characterized by two successive sets of teeth: the *deciduous (milk) teeth, which are followed by the *permanent (adult) teeth. Mammals have a diphyodont dentition. *Compare* MONOPHYODONT; POLYPHYODONT.

diploblastic Describing an animal with a body wall composed only of two layers, *ectoderm and *endoderm, sometimes with a noncellular *mesoglea between them. Cnidarians are diploblastic. *Compare* TRIPLOBLASTIC.

diploid Describing a nucleus, cell, or organism with twice the *haploid number of chromosomes characteristic of the species. The diploid number is designated as 2*n*. Two sets of chromosomes are present, one set being derived from the female parent and the other from the male. In animals, all the cells except the reproductive cells are diploid.

Diplopoda A class of terrestrial *arthropods comprising the millipedes and belonging to the subphylym *Myriapoda. Diplopods are characterized by 20 to over 60 body segments each bearing two pairs of legs. They are slow moving and feed on decaying leaves.

diplotene The period in the first prophase of *meiosis when paired *homologous chromosomes begin to move apart. They remain attached at a number of points (*see* CHIASMA).

Dipnoi A subclass or order of bony fishes that contains the lungfishes, which have lungs and breathe air. They are found in Africa, Australia, and South America, where they live in freshwater lakes and marshes that tend to become stagnant or even dry up in summer. They survive in these conditions by burrowing into the mud, leaving a small hole for breathing air, and entering a state of *aestivation, in which they can remain for six months or more. The Dipnoi date from the Devonian era (416–360 million years ago) and share many features with the modern *Amphibia.

dipole **1.** A pair of separated opposite electric charges. The **dipole moment** (symbol μ) is the product of the positive charge and the distance between the charges. Dipole moments are often stated in *debyes; the SI unit is the coulomb metre. In a diatomic molecule, such as HCl, the dipole moment is a measure of the polar nature of the bond (*see* POLAR MOLECULE); i.e. the extent to which the average electron charge is displaced towards one atom (in the case of HCl, the electrons are attracted towards the more electronegative chlorine atom). In a polyatomic molecule, the dipole moment is the vector sum of the dipole moments of the individual bonds. In a symmetrical molecule, such as tetrachloromethane (CCl_4), there is no overall dipole moment, although the individual C–Cl bonds are polar. **2.** An aerial commonly used for frequencies below 30 megahertz, although some are in use above this frequency. It consists of a rod, fed or tapped at its centre. It may be half a wavelength or a full wavelength long.

dipole radiation *See* FORBIDDEN TRANSITIONS.

Diptera An order of insects comprising the true, or two-winged, flies. Flies possess only one pair of wings – the forewings; the hindwings are modified to form small clublike **halteres** that function as balancing organs. Typically fluid feeders, flies have mouthparts adapted for piercing and sucking or for lapping; the diet includes nectar, sap, decaying organic matter, and blood. Some species prey on insects; others are parasitic. Dipteran larvae (**maggots**) are typically wormlike with an inconspicuous head. They undergo metamorphosis via a pupal stage to the adult form. Many flies or their larvae are serious pests, either by feeding on crops (e.g. fruit flies) or as vectors of disease organisms (e.g. the house fly (*Musca domestica*) and certain mosquitoes).

Dirac, Paul Adrien Maurice (1902–84) British physicist, who shared the 1933 Nobel Prize for physics with Erwin *Schrödinger for developing Schrödinger's non-relativistic wave equations to take account of relativity. This modified equation predicted the existence and properties of the *positron. Dirac also invented, independently of Enrico Fermi, the form of *quantum statistics known as Fermi–Dirac statistics.

Dirac constant *See* PLANCK CONSTANT.

Dirac equation A version of the nonrelativistic *Schrödinger equation taking special relativity theory into account. The Dirac equation is needed to discuss the quantum

mechanics of electrons in heavy atoms and, more generally, to discuss fine-structure features of atomic spectra. The equation was put forward by Paul Dirac in 1928. It can be solved exactly in the case of the hydrogen atom but can only be solved using approximation techniques for more complicated atoms.

direct current (d.c.) An electric current in which the net flow of charge is in one direction only. *Compare* ALTERNATING CURRENT.

direct-current motor *See* ELECTRIC MOTOR.

direct dye *See* DYES.

direct motion **1.** The apparent motion of a planet from west to east as seen from the earth against the background of the stars. **2.** The anticlockwise rotation of a planet, as seen from its north pole. *Compare* RETROGRADE MOTION.

directrix **1.** A plane curve defining the base of a *cone. **2.** A straight line from which the distance to any point on a *conic is in a constant ratio to the distance from that point to the focus.

disaccharide A sugar consisting of two linked *monosaccharide molecules. For example, sucrose comprises one glucose molecule and one fructose molecule bonded together.

discharge **1.** The conversion of the chemical energy stored in a *secondary cell into electrical energy. **2.** The release of electric charge from a capacitor in an external circuit. **3.** The passage of charge carriers through a gas at low pressure in a **discharge tube**. A potential difference applied between cathode and anode creates an electric field that accelerates any free electrons and ions to their appropriate electrodes. Collisions between electrons and gas molecules create more ions. Collisions also produce excited ions and molecules (*see* EXCITATION), which decay with emission of light in certain parts of the tube.

discontinuous function *See* CONTINUOUS FUNCTION.

discontinuous variation (qualitative variation) Clearly defined differences in a characteristic that can be observed in a population. Characteristics that are determined by different *alleles at a single locus show discontinuous variation, e.g. garden peas are either wrinkled or smooth. *Compare* CONTINUOUS VARIATION.

disease A condition in which the normal function of some part of the body (cells, tissues, or organs) is disturbed. A variety of microorganisms and environmental agents are capable of causing disease. The functional disturbances are often accompanied by structural changes in tissue.

disilane *See* SILANE.

disinfectant Any substance that kills or inhibits the growth of disease-producing microorganisms and is in general toxic to human tissues. Disinfectants include cresol, bleaching powder, and phenol. They are used to cleanse surgical apparatus, sickrooms, and household drains and if sufficiently diluted can be used as *antiseptics.

disintegration Any process in which an atomic nucleus breaks up spontaneously into two or more fragments in a radioactive decay process or breaks up as a result of a collision with a high-energy particle or nuclear fragment.

disintegration constant *See* DECAY.

dislocation *See* CRYSTAL DEFECTS (Feature).

disodium hydrogenphosphate(V) (disodium orthophosphate) A colourless crystalline solid, Na_2HPO_4, soluble in water and insoluble in ethanol. It is known as the dihydrate (r.d. 2.066), heptahydrate (r.d. 1.68), and dodecahydrate (r.d. 1.52). It may be prepared by titrating phosphoric acid with sodium hydroxide to an alkaline end point (phenolphthalein) and is used in treating boiler feed water and in the textile industry.

disodium orthophosphate *See* DISODIUM HYDROGENPHOSPHATE(V).

disodium tetraborate-10-water *See* BORAX.

***d*-isomer** *See* OPTICAL ACTIVITY.

D-isomer *See* ABSOLUTE CONFIGURATION.

disordered solid A material that neither has the structure of a perfect *crystal lattice nor of a crystal lattice with isolated *crystal defects. In a **random alloy**, one type of disordered solid, the order of the different types of atom occurs at random. Another type of disordered solid is formed by introducing a high concentration of defects, with the defects distributed randomly throughout the

solid. In an *amorphous solid, such as glass, there is a random network of atoms with no lattice. The theory of disordered solids is more complicated than the theory of crystals, requiring such concepts as *localization and *spin glasses.

dispersal The dissemination of offspring of plants or sessile animals. Dispersal provides organisms that are not mobile with a better chance of survival by reducing *competition among offspring and parents. It also promotes the colonization of new habitats. Flowering plants produce fruits or seeds that are dispersed by such agents as wind, water, or animals. Specialized structures have evolved in many species to aid dispersal (*see* FRUIT).

disperse dye *See* DYES.

disperse phase *See* COLLOIDS.

dispersion The splitting up of a ray of light of mixed wavelengths by refraction into its components. Dispersion occurs because the *deviation for each wavelength is different on account of the different speeds at which waves of different wavelengths pass through the refracting medium. If a ray of white light strikes one face of a prism and passes out of another face, the white light will be split into its components and the full visible spectrum will be formed. The **dispersive power** of a prism (or other medium) for white light is defined by

$$(n_b - n_r)/(n_y - 1),$$

where n_b, n_r, and n_y are the *refractive indexes for blue, red, and yellow light respectively. The term is sometimes applied to the separation of wavelengths produced by a *diffraction grating.

dispersion forces *See* VAN DER WAALS' FORCE.

dispersive power *See* DISPERSION.

displacement **1.** Symbol *s*. A specified distance in a specified direction. It is the vector equivalent of the scalar distance. **2.** *See* ELECTRIC DISPLACEMENT.

displacement activity An activity shown by an animal that appears to be irrelevant to its situation. Displacement activities are frequently observed when there is conflict between opposing tendencies. For example, birds in aggressive situations, in which there are simultaneous tendencies to attack and to flee, may preen their feathers as a displacement activity.

displacement current A term of the form $\partial \boldsymbol{D}/\partial t$, where $\boldsymbol{D}$ is the *electric displacement, which is added to the electric current density $\boldsymbol{J}$ to modify *Ampère's law in the fourth of *Maxwell's equations. The necessity for the displacement current term was postulated by Maxwell when he put forward his equations to introduce a degree of symmetry between electricity and magnetism.

displacement reaction *See* SUBSTITUTION REACTION.

display behaviour Stereotyped movement or posture that serves to influence the behaviour of another animal. Many displays in *courtship and *aggression are conspicuous and characteristic of the species; special markings or parts of the body may be prominently exhibited (for example, the male peacock spreads its tail in courtship). Other displays are cryptic and make it harder for a predator to recognize the displaying animal as potential prey. For example, geometer moth caterpillars, which look like twigs, hold themselves on plant stems with one end sticking into the air.

disproportionation A type of chemical reaction in which the same compound is simultaneously reduced and oxidized. For example, copper(I) chloride disproportionates thus:

$$2CuCl \rightarrow Cu + CuCl_2$$

The reaction involves oxidation of one molecule

$$Cu^{I} \rightarrow Cu^{II} + e$$

and reduction of the other

$$Cu^{I} + e \rightarrow Cu$$

The reaction of halogens with hydroxide ions is another example of a disproportionation reaction, for example

$$Cl_2(g) + 2OH^-(aq) \rightleftharpoons Cl^-(aq) + ClO^-(aq) + H_2O(l)$$

The reverse process is *comproportionation.

dissipative structure A state of matter that occurs when a system is driven away from thermal *equilibrium by external constraints that have exceeded certain critical values. A dissipative structure, which is associated with *broken symmetry, is an example of *complexity and *self-organization. An example of dissipative structure is a *Bénard cell. The order in a dissipative structure that

is not in thermal equilibrium occurs as a response to such parameters as heat.

dissipative system A system that involves irreversible processes (*see* IRREVERSIBILTY). All real systems are dissipative (in contrast to such idealized systems as the frictionless pendulum, which is invariant under time reversal). In a dissipative system the system is moving towards a state of equilibrium, which can be regarded as moving toward a point *attractor in *phase space; this is equivalent to moving towards the minimum of the *free energy, *F*.

dissociation The breakdown of a molecule, ion, etc., into smaller molecules, ions, etc. An example of dissociation is the reversible reaction of hydrogen iodide at high temperatures

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

The *equilibrium constant of a reversible dissociation is called the **dissociation constant**. The term 'dissociation' is also applied to ionization reactions of *acids and *bases in water; for example

$$HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$$

which is often regarded as a straightforward dissociation into ions

$$HCN \rightleftharpoons H^+ + CN^-$$

The equilibrium constant of such a dissociation is called the **acid dissociation constant** or **acidity constant**, given by

$$K_a = [H^+][A^-]/[HA]$$

for an acid HA (the concentration of water $[H_2O]$ can be taken as constant). K_a is a measure of the strength of the acid. Similarly, for a nitrogenous base B, the equilibrium

$$B + H_2O \rightleftharpoons BH^+ + OH^-$$

is also a dissociation; with the **base dissociation constant**, or **basicity constant**, given by

$$K_b = [BH^+][OH^-]/[B]$$

For a hydroxide MOH,

$$K_b = [M^+][OH^-]/[MOH]$$

dissociation pressure When a solid compound dissociates to give one or more gaseous products, the dissociation pressure is the pressure of gas in equilibrium with the solid at a given temperature. For example, when calcium carbonate is maintained at a constant high temperature in a closed container, the dissociation pressure at that temperature is the pressure of carbon dioxide from the equilibrium

$$CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$$

distal Describing the part of an organ that is farthest from the organ's point of attachment to the rest of the body. For example, hands and feet are at the distal ends of arms and legs, respectively. *Compare* PROXIMAL.

distal convoluted tubule (second convoluted tubule) The part of a *nephron that leads from the thick ascending limb of the *loop of Henle and drains into a *collecting duct. The main function of the distal tubule is to absorb sodium chloride and other inorganic salts while retaining water.

distillation The process of boiling a liquid and condensing and collecting the vapour. The liquid collected is the **distillate**. It is used to purify liquids and to separate liquid mixtures (*see* FRACTIONAL DISTILLATION; STEAM DISTILLATION). *See also* DESTRUCTIVE DISTILLATION; EXTRACTIVE DISTILLATION.

distilled water Water purified by distillation so as to free it from dissolved salts and other compounds. Distilled water in equilibrium with the carbon dioxide in the air has a conductivity of about 0.8×10^{-6} siemens cm^{-1}. Repeated distillation in a vacuum can bring the conductivity down to 0.043×10^{-6} siemens cm^{-1} at 18°C (sometimes called **conductivity water**). The limiting conductivity is due to self-ionization: $H_2O \rightleftharpoons H^+ + OH^-$.

distortion The extent to which a system fails to reproduce the characteristics of its input in its output. It is most commonly applied to electronic amplifiers and to optical systems. *See* ABERRATION.

distribution function A function of some variable, such as velocity, that expresses the probability that a particle, such as a molecule of gas, will have a particular value of that variable.

distributive law The mathematical law stating that one operation is independent of being carried out before or after another operation. For example, multiplication is distributive with respect to addition and subtraction, i.e. $x(y + z) = xy + xz$. *Compare* ASSOCIATIVE LAW; COMMUTATIVE LAW.

disulphide bridge (sulphur bridge) A covalent bond (S–S) formed between the thiol groups (–SH) of two cysteine residues, usually in the polypeptide chains of proteins. Easily hydrolysed and prone to rearrange-

ment, these bonds contribute to the tertiary structure of *proteins.

disulphur dichloride (sulphur monochloride) An orange–red liquid, S_2Cl_2, which is readily hydrolysed by water and is soluble in benzene and ether; r.d. 1.678; m.p. –80°C; b.p. 136°C. It may be prepared by passing chlorine over molten sulphur; in the presence of iodine or metal chlorides **sulphur dichloride**, SCl_2, is also formed. In the vapour phase S_2Cl_2 molecules have Cl–S–S–Cl chains. The compound is used as a solvent for sulphur and can form higher **chlorosulphanes** of the type $Cl–(S)_n–Cl$ ($n < 100$), which are of great value in *vulcanization processes.

disulphuric(VI) acid (pyrosulphuric acid) A colourless hygroscopic crystalline solid, $H_2S_2O_7$; r.d. 1.9; m.p. 35°C. It is commonly encountered mixed with sulphuric acid as it is formed by dissolving sulphur trioxide in concentrated sulphuric acid. The resulting fuming liquid, called **oleum** or **Nordhausen sulphuric acid**, is produced during the *contact process and is also widely used in the *sulphonation of organic compounds. *See also* SULPHURIC ACID.

dithionate A salt of dithionic acid, containing the ion $S_2O_6^{2-}$, usually formed by the oxidation of a sulphite using manganese(IV) oxide. The ion has neither pronounced oxidizing nor reducing properties.

dithionic acid An acid, $H_2S_2O_6$, known in the form of its salts (dithionates).

dithionite *See* SULPHINATE.

dithionous acid *See* SULPHINIC ACID.

diuretic A drug or other agent that increases the rate of urine formation and hence the rate at which water and certain salts are lost from the body. Many diuretic drugs work by decreasing the reabsorption of sodium and chloride ions from the filtrate in the kidney tubules, so that less water is reabsorbed. They are used to treat fluid retention (oedema) arising from disorders of the heart, kidneys, or other organs, and are used in helping to reduce high blood pressure (hypertension). There are several groups of diuretic drugs, with different modes of action. The most powerful are **loop diuretics**, such as frusemide, which act primarily by blocking $Na^+/K^+/Cl^-$ carriers in cells of the *loop of Henle. Another group consists of the thiazides, such as metolazone, which inhibit Na^+/Cl^- transport in the *distal convoluted tubule. Spironolactone exerts its diuretic effect by blocking the binding of the hormone *aldosterone to its receptors. The **osmotic diuretics**, such as mannitol, act by increasing the osmolarity of the filtrate, and hence increasing urine volume.

diurnal Daily; denoting an event that happens once every 24 hours.

diurnal rhythm *See* CIRCADIAN RHYTHM.

divalent (bivalent) Having a valency of two.

divergence (div) The *scalar product of the *gradient operator ∇ with a vector. For a vector $\boldsymbol{u}$ that has components u_1, u_2, and u_3 in the *x*, *y*, and *z* directions, and is a function of *x*, *y*, and *z*, the divergence is given by:

$$\mathrm{div}\,\boldsymbol{u} = \nabla.\boldsymbol{u} = \partial u_1/\partial x + \partial u_2/\partial y + \partial u_3/\partial z.$$

The divergence of a vector at a given point represents the flux of the vector per unit volume in the neighbourhood of that point. *See also* CURL; LAPLACE EQUATION.

divergence theorem A theorem that gives the relation between the total flux of a vector $\boldsymbol{F}$ out of a surface *S*, which surrounds the volume *V*, to the vector inside the volume. The divergence theorem states that

$$\int_v \mathrm{div}\boldsymbol{F}\mathrm{d}V = \int_s \boldsymbol{F}\cdot\mathrm{d}S.$$

The divergence theorem is also known as **Gauss' theorem** and **Ostrogradsky's theorem** (named after the Russian mathematician Michel Ostrogradsky (1801–61), who stated it in 1831). *Gauss' law for electric fields is a particular case of the divergence theorem.

divergent evolution *See* ADAPTIVE RADIATION.

divergent series *See* CONVERGENT SERIES.

diverging lens or mirror A lens or mirror that can refract or reflect a parallel beam of light into a diverging beam. A diverging lens is predominantly concave; a diverging mirror is convex. *Compare* CONVERGING LENS OR MIRROR.

diverticulum A saclike or tubular outgrowth from a tubular or hollow internal organ. Diverticula may occur as normal structures (e.g. the *caecum and *appendix in the alimentary canal) or abnormally, from a weakened area of the organ.

division A category used traditionally in the *classification of plants that consists of

one or several similar classes. Division names end in -phyta; an example is the Spermatophyta (seed-bearing plants).

dizygotic twins *See* FRATERNAL TWINS.

D-lines Two close lines in the yellow region of the visible spectrum of sodium, having wavelengths 589.0 and 589.6 nm. As they are prominent and easily recognized they are used as a standard in spectroscopy.

***dl*-isomer** *See* OPTICAL ACTIVITY; RACEMIC MIXTURE.

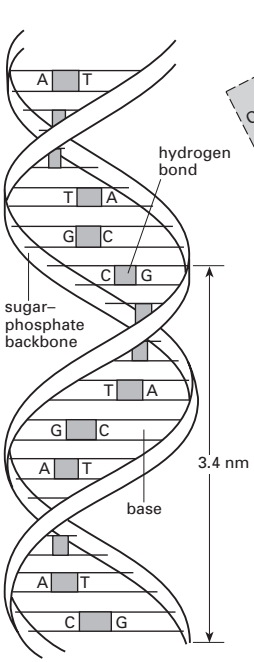
DMF *See* DIMETHYLFORMAMIDE.

DMG *See* DIMETHYLGLYOXIME.

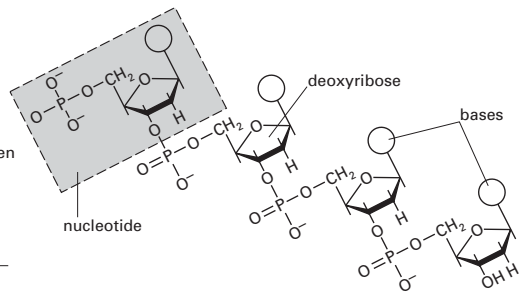
DMSO *See* DIMETHYL SULPHOXIDE.

DNA (deoxyribonucleic acid) The genetic material of most living organisms, which is a major constituent of the *chromosomes within the cell nucleus and plays a central role in the determination of hereditary characteristics by controlling *protein synthesis in cells (*see also* GENETIC CODE). It is also found in chloroplasts and mitochondria (*see* CYTOPLASMIC INHERITANCE; MITOCHONDRIAL DNA). DNA is a nucleic acid composed of two chains of *nucleotides in which the sugar is **deoxyribose** and the bases are *adenine, *cytosine, *guanine, and *thymine (*compare* RNA). The two chains are wound round each other and linked together by hydrogen bonds between specific complementary bases (*see* BASE PAIRING) to form a spiral ladder-shaped molecule (**double helix**). See illustration.

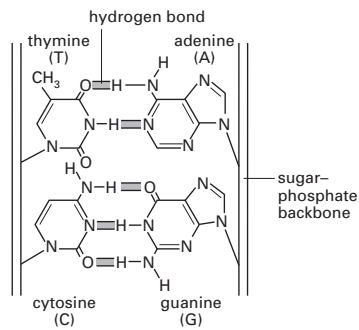
When the cell divides, its DNA also replicates in such a way that each of the two



Double helical structure of DNA



Detail of molecular structure of sugar–phosphate backbone. Each deoxyribose unit is attached to a phosphate group and a base, forming a nucleotide



The four bases of DNA, showing the hydrogen bonding between base pairs

DNA. Its molecular structure.

daughter molecules is identical to the parent molecule (*see* DNA REPLICATION). *See also* COMPLEMENTARY DNA.

SEE WEB LINKS

- An animated primer on basic aspects of DNA, genes, and heredity; produced for the Cold Spring Harbor Laboratory.

DNAase *See* DNASE.

DNA blotting *See* SOUTHERN BLOTTING.

DNA chip *See* DNA MICROARRAY.

DNA cloning *See* GENE CLONING.

DNA-dependent RNA polymerase *See* POLYMERASE.

DNA fingerprinting *See* DNA PROFILING.

DNA hybridization A method of determining the similarity of DNA from different sources. Single strands of DNA from two sources, e.g. different bacterial species, are put together and the extent to which double hybrid strands are formed is estimated. The greater the tendency to form these hybrid molecules, the greater the extent of complementary base sequences, i.e. gene similarity. The method is one way of determining the genetic relationships of species.

DNA library (gene library; gene bank) A collection of cloned DNA fragments representing the entire genetic material of an organism. This facilitates screening and isolation of any particular gene. DNA libraries are created by fractionating the genomic DNA into fragments using *restriction enzymes and/or physical methods. These fragments are cloned (*see* GENE CLONING) and the host cells containing the recombinant fragments are centrifuged and frozen; alternatively, the phage *vectors are maintained in culture. Individual genes in the library are identified using specific *gene probes with the *Southern blotting technique or, via their protein products, using *Western blotting. DNA libraries are thus repositories of raw material for use in genetic engineering. A large genome, such as that of humans, is most conveniently cloned using vectors that can accommodate large fragments of DNA, such as yeast *artificial chromosomes, maintained in cell culture.

DNA ligase An enzyme that is able to join together two portions of DNA and therefore plays an important role in *DNA repair. DNA ligase is also used in recombinant DNA technology (*see* GENETIC ENGINEERING) as it ensures that the foreign DNA (e.g. the complementary DNA used in *gene cloning) is bound to the plasmid into which it is incorporated.

DNA methylation The addition of methyl groups to constituent bases of DNA. In both prokaryotes and eukaryotes certain bases of the DNA generally occur in a methylated form. In bacteria this methylation protects the cell's DNA from attack by its own restriction enzymes, which cleave foreign unmethylated DNA and thereby help to eliminate viral DNA from the bacterial chromosome. Methylation is also important in helping *DNA repair enzymes to distinguish the parent strand from the progeny strand when repairing mismatched bases in newly replicated DNA, and it also plays a role in controlling the transcription of DNA.

DNA microarray (DNA chip) A *microarray containing numerous small DNA molecules. DNA microarrays consist of thousands of short synthetic single-stranded DNA molecules, each comprising 20–25 nucleotides and all with unique sequences designed to complement and bind to specific target nucleotide sequences. They can be used to quantify gene expression by determining the total output of messenger RNAs (mRNAs) (i.e. the *transcriptome) of a cell or tissue. This involves adding fluorescent labels to the mRNAs, then incubating these with the microarray so that they bind to complementary oligonucleotides on it. A computerized scanner measures the intensity of fluorescence and thereby the amount of bound mRNA. DNA microarrays can also detect mutations in particular genes, for example the *BRCA* genes involved in hereditary forms of breast cancer. An individual's DNA is denatured, and its binding to a microarray is compared with that of normal (control) DNA on the same microarray. Any disparities between the two binding patterns will pinpoint sequences from the individual with possible abnormalities, enabling closer examination.

DNA polymerase *See* POLYMERASE.

DNA probe *See* GENE PROBE.

DNA profiling (genetic fingerprinting) A technique in which an individual's DNA is analysed to reveal the pattern of repetition of certain short nucleotide sequences, called short tandem repeats: (STRs), throughout the genome. This pattern is claimed to be

unique to the individual concerned, and the technique is therefore used for identification purposes in forensic science and paternity disputes, and in veterinary science. Sufficient DNA can be obtained from very small samples of body tissue, such as blood, semen, or hair.

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DNA repair A variety of mechanisms that help to ensure that the genetic sequence, as expressed in the DNA, is maintained and that errors that occur during *DNA replication, by mutation, are not allowed to accumulate. An error in the genetic sequence could cause cell death by interfering with the replication process. The mechanisms work because DNA is made up of two strands, each of which contains a copy of the genetic sequence. A damaged section of a strand, or a mismatched base, can be recognized and removed by enzymes and replaced by the correct form by DNA *polymerases. The phosphodiester backbone is then sealed by *DNA ligase.

DNA replication The process whereby DNA makes exact copies of itself, which is controlled by the enzyme DNA *polymerase. Replication occurs at rates of between 50 nucleotides per second (in mammals) and 500 nucleotides per second (in bacteria). The hydrogen bonds between the complementary bases on the two strands of the parent DNA molecule break and the strands unwind, each strand acting as a template for the synthesis of a new one complementary to itself. DNA polymerases move down the two single strands linking free nucleotides to their complementary bases (*see* BASE PAIRING) on the templates. The process continues until all the nucleotides on the templates have joined with appropriate free nucleotides and two identical molecules of DNA have been formed. This process is known as **semiconservative replication** as each new molecule contains half of the original parent DNA molecule. Sometimes mutations occur that may cause the exact sequence of the parent DNA not to be replicated. However, *DNA repair mechanisms reduce this possibility.

DNase (DNAase; deoxyribonuclease) An enzyme that catalyses the cleavage of DNA. DNase I is a digestive enzyme, secreted by the pancreas, that degrades DNA into shorter nucleotide fragments. Many other *endonucleases and *exonucleases cleave DNA, including the *restriction enzymes and enzymes involved in DNA repair and replication.

DNA sequencing (gene sequencing) The process of elucidating the nucleotide sequence of a DNA fragment. The method now used almost universally is the Sanger method (named after Frederick *Sanger), also called the dideoxy method, which involves synthesizing a new DNA strand using as template single-stranded DNA from the gene being sequenced. Synthesis of the new strand can be stopped at any of the four bases by adding the corresponding dideoxy (dd) derivative of the deoxyribonucleoside phosphates; for example, by adding ddATP the synthesis terminates at an adenosine; by adding ddGTP it terminates at a guanosine, etc. The fragments, which comprise fluorescently labelled nucleotides, are subjected to electrophoresis and scanned by a fluorescence detector. A big advantage of the Sanger method is that it can easily be adapted to sequencing RNA, by making single-stranded DNA from the RNA template using the enzyme *reverse transcriptase. This enables, for example, sequencing of ribosomal RNA for use in *molecular systematics. After separation of the fragments, the products of all four reactions are detected by fluorescence spectroscopy and analysed by computer, which gives a printout of the base sequence. DNA sequencing using fully automated sequencers is now employed on a major scale, for example in determining the nucleotide sequence of entire genomes (*see* GENOME PROJECT).

DNS *See* DOMAIN NAME SYSTEM.

Döbereiner's triads A set of triads of chemically similar elements noted by Johann Döbereiner (1780–1849) in 1817. Even with the inaccurate atomic mass data of the day it was observed that when each triad was arranged in order of increasing atomic mass, then the mass of the central member was approximately the average of the values for the other two. The chemical and physical properties were similarly related. The triads are now recognized as consecutive members of the groups of the periodic table. Examples are: lithium, sodium, and potassium; calcium, strontium, and barium; and chlorine, bromine, and iodine.

SEE WEB LINKS

- Döbereiner's original paper

Document Object Model (DOM) A stan-

dard interface for representing *XML and *HTML documents. The data is parsed into a tree of objects, which a programmer can navigate and manipulate. It is especially relevant to web browsers, and in particular to the implementation of dynamic HTML. The World Wide Web Consortium released the first version of the DOM (level 1) in 1998, although a previous intermediate version (level 0) had already been incorporated in HTML 4; levels 2 and 3 have subsequently been released. Adoption of the DOM by web browsers – which had previously implemented idiosyncratic and incompatible models – was initially slow and is still not uniform.

SEE WEB LINKS

- The WSC's DOM page

dodecanoic acid (lauric acid) A white crystalline *fatty acid, $CH_3(CH_2)_{10}COOH$; r.d. 0.868; m.p. 44°C; b.p. 131°C. Glycerides of the acid are present in natural fats and oils (e.g. coconut and palm-kernel oil).

dodecene A straight-chain alkene, $CH_3(CH_2)_9CH{:}CH_2$, obtained from petroleum and used in making *dodecylbenzene.

dodecylbenzene A hydrocarbon, $CH_3(CH_2)_{11}C_6H_5$, manufactured by a Friedel–Crafts reaction between dodecene ($CH_3(CH_2)_9CH{:}CH_2$) and benzene. It can be sulphonated, and the sodium salt of the sulphonic acid is the basis of common *detergents.

dolomite A carbonate mineral consisting of a mixed calcium–magnesium carbonate, $CaCO_3.MgCO_3$, crystallizing in the rhombohedral system. It is usually white or colourless. The term is also used to denote a rock with a high ratio of magnesium to calcium carbonate. *See* LIMESTONE.

DOM *See* DOCUMENT OBJECT MODEL.

Domagk, Gerhard (1895–1964) German biochemist who went to work for IG Farbenindustrie to investigate new drugs. In 1935 he discovered the antibacterial properties of a dye, Prontosil, which became the first sulpha drug (*see* SULPHONAMIDES). He was offered the 1939 Nobel Prize for physiology or medicine but was forced by Hitler to refuse; he finally received the award in 1947.

domain **1.** (in taxonomy) The highest taxonomic category, consisting of one or more *kingdoms. Living organisms are divided into three domains: *Archaea (archaebacteria), Eubacteria (*see* BACTERIA), and Eukarya (*see* EUKARYOTE). **2.** (in physics) *See* MAGNETISM.

domain name system (DNS) In computing, a system that provides mappings between the human-oriented names of users or services in a network, and the machine-oriented network addresses of the named entity. It is used primarily on *TCP/IP networks, primarily the Internet, to map such human-oriented names as www.oup.co.uk to the equivalent IP address; however, other networks have similar facilities. Names are usually hierarchical, and in general terms the boundaries of a *domain will coincide with some form of natural boundary within the network environment, such as a country, a community of users within a country, or the users on a site. The above example consists of the four domains 'uk' (the top-level domain), 'co', 'oup', and 'www'. While the arrangement of IP addresses is also usually hierarchical, there is no assumption in the mapping between the two that the hierarchies are in any way equivalent.

SEE WEB LINKS

- Introduction to the Internet domain name system
- Domain names – implementation and specification

dominance hierarchy *See* DOMINANT.

dominant **1.** (in genetics) Describing the *allele that is expressed in the *phenotype when two different alleles of a gene are present in the cells of an organism. For example, the height of garden peas is controlled by two alleles, 'tall' (*T*) and 'dwarf' (*t*). When both are present (*Tt*), i.e. when the cells are *heterozygous, the plant is tall since *T* is dominant and *t* is *recessive. *See also* CODOMINANCE; INCOMPLETE DOMINANCE. **2.** (in ecology) Describing the most conspicuously abundant and characteristic species in a *community. The term is usually used of a plant species in plant ecology; for example, pine trees in a pine forest. **3.** (in animal behaviour) Describing an animal that is allowed priority in access to food, mates, etc., by others of its species because of its success in previous aggressive encounters. Less dominant animals frequently show *appeasement behaviour towards a more dominant individual, so overt *aggression is minimized. In a stable group there may be a linear **dominance hierarchy** or **peck order** (so called because it was first observed in do-

mestic fowl), with each animal being subservient to those above it in the hierarchy and taking precedence over those below it.

donor **1.** (in chemistry) An atom, ion, or molecule that provides a pair of electrons in forming a coordinate bond. **2.** (in electronics) A substance added as an impurity to a *semiconductor because it can donate electrons to the conduction bands, causing *n*-type conduction by electrons. *Compare* ACCEPTOR. **3.** (in medicine) An individual whose tissues or organs are transferred to another (the **recipient**). Donors may provide blood for transfusion or a kidney or heart for transplantation. **4.** (in genetics) A cell that contributes genetic material for insertion into another cell, for example to produce a transgenic cell by genetic engineering.

donor levels Energy levels of a donor atom in a *semiconductor, such as arsenic in silicon. These energy levels are very near the bottom of the conduction band, thus causing *n*-type conduction. *See also* ENERGY BANDS.

dopa (dihydroxyphenylalanine) A derivative of the amino acid tyrosine. It is found in particularly high levels in the adrenal glands and is a precursor in the synthesis of *dopamine, *noradrenaline, and *adrenaline. The laevorotatory form, **L-dopa**, is administered in the treatment of Parkinson's disease, in which brain levels of dopamine are reduced.

dopamine A *catecholamine that is a precursor in the synthesis of *noradrenaline and *adrenaline. It also functions as a neurotransmitter, especially in the brain.

doping *See* SEMICONDUCTOR.

Doppler broadening Broadening of a spectral line caused by the *Doppler effect. Shifts in frequency occur according to whether the emitting atom or molecule is moving towards or away from the observer. The effect depends on temperature and is used for temperature measurement in astronomy.

Doppler cooling *See* LASER COOLING.

Doppler effect The apparent change in the observed frequency of a wave as a result of relative motion between the source and the observer. For example, the sound made by a low-flying aircraft as it approaches appears to fall in pitch as it passes and flies away. In fact, the frequency of the aircraft engine remains constant but as it is approaching more sound waves per second impinge on the ear and as it recedes fewer sound waves per second impinge on the ear. The apparent frequency, F, is given by

$$F = f(c - u_o)/(c - u_s),$$

where f is the true frequency, c is the speed of sound, and u_o and u_s are the speeds of the observer and the source, respectively.

Although the example of sound is most commonly experienced, the effect was suggested by Christian Johann Doppler (1803–53), an Austrian physicist, as an attempt to explain the coloration of stars. In fact the Doppler effect cannot be observed visually in relation to the stars, although the effect does occur with electromagnetic radiation and the *redshift of light from receding stars can be observed spectroscopically. The Doppler effect is also used in radar to distinguish between stationary and moving targets and to provide information regarding the speed of moving targets by measuring the frequency shift between the emitted and reflected radiation.

For electromagnetic radiation, the speed of light, c, features in the calculation and as there is no fixed medium to provide a frame of reference, relativity has to be taken into account, so that

$$F = f\sqrt{[(1 - v/c)/(1 + v/c)]},$$

where v is the speed at which source and observer are moving apart. If v^2/c^2 is small compared to 1, i.e. if the speed of separation is small compared to the speed of light, this equation simplifies to

$$F = f(1 - v/c).$$

***d*-orbital** *See* ORBITAL.

dormancy An inactive period in the life of an animal or plant during which growth slows or completely ceases. Physiological changes associated with dormancy help the organism survive adverse environmental conditions. Annual plants survive the winter as dormant seeds while many perennial plants survive as dormant tubers, rhizomes, or bulbs. *Hibernation and *aestivation in animals help them survive extremes of cold and heat, respectively.

dorsal Describing the surface of a plant or animal that is farthest from the ground or other support, i.e. the upper surface. In vertebrates, the dorsal surface is that down which the backbone runs. Thus in upright (bipedal) mammals, such as man and kanga-

roos, it is the backward-directed (*posterior) surface. *Compare* VENTRAL.

dorsal root The part of a spinal nerve that enters the *spinal cord on the dorsal side and contains only sensory fibres. The cell bodies of these fibres form the **dorsal root ganglion** (*see* GANGLION), a swelling in the root that lies just outside the cord. *Compare* VENTRAL ROOT.

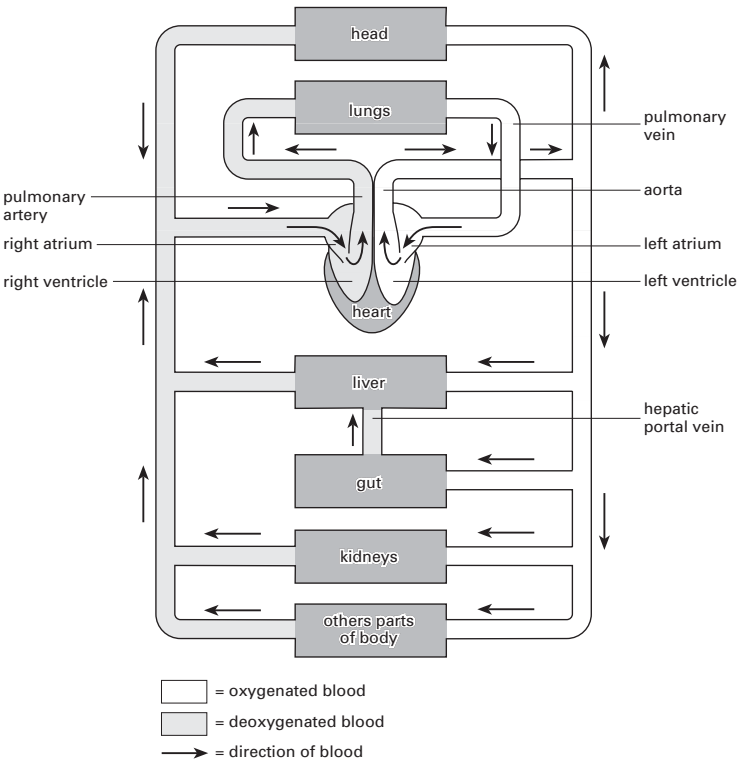
dose A measure of the extent to which matter has been exposed to *ionizing radiation. The **absorbed dose** is the energy per unit mass absorbed by matter as a result of such exposure. The SI unit is the gray, although it is often measured in rads (1 rad = 0.01 gray; *see* RADIATION UNITS). The **maximum permissible dose** is the recommended upper limit of absorbed dose that a person or organ should receive in a specified period according to the International Commission on Radiological Protection. *See also* LINEAR ENERGY TRANSFER.

dosimeter Any device used to measure absorbed *dose of ionizing radiation. Methods used include the *ionization chamber, photographic film, or the rate at which certain chemical reactions occur in the presence of ionizing radiation.

dot product *See* SCALAR PRODUCT.

double bond *See* CHEMICAL BOND.

double circulation The type of circulatory system that occurs in mammals, in which the blood passes through the heart twice before completing a full circuit of the body (see illustration). Blood is pumped



Double circulation.

from the heart to the lungs and returns to the heart before being distributed to the other organs and tissues of the body. The heart is divided into two separate compartments to prevent oxygenated blood returning from the lungs from mixing with deoxygenated blood from the other parts of the body. *See also* PULMONARY CIRCULATION; SYSTEMIC CIRCULATION. *Compare* SINGLE CIRCULATION.

double decomposition *See* METATHESIS.

double fertilization A process, unique to flowering plants, in which two male nuclei, which have travelled down the pollen tube, separately fuse with different female nuclei in the *embryo sac. The first male nucleus fuses with the egg cell to form the zygote; the second male nucleus fuses with the two polar nuclei to form a triploid nucleus that develops into the endosperm.

double helix *See* DNA.

double recessive An organism with two *recessive alleles for a particular characteristic.

double refraction The property, possessed by certain crystals (notably calcite), of forming two refracted rays from a single incident ray. The **ordinary ray** obeys the normal laws of refraction. The other refracted ray, called the **extraordinary ray**, follows different laws. The light in the ordinary ray is polarized at right angles to the light in the extraordinary ray. Along an *optic axis the ordinary and extraordinary rays travel with the same speed. Some crystals, such as calcite, quartz, and tourmaline, have only one optic axis; they are **uniaxial crystals**. Others, such as mica and selenite, have two optic axes; they are **biaxial crystals**. The phenomenon is also known as **birefringence** and the double-refracting crystal as a **birefringent crystal**. *See also* POLARIZATION.

double salt A crystalline salt in which there are two different anions and/or cations. An example is the mineral dolomite, $CaCO_3.MgCO_3$, which contains a regular arrangement of Ca^{2+} and Mg^{2+} ions in its crystal lattice. *Alums are double sulphates. Double salts only exist in the solid; when dissolved they act as a mixture of the two separate salts. **Double oxides** are similar.

doublet **1.** A pair of optical lenses of different shapes and made of different materials used together so that the chromatic aberration produced by one is largely cancelled by the reverse aberration of the other. **2.** A pair of associated lines in certain spectra, e.g. the two lines that make up the sodium D-lines.

down feathers (plumules) Small soft feathers that cover and insulate the whole body of a bird. In nestlings they are the only feathers; in adults they lie between and beneath the *contour feathers. Down feathers have a fluffy appearance as their *barbs are not joined together to form a smooth vane.

Downs process A process for extracting sodium by the electrolysis of molten sodium chloride. The **Downs cell** has a central graphite anode surrounded by a cylindrical steel cathode. Chlorine released is led away through a hood over the anode. Molten sodium is formed at the cathode and collected through another hood around the top of the cathode cylinder (it is less dense than the sodium chloride). The two hoods and electrodes are separated by a coaxial cylindrical steel gauze. A small amount of calcium chloride is added to the sodium chloride to lower its melting point. The sodium chloride is melted electrically and kept molten by the current through the cell. More sodium chloride is added as the electrolysis proceeds.

Down's syndrome A congenital form of mental retardation due to a chromosome defect in which there are three copies of chromosome no. 21 instead of the usual two (*see* TRISOMY). The affected individual has a short broad face and slanted eyes (as in the Mongolian races), short fingers, and weak muscles. Down's syndrome can be detected before birth by *amniocentesis. It is named after the British physician John Down (1828–96), who first studied the incidence of the disorder.

Dragendorff test A *presumptive test for alkaloids. The **Dragendorff reagent** has two solutions. One is bismuth nitrate in acetic acid. This is followed by a sodium nitrate solution. Alkaloids are indicated by a reddish-brown deposit.

dragonflies *See* ODONATA.

drain *See* TRANSISTOR.

dreikanter (German: three edges) A faceted stone or pebble formed in desert regions by erosion by wind-blown sand. The stones are too heavy to be blown along the desert floor and are merely battered back and forth. Most have three curved facets.

drift-tube accelerator *See* LINEAR ACCELERATOR.

drone A fertile male in a colony of social bees, especially the honeybee (*Apis mellifera*). The drones die after mating with the queen bee as the male reproductive organs explode within the female.

Drosophila A genus of fruit flies often used in genetic research because the larvae possess **giant chromosomes** in their salivary glands. These chromosomes have resulted from repeated duplication without separation of the chromatids; they have conspicuous transverse bands, which can be studied microscopically to reveal gene activity. Fruit flies have a short life cycle and produce a large number of offspring, which also makes them a good model animal for genetic research.

drug Any chemical substance that alters the physiological state of a living organism. Drugs are widely used in medicine for the prevention, diagnosis, and treatment of diseases; they include *analgesics, *antibiotics, anaesthetics, *antihistamines, and *anticoagulants. Some drugs are taken solely for the pleasurable effects they induce; these include *narcotics; stimulants, such as cocaine and *amphetamine; *hallucinogens, such as *LSD; and some tranquillizers. Many of these drugs are habit-forming and their use is illegal.

drupe (pyrenocarp) A fleshy fruit that develops from either one or several fused carpels and contains one or many seeds. The seeds are enclosed by the hard protective endocarp (*see* PERICARP) of the fruit. Thus the stone of a peach is the endocarp containing the seed. Plums, cherries, coconuts, and almonds are other examples of one-seeded drupes; holly and elder fruits are examples of many-seeded drupes. *See also* ETAERIO.

dry cell A primary or secondary cell in which the electrolytes are restrained from flowing in some way. Many torch, radio, and calculator batteries are *Leclanché cells in which the electrolyte is an ammonium chloride paste and the container is the negative zinc electrode (with an outer plastic wrapping). Various modifications of the Leclanché cell are used in dry cells. In the **zinc chloride cell**, the electrolyte is a paste of zinc chloride rather than ammonium chloride. The electrical characteristics are similar to those of the Leclanché cell but the cell works better at low temperatures and has more efficient depolarization characteristics. A number of alkaline secondary cells can be designed for use as dry cells. In these, the electrolyte is a liquid (sodium or potassium hydroxide) held in a porous material or in a gel. Alkaline dry cells typically have zinc–manganese dioxide, silver oxide–zinc, nickel–cadmium, or nickel–iron electrode systems (*see* NICKEL–IRON ACCUMULATOR). For specialized purposes, dry cells and batteries have been produced with solid electrolytes. These may contain a solid crystalline salt, such as silver iodide, an ion-exchange membrane, or an organic wax with a small amount of dissolved ionic material. Such cells deliver low currents. They are used in miniature cells for use in electronic equipment.

dry ice Solid carbon dioxide used as a refrigerant. It is convenient because it sublimes at –78°C (195 K) at standard pressure rather than melting.

drying oil A natural oil, such as linseed oil, that hardens on exposure to the air. Drying oils contain unsaturated fatty acids, such as linoleic and linolenic acids, which polymerize on oxidation. They are used in paints, varnishes, etc.

dry mass The mass of a biological sample after the water content has been removed, usually by placing the sample in an oven. The dry mass is used as a measure of the *biomass of a sample.

Dryopithecus A genus of extinct apes, fossils of which have been found in Europe and Asia and dated to the mid-Miocene (about 9–13 million years ago). Fossils of *Dryopithecus* and of the similar genus *Proconsul* are often referred to as **dryopithecines**. Dryopithecines are believed to have split into several lines, some of which survived to give rise to the chimpanzees, gorillas, early hominids, and orang-utans.

DSC Differential scanning calorimetry. *See* THERMAL ANALYSIS.

D-series *See* ABSOLUTE CONFIGURATION.

DTA Differential thermal analysis. *See* THERMAL ANALYSIS.

DTD Document type definition. A file associated with an *SGML or *XML document, giving a formalized description of the tags used and the structure of the document, as well as special entities that may be present.

DTDs are optional for XML documents but compulsory for SGML documents. To **validate** a document is to check its structure against its DTD; a document that passes this test without errors is said to be 'valid' or to **conform to** its DTD.

dubnium Symbol Db. A radioactive *transactinide element; a.n. 105. It was first reported in 1967 by a group at Dubna near Moscow and was confirmed in 1970 at Dubna and at Berkeley, California. It can be made by bombarding californium-249 nuclei with nitrogen-15 nuclei. Only a few atoms have ever been made.

SEE WEB LINKS

- Information from the WebElements site

duct A tube or passage in an organism that is involved in the secretion or excretion of substances (*see* GLAND).

ductility The ability of certain metals, such as copper, to retain their strength when their shape is changed, especially the ability of such metals to be drawn into a thin wire without cracking or breaking.

ductless gland *See* ENDOCRINE GLAND.

ductus arteriosus A channel that connects the pulmonary artery with the aorta in the mammalian fetus and therefore allows blood to bypass the inactive lungs of the fetus. It normally closes soon after birth.

Dulong and Petit's law For a solid element the product of the relative atomic mass and the specific heat capacity is a constant equal to about 25 J mol^{-1} K^{-1}. Formulated in these terms in 1819 by the French scientists Pierre Dulong (1785–1838) and Alexis Petit (1791–1820), the law in modern terms states: the molar heat capacity of a solid element is approximately equal to 3*R*, where *R* is the *gas constant. The law is only approximate but applies with fair accuracy at normal temperatures to elements with a simple crystal structure.

SEE WEB LINKS

- A translation of the original 1819 paper in *Annals of Philosophy*

Dumas, Jean Baptiste André (1800–84) French chemist, who became an apothecary in Geneva, where in 1818 he investigated the use of iodine to treat goitre. He then took up chemistry and moved to Paris. In 1826 he devised a method of measuring *vapour density. He went on to discover various organic compounds, including anthracene (1832), urethane (1833), and methanol (1834), which led him in 1840 to propose the theory of types (functional groups).

Dumas' method **1.** A method of finding the amount of nitrogen in an organic compound. The sample is weighed, mixed with copper(II) oxide, and heated in a tube. Any nitrogen present in the compound is converted into oxides of nitrogen, which are led over hot copper to reduce them to nitrogen gas. This is collected and the volume measured, from which the mass of nitrogen in a known mass of sample can be found. **2.** A method of finding the relative molecular masses of volatile liquids by weighing. A thin-glass bulb with a long narrow neck is used. This is weighed full of air at known temperature, then a small amount of sample is introduced and the bulb heated (in a bath) so that the liquid is vaporized and the air is driven out. The tip of the neck is sealed and the bulb cooled and weighed at known (room) temperature. The volume of the bulb is found by filling it with water and weighing again. If the density of air is known, the mass of vapour in a known volume can be calculated.

The techniques are named after J. B. A. Dumas.

dune A mound or ridge of unconsolidated sand formed by the action of wind. Dunes are characteristic of desert regions and some coastlines. Coastal dunes are usually anchored by vegetation, whereas desert dunes generally move gradually in the direction of the prevailing wind. There are various types, often named after their shapes. Crescent-shaped dunes are called **barchans**, and longitudinal dunes are **seif dunes**; others include sinuous anklé dunes, star dunes, whaleback dunes and tail dunes, which form in the lee of an obstacle. A large seif dune may be up to 100 m high and 10 km long. Similar structures to dunes may also form underwater by the action of currents.

duodenum The first section of the *small intestine of vertebrates. It is the site where food from the stomach is subjected to the action of bile (from the bile duct) and pancreatic enzymes (from the pancreatic duct) as well as the enzymes secreted by digestive glands in the duodenum itself, which are required in the breakdown of proteins, carbohydrates, and fats. By neutralizing the acidic secretions of the stomach, the duodenum

provides an alkaline environment necessary for the action of the intestinal enzymes. *See also* INTESTINAL JUICE.

duplet A pair of electrons in a covalent chemical bond.

duplex Describing a biological molecule comprising two cross-linked polymeric chains oriented lengthways side by side. The term is applied particularly to the double-stranded structure of *DNA.

duplication (in genetics) The doubling or repetition of part of a chromosome, which generally originates during the *crossing over phase of meiosis. Occasionally this type of *chromosome mutation may have beneficial effects on a population. For example, a beneficial duplication resulted in the evolution of four types of haemoglobin in man and apes from a single form. One of these types of haemoglobin (gamma or fetal haemoglobin) has a greater affinity for oxygen and maximizes fetal uptake of oxygen from the mother's blood.

Duralumin Trade name for a class of strong lightweight aluminium alloys containing copper, magnesium, manganese, and sometimes silicon. Duralumin alloys combine strength with lightness and are extensively used in aircraft, racing cars, etc.

dura mater The outermost and toughest of the three membranes (*meninges) that surround the central nervous system in vertebrates. It lies adjacent to the skull and its purpose is to protect the delicate inner meninges (the *arachnoid membrane and the *pia mater).

duramen *See* HEARTWOOD.

dust core *See* CORE.

Dutch metal An alloy of copper and zinc, which can be produced in very thin sheets and used as imitation gold leaf. It spontaneously inflames in chlorine.

DVD Digital versatile disk: a disk format similar to a compact disk (*see* CD-ROM) but containing much more data. It was introduced in 1996. DVD disks are the same 120 mm diameter as CDs with potential capacities of up to 4.7 gigabytes for a single-sided single-layer disk. The technology involved in DVD storage is similar to that in compact disks, but more precise. The extra capacity is achieved in a number of ways. The tracks on a DVD are closer and the pits are smaller, allowing more pits per unit area. The key to this was the use of a shorter wavelength laser (typically 635 or 650 nm in the red region for DVDs as opposed to 780 nm in the infrared for CDs). Moreover, a DVD can have two layers on the same side of the disk. The top layer is translucent and the bottom layer opaque. Data can be read from either layer by refocusing the laser. In addition DVDs may be double-sided. DVD formats also have a more efficient error-correction system. The potential capacity of a double-sided double-layer DVD is up to 17 gigabytes. DVDs have been increasingly used in computing as a higher-capacity version of compact disks. As with compact disks, there are various types. **DVD-ROM** (DVD read-only memory) is similar to CD-ROM. **DVD-R** (DVD-recordable) is similar to CD-R. There are also different rewritable formats: **DVD-RAM**, **DVD+RW**, and **DVD-RW**.

SEE WEB LINKS

- The DVD Forum home page

dwarf galaxy A galaxy made up of only a few billion stars rather than the 200 to 400 billion that form the Milky Way System. Dwarf galaxies are classified like ordinary galaxies. In the *Local Group, several dwarf galaxies are satellites of the group's three largest galaxies.

dwarf planet A *small solar system body that is in direct orbit around the sun, not around another planet, and has sufficient mass to have contracted to a spherical or nearly spherical shape but has not cleared its orbital zone of *planetesimals. Five objects have been classified as dwarf planets since 2006, including *Pluto (formerly the ninth planet of the solar system and now recognized as a *Kuiper belt object [KBO]), *Eris (the largest dwarf planet so far known), the asteroid (1) Ceres, and the KBOs (136472) Makemake and (136108) Haumea.

SEE WEB LINKS

- International Astronomical Union 2006 General Assembly: Result of the IAU resolution votes. This press release carries the official definition of a planet & dwarf planet
- NASA's explanation of the IAU's definitions of 'planet' and 'dwarf planet'

dwarf star A star, such as the sun, that lies on the main sequence in a *Hertzsprung–Russell diagram and is of average or normal size in relation to its mass. *See also* BLACK DWARF; BROWN DWARF; RED DWARF; WHITE DWARF.

dye laser A type of laser in which the active material is a dye dissolved in a suitable solvent (e.g. Rhodanine G in methanol). The dye is excited by an external source. The solvent broadens the states into bands and consequently laser action can be obtained over a range of wavelengths. This allows one to select a specific wavelength (using a grating) and to change the wavelength of the laser. Such a device is called a **tuneable laser**. Dye lasers are also used in producing very short pulses of radiation. The technique is to use a dye that stops absorbing radiation when a high proportion of its molecules become excited. The cavity then becomes resonant and a pulse of radiation is produced. This technique can give pulses of about 10 nanoseconds duration and is used in *femtochemistry.

dyes Substances used to impart colour to textiles, leather, paper, etc. Compounds used for dyeing (**dyestuffs**) are generally organic compounds containing conjugated double bonds. The group producing the colour is the *chromophore; other noncoloured groups that influence or intensify the colour are called *auxochromes. Dyes can be classified according to the chemical structure of the dye molecule. For example, **azo dyes** contain the –N=N– group (*see* AZO COMPOUNDS). In practice, they are classified according to the way in which the dye is applied or is held on the substrate.

Acid dyes are compounds in which the chromophore is part of a negative ion (usually an organic sulphonate RSO_2O^-). They can be used for protein fibres (e.g. wool and silk) and for polyamide and acrylic fibres. Originally, they were applied from an acidic bath. **Metallized dyes** are forms of acid dyes in which the negative ion contains a chelated metal atom. **Basic dyes** have chromophores that are part of a positive ion (usually an amine salt or ionized imino group). They are used for acrylic fibres and also for wool and silk, although they have only moderate fastness with these materials.

Direct dyes are dyes that have a high affinity for cotton, rayon, and other cellulose fibres. They are applied directly from a neutral bath containing sodium chloride or sodium sulphate. Like acid dyes, they are usually sulphonic acid salts but are distinguished by their greater substantivity (affinity for the substrate), hence the alternative name **substantive dyes**.

Vat dyes are insoluble substances used for cotton dyeing. They usually contain keto groups, C=O, which are reduced to C–OH groups, rendering the dye soluble (the **leuco form** of the dye). The dye is applied in this form, then oxidized by air or oxidizing agents to precipitate the pigment in the fibres. Indigo and anthroquinone dyes are examples of vat dyes. **Sulphur dyes** are dyes applied by this technique using sodium sulphide solution to reduce and dissolve the dye. Sulphur dyes are used for cellulose fibres.

Disperse dyes are insoluble dyes applied in the form of a fine dispersion in water. They are used for cellulose acetate and other synthetic fibres.

Reactive dyes are compounds that contain groups capable of reacting with the substrate to form covalent bonds. They have high substantivity and are used particularly for cellulose fibres.

dyke A sheetlike vertical *intrusion of igneous rock cutting across the strata of older rocks. Dykes vary in thickness from a few centimetres to several metres. Several dykes may be grouped, radially or in parallel, as a dyke swarm. Depending on composition and how long it took to cool, a dyke's grain structure may be coarse, medium, or fine.

dynamical meteorology The branch of meteorology concerned with motions in the atmosphere. It is based on hydrodynamics and thermodynamics.

dynamic equilibrium *See* EQUILIBRIUM.

dynamics The branch of mechanics concerned with the motion of bodies under the action of forces. Time intervals, distances, and masses are regarded as fundamental and bodies are assumed to possess *inertia. Bodies in motion have an attribute called *momentum (*see* NEWTON'S LAWS OF MOTION), which can only be changed by the application of a force. *Compare* KINETICS; STATICS.

dynamite Any of a class of high explosives based on nitroglycerin. The original form, invented in 1867 by Alfred Nobel, consisted of nitroglycerin absorbed in kieselguhr. Modern dynamites, which are used for blasting, contain sodium or ammonium nitrate sensitized with nitroglycerin and use other absorbers (e.g. wood pulp).

dynamo An electric *generator, especially one designed to provide *direct current. Alternating-current generators can be called

dynamos but are more often called alternators.

dynamo action The generation of electrical current and magnetic field by the motion of an electrically conducting fluid. It is generally believed that the magnetic fields of the earth and the sun are produced by dynamo action in the molten iron–nickel core of the earth and in the plasma of the solar interior.

dynamometer **1.** An instrument used to measure a force, often a spring balance. **2.** A device used to measure the output power of an engine or motor. **3. (current dynamometer)** A variety of *current balance, for measuring electric current.

dyne The unit of force in the *c.g.s. system; the force required to give a mass of one gram an acceleration of 1 cm s^{-2}. 1 dyne = 10^{-5} newton.

dysprosium Symbol Dy. A soft silvery metallic element belonging to the *lanthanoids; a.n. 66; r.a.m. 162.50; r.d. 8.551 (20°C); m.p. 1412°C; b.p. 2562°C. It occurs in apatite, gadolinite, and xenotime, from which it is extracted by an ion-exchange process. There are seven natural isotopes and twelve artificial isotopes have been identified. It finds limited use in some alloys as a neutron absorber, particularly in nuclear technology. It was discovered by Paul Lecoq de Boisbaudran (1838–1912) in 1886.

SEE WEB LINKS

- Information from the WebElements site

dystectic mixture A mixture of substances that has a constant maximum melting point.

dystrophic Describing a body of water, such as a lake, that contains large amounts of undecomposed organic matter derived from terrestrial plants. Dystrophic lakes are poor in dissolved nutrients and therefore unproductive; they are common in peat areas and may develop into peat bogs.