vacancy *See* CRYSTAL DEFECT.

vaccination *See* IMMUNIZATION.

vaccine A liquid preparation of treated disease-producing microorganisms or their products used to stimulate an *immune response in the body and so confer resistance to the disease (*see* IMMUNIZATION). Vaccines are administered orally or by injection (**inoculation**). They take the form of dead viruses or bacteria that can still act as antigens, live but weakened microorganisms (*see* ATTENUATION), specially treated *toxins, or antigenic extracts of the microorganism.

vacuole A space within the cytoplasm of a living *cell that is filled with air, water or other liquid, sap, or food particles. In plant cells there is usually one large vacuole bounded by a single-layered membrane (**tonoplast** or **vacuole membrane**); animal cells usually have several small vacuoles. *See also* CONTRACTILE VACUOLE.

vacuum A space in which there is a low pressure of gas, i.e. relatively few atoms or molecules. A **perfect vacuum** would contain no atoms or molecules, but this is unobtainable as all the materials that surround such a space have a finite *vapour pressure. In a **soft** (or **low**) **vacuum** the pressure is reduced to about 10^{-2} pascal, whereas a **hard** (or **high**) vacuum has a pressure of 10^{-2}–10^{-7} pascal. Below 10^{-7} pascal is known as an **ultrahigh vacuum** (**UHV**). *See also* VACUUM PUMP.

vacuum distillation Distillation under reduced pressure. The depression in the boiling point of the substance distilled means that the temperature is lower, which may prevent the substance from decomposing.

vacuum pump A pump used to reduce the gas pressure in a container. The normal laboratory rotary oil-seal pump can maintain a pressure of 10^{-1} Pa. For pressures down to 10^{-7} Pa a *diffusion pump is required. *Ion pumps can achieve a pressure of 10^{-9} Pa and a *cryogenic pump combined with a diffusion pump can reach 10^{-13} Pa.

vacuum state The ground state in a relativistic *quantum field theory. A vacuum state does not mean a state of nothing. Because one is dealing with *quantum mechanics, the vacuum state has a *zero-point energy, which gives rise to **vacuum fluctuations**. The existence of vacuum fluctuations has observable consequences in *quantum electrodynamics.

vacuum tube *See* THERMIONIC VALVE.

vagina The tube leading from the uterus to the outside. Sperm are deposited in the vagina during copulation and the fully developed fetus is born through it. In a number of mammals the vagina may be sealed when the animal is not sexually receptive and only open during oestrus. Its lining produces mucus, which prevents friction and the entry of infective organisms.

vagus nerve The tenth *cranial nerve: a paired nerve that supplies branches to many major internal organs. It carries motor nerve fibres to the heart, lungs, and viscera and sensory fibres from the viscera.

valence *See* VALENCY.

valence band *See* ENERGY BANDS.

valence bond theory A theory of the electronic structure of molecules and solids in which the quantum state of the system corresponds to a mixture of molecular structures involving chemical bonds formed by pairs of electrons. Valence bond theory is a complementary starting point to *molecular orbital theory for understanding the electronic structure of molecules and solids.

valence electron An electron in one of the outer shells of an atom that takes part in forming chemical bonds.

valency (valence) The combining power of an atom or radical, equal to the number of hydrogen atoms that the atom could combine with or displace in a chemical compound (hydrogen has a valency of 1). It is equal to the ionic charge in ionic compounds; for example, in Na_2S, sodium has a valency of 1 (Na^+) and sulphur a valency of 2

(S^{2-}). In covalent compounds it is equal to the number of bonds formed; in CO_2 oxygen has a valency of 2 and carbon has a valency of 4.

valine *See* AMINO ACID.

Valium *See* DIAZEPAM.

valley of stability The bottom region of the surface defined by plotting the numbers of protons and neutrons of a nucleus horizontally and the energy per nucleon of the nucleus vertically. Stable nuclei form a 'valley' with the most stable nuclei, such as iron and nickel, being at the bottom of the valley. The concept of the valley of stability enables several important topics in nuclear physics, such as *nuclear fission and *nuclear fusion, to be understood in a clear physical way. There are occasional 'pits' in the valley of stability due to nuclei with *magic numbers being more stable than nuclei with similar numbers of protons and neutrons.

valve **1.** (in anatomy) Any of various structures for restricting the flow of a fluid through an aperture or along a tube to one direction. Valves in the heart (*see* BICUSPID VALVE; TRICUSPID VALVE), veins, and lymphatic vessels consist of two or three flaps of tissue (**cusps**) fastened to the walls. The cusps are flattened to the walls to allow the normal passage of blood or lymph, but a reverse flow causes them to block the vessel or aperture, so preventing further backflow. **2.** (in biology) **a.** Any of the parts that make up a capsule or other dry fruit that sheds its seeds. **b.** One of the two halves of the cell wall of a diatom. **c.** Either of the two hinged portions of the shell of a bivalve mollusc. **3.** (in electronics) *See* THERMIONIC VALVE.

vanadium Symbol V. A silvery-white metallic *transition element; a.n. 23; r.a.m. 50.94; r.d. 5.96; m.p. 1890°C; b.p. 3380°C. It occurs in a number of complex ores, including vanadinite ($Pb_5Cl(VO_4)_3$) and carnotite ($K_2(ClO_2)_2(VO_4)_2$). The pure metal can be obtained by reducing the oxide with calcium. The element is used in a large number of alloy steels. Chemically, it reacts with non-metals at high temperatures but is not affected by hydrochloric acid or alkalis. It forms a range of complexes with oxidation states from +2 to +5. Vanadium was discovered in 1801 by Andrés del Rio (1764–1849), who allowed himself to be persuaded that what he had discovered was an impure form of chromium. The element was rediscovered and named by Nils Sefström (1787–1854) in 1830.

vanadium(V) oxide (vanadium pentoxide) A crystalline compound, V_2O_5, used extensively as a catalyst in industrial gas-phase oxidation processes.

vanadium pentoxide *See* VANADIUM(V) OXIDE.

Van Allen belts (radiation belts) Belts that are sources of intense radiation surrounding the earth, consisting of high-energy charged particles trapped in the earth's magnetic field within which they follow roughly helical paths. They were discovered in 1958 by James Van Allen (1914–2006) as a result of radiation detectors carried by Explorer satellites. The lower belt, extending from 1000 to 5000 km above the equator, contains electrons and protons, while the upper belt, 15 000–25 000 km above the equator, contains mainly electrons (see illustration).
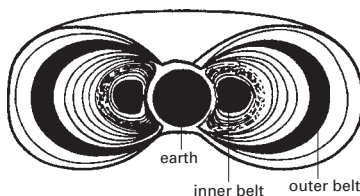

Van Allen belts.

Van de Graaff accelerator *See* LINEAR ACCELERATOR.

Van de Graaff generator An electrostatic generator used to produce a high voltage, usually in the megavolt range. It consists of a large metal dome-shaped terminal mounted on a hollow insulating support. An endless insulating belt runs through the support from the base to a pulley within the spherical terminal. In the original type, charge is sprayed by point discharge from metal needles, held at a potential of about 10 kV, on to the bottom of the belt. A row of needles near the upper belt pulley removes the charge from the belt and passes it to the outer surface of the spherical terminal. The voltage achieved by the device is proportional to the radius of the spherical terminal. A typical de-

vice with a terminal having a radius of 1 m will produce about 1 MV. However, terminals can be made smaller, for a given voltage, by enclosing the apparatus in nitrogen at a pressure of 10–20 atmospheres (1–2 MPa) to reduce sparking. Generators having a positive-ion source are fitted with an evacuated tube through which the particles can be accelerated for research purposes (*see* LINEAR ACCELERATOR). Machines having an electron source are used for various medical and industrial purposes. The generator was invented by Robert Van de Graaff (1901–67).

Modern patterns of the generator have a chainlike belt of alternate links of metal and insulator. The metal links are charged by contact with a metal pulley, and discharge to the dome in the same way. This permits much higher current drain that the point discharge.
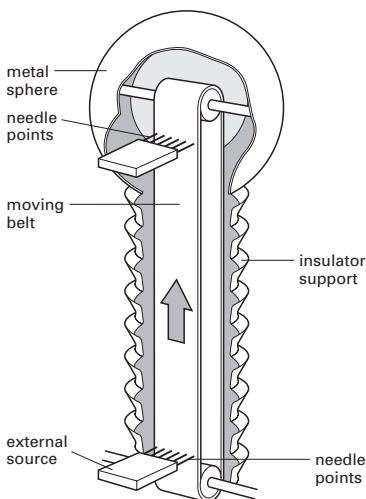
Van de Graaff generator.

van der Waals' equation   *See* EQUATION OF STATE.

van der Waals' force   An attractive force between atoms or molecules, named after Johannes van der Waals (1837–1923). The force accounts for the term a/V^2 in the van der Waals equation (*see* EQUATION OF STATE). These forces are much weaker than those arising from valence bonds and are inversely proportional to the seventh power of the distance between the atoms or molecules. They are the forces responsible for nonideal behaviour of gases and for the lattice energy of molecular crystals. There are three factors causing such forces: (1) dipole–dipole interaction, i.e. electrostatic attractions between two molecules with permanent dipole moments; (2) dipole-induced dipole interactions, in which the dipole of one molecule polarizes a neighbouring molecule; (3) dispersion forces arising because of small instantaneous dipoles in atoms.

vanillin (4-hydroxy-3-methoxybenzaldehyde)   A white crystalline solid, $C_8H_8O_3$, m.p. 82°C. It has the characteristic taste and smell of vanilla, in which it occurs; it is also made from the by-products of wood pulp manufacture. It is widely used in flavourings and perfumes, and in some pharmaceutical products.

van't Hoff factor   Symbol *i*. A factor appearing in equations for *colligative properties, equal to the ratio of the number of actual particles present to the number of undissociated particles. It was first suggested by Jacobus van't Hoff (1852–1911).

van't Hoff's isochore   An equation for the variation of equilibrium constant with temperature:

$$(\mathrm{d}\log_e K)/\mathrm{d}T = \Delta H/RT^2,$$

where K is the equilibrium constant, R is the gas constant, T is the thermodynamic temperature, and ΔH the enthalpy of the reaction.

vapour density   The density of a gas or vapour relative to hydrogen, oxygen, or air. Taking hydrogen as the reference substance, the vapour density is the ratio of the mass of a particular volume of a gas to the mass of an equal volume of hydrogen under identical conditions of pressure and temperature. Taking the density of hydrogen as 1, this ratio is equal to half the relative molecular mass of the gas.

V

vapour pressure   The pressure exerted by a vapour. All solids and liquids give off vapours, consisting of atoms or molecules of the substances that have evaporated from the condensed forms. These atoms or molecules exert a vapour pressure. If the substance is in an enclosed space, the vapour pressure will reach an equilibrium value that depends only on the nature of the substance and the temperature. This equilibrium value

occurs when there is a dynamic equilibrium between the atoms or molecules escaping from the liquid or solid and those that strike the surface of the liquid or solid and return to it. The vapour is then said to be a **saturated vapour** and the pressure it exerts is the **saturated vapour pressure**.

variable star Any star that varies in brightness. There are several types, depending on the cause of the variation. Some, such as eclipsing *binary stars, are actually a pair of stars whose combined light output varies as one star passes in front (or behind) the other. **Intrinsic variables** are caused by some internal phenomenon. The brightness of *Cepheid variables, *Mira-type variables, and *RR Lyrae variables alternates regularly (with timescales from hours to years); *flare stars and *T Tauri stars vary irregularly. Other irregular variable stars, sometimes called cataclysmic variables, include *novae and *supernovae.

variance In *statistics, the square of the *standard deviation, usually written σ^2. It represents the dispersion of a random variable's distribution, equal to $E[(X - E(X))^2]$, where X is the random variable and E is the expected value of the square of the difference between the variable and its *mean. *See also* COVARIANCE.

variation **1.** (in biology) The differences between individuals of a plant or animal species. Variation may be the result of environmental conditions; for example, water supply and light intensity affect the height and leaf size of a plant. Differences of this kind, acquired during the lifetime of an individual, are not transmitted to succeeding generations since the genes are not affected. **Genetic variation**, due to differences in genetic constitution, is inherited (*see* CONTINUOUS VARIATION; DISCONTINUOUS VARIATION). The most important sources of genetic variation are *mutation and *recombination (*see also* CROSSING OVER). It is also increased by *outbreeding. Wide genetic variation improves the ability of a species to survive in a changing environment, since the chances that some individuals will tolerate a particular change are increased. Such individuals will survive and transmit the advantageous genes to their offspring. **2.** (in magnetism) *See* GEOMAGNETISM.

variegation The occurrence of differently coloured patches, spots, or streaks in plant leaves, petals, or other parts, due to absence of pigment or different combinations of pigment in the affected area of the part. Variegation may be brought about by infection, for example *tobacco mosaic virus infection, or by genetic differences between the cells of the variegated part.

variety A category used in the *classification of plants and animals below the *species level. A variety consists of a group of individuals that differ distinctly from but can interbreed with other varieties of the same species. The characteristics of a variety are genetically inherited. Examples of varieties include breeds of domestic animals and the human *races. *See also* CULTIVAR. *Compare* SUBSPECIES.

variometer **1.** A variable inductor consisting of two coils connected in series and able to move relative to each other. It is used to measure inductance as part of an a.c. bridge. **2.** Any of several devices for detecting and measuring changes in the geomagnetic elements (*see* GEOMAGNETISM).

varve dating (geochronology) An absolute *dating technique using thin sedimentary layers of clays called **varves**. The varves, which are particularly common in Scandinavia, have alternate light and dark bands corresponding to winter and summer deposition. Most of them are found in the Pleistocene series, where the edges of varve deposits can be correlated with the annual retreat of the ice sheet, although some varve formation is taking place in the present day. By counting varves it is possible to establish an absolute time scale for fossils up to about 20 000 years ago.

vascular bundle (fascicle) A long continuous strand of conducting (vascular) tissue in tracheophyte plants that extends from the roots through the stem and into the leaves. It consists of *xylem and *phloem, which are separated by a *cambium in plants that undergo secondary thickening. *See* VASCULAR TISSUE.

vascular cambium *See* CAMBIUM.

vascular plants All plants possessing organized *vascular tissue. *See* TRACHEOPHYTE.

vascular system **1.** A specialized network of vessels for the circulation of fluids throughout the body tissues of an animal. All animals, apart from simple invertebrate groups, possess a **blood vascular system**, which enables the passage of respiratory

gases, nutrients, excretory products, and other metabolites into and out of the cells. In vertebrates it consists of a muscular *heart, which pumps blood through major blood vessels (*arteries) into increasingly finer branches until in the *capillaries it is in intimate contact with tissues. It then returns to the heart via another network of vessels (the *veins). This *circulation also enables a stable *internal environment for tissue function (*see* HOMEOSTASIS), the transmission of chemical messengers (*hormones) around the body, and a means of defending the body against pathogens and damage via the immune system. A **water vascular system** is characteristic of the *Echinodermata. **2.** The system of *vascular tissue in plants.

vascular tissue (vascular system) The tissue that conducts water and nutrients through the plant body in higher plants (*tracheophytes). It consists of *xylem and *phloem. Since the xylem and phloem tissues are always in close proximity to each other, distinct regions of vascular tissue can be identified (*see* VASCULAR BUNDLE). The possession of vascular tissue has enabled the higher plants to attain a considerable size and dominate most terrestrial habitats.

vas deferens One of a pair of ducts carrying sperm from the testis (or *epididymis) to the outside, in mammals through the *urethra.

vas efferens Any of various small ducts carrying sperm. In reptiles, birds, and mammals they convey sperm from the seminiferous tubules of the testis to the *epididymis; in invertebrates they carry sperm from the testis to the vas deferens.

Vaseline *See* PETROLEUM JELLY.

vasoactive intestinal peptide *See* VIP.

vasoconstriction The reduction in the internal diameter of blood vessels, especially arterioles or capillaries. The constriction of arterioles is mediated by the action of nerves on the smooth muscle fibres of the arteriole walls and results in an increase in blood pressure.

vasodilation (vasodilatation) The increase in the internal diameter of blood vessels, especially arterioles or capillaries. The vasodilation of arterioles is mediated by the action of nerves on the smooth muscle fibres of the arteriole walls and results in a decrease in blood pressure.

vasomotor nerves The nerves of the *autonomic nervous system that control the diameter of blood vessels. **Vasoconstrictor nerves** decrease the diameter (*see* VASOCONSTRICTION); **vasodilator nerves** increase it (*see* VASODILATION).

vasopressin *See* ANTIDIURETIC HORMONE.

vector 1. (in mathematics) A quantity in which both the magnitude and the direction must be stated (*compare* SCALAR QUANTITY). Force, velocity, and field strength are examples of vector quantities. Note that distance and speed are scalar quantities, whereas displacement and velocity are vector quantities. Vector quantities must be treated by **vector algebra**, for example, the resultant of two vectors may be found by a *parallelogram of vectors. A (three-dimensional) vector $\boldsymbol{V}$ may be written in terms of components V_1, V_2, and V_3 along the x, y, and z axes (say) as $V_1\boldsymbol{i} + V_2\boldsymbol{j} + V_3\boldsymbol{k}$, where $\boldsymbol{i}$, $\boldsymbol{j}$, and $\boldsymbol{k}$ are **unit vectors** (i.e. vectors of unit length) along the x, y, and z axes. *See* TRIANGLE OF VECTORS. **2.** (in medicine) An animal, usually an insect, that passively transmits disease-causing microorganisms from one animal or plant to another or from an animal to a human. *Compare* CARRIER. **3. (cloning vector)** (in genetics) A vehicle used in *gene cloning to insert a foreign DNA fragment into the genome of a host cell. For bacterial hosts various different types of vector are used: *bacteriophages, *artificial chromosomes, *plasmids, and their hybrid derivatives, *cosmids. The foreign DNA is spliced into the vector using specific *restriction enzymes and *ligases to cleave the vector DNA and join the foreign DNA to the two ends created (**insertional vectors**). In some phage vectors, part of the viral genome is enzymically removed and replaced with the foreign DNA (**replacement vectors**). *Retroviruses can be effective vectors for introducing recombinant DNA into mammalian cells. In plants, derivatives of the tumour-inducing (Ti) plasmid of the crown gall bacterium, *Agrobacterium tumefaciens*, are used as vectors.

vector product (cross product) The product of two *vectors $\boldsymbol{U}$ and $\boldsymbol{V}$, with components U_1, U_2, U_3 and V_1, V_2, V_3, respectively, given by:

$$\boldsymbol{U} \times \boldsymbol{V} = (U_2 V_3 - U_3 V_2)\boldsymbol{i} + (U_3 V_1 - U_1 V_3)\boldsymbol{j} + (U_1 V_2 - U_2 V_1)\boldsymbol{k}.$$

It is itself a vector, perpendicular to both $\boldsymbol{U}$ and $\boldsymbol{V}$, and of length $UV\sin\theta$, where U and V are the lengths of $\boldsymbol{U}$ and $\boldsymbol{V}$, respectively, and

θ is the angle between them. *Compare* SCALAR PRODUCT.

vector space A set of *vectors for which an operation of addition is defined so that if v_1 and v_2 are vectors, the sum $v_1 + v_2$ is also a vector; an operation of *scalar multiplication is defined so that if v is a vector and c is a scalar, the product cv is also a vector. *See also* HILBERT SPACE.

vector triple product *See* TRIPLE PRODUCT.

vegetative propagation (vegetative reproduction) **1.** A form of *asexual reproduction in plants whereby new individuals develop from specialized multicellular structures (e.g. *tubers, *bulbs) that become detached from the parent plant. Examples are the production of strawberry plants from *runners and of gladioli from daughter *corms. Artificial methods of vegetative propagation include grafting (*see* GRAFT), *budding, and making *cuttings. **2.** Asexual reproduction in animals, e.g. budding in *Hydra.*

vein **1.** A blood vessel that carries blood towards the heart. Most veins carry deoxygenated blood (the *pulmonary vein is an exception). The largest veins are fed by smaller ones, which are formed by the merger of *venules. Veins have thin walls and a relatively large internal diameter. *Valves within the veins ensure that the flow of blood is always towards the heart. *Compare* ARTERY. **2.** A vascular bundle in a leaf (*see* VENATION). **3.** Any of the tubes of chitin that strengthen an insect's wing.

velamen A whitish spongy sheath of dead empty cells that surrounds the aerial roots of epiphytic plants, such as certain orchids. It absorbs any surface water on the roots.

velocity Symbol v. The rate of displacement of a body. It is the *speed of a body in a specified direction. Velocity is thus a *vector quantity, whereas speed is a scalar quantity.

velocity modulation *See* KLYSTRON.

velocity ratio (distance ratio) The ratio of the distance moved by the point of application effort in a simple *machine to the distance moved by the point of application load in the same time.

velum *See* ANNULUS.

vena cava Either of the two large veins that carry deoxygenated blood into the right atrium of the heart. The **precaval vein** (**anterior** or **superior vena cava**) receives blood from the head and forelimbs; the **postcaval vein** (**posterior** or **inferior vena cava**) drains blood from the trunk and hindlimbs.

venation **1.** The arrangement of veins (vascular bundles) in a leaf. The leaves of dicotyledons have a central main vein (midrib) with side branches that themselves further subdivide to form a network (**net** or **reticulate venation**). The leaves of monocotyledons have parallel veins (**parallel venation**). **2.** The arrangement of the veins in an insect's wing, which is often important in classification.

Venn diagram *See* SETS.

venter (in botany) The swollen base of an *archegonium, in which the egg cell (oosphere) develops.

ventilation The process by which a continuous exchange of gases is maintained across respiratory surfaces. Often called external *respiration, this is achieved by *respiratory movements; in air-breathing vertebrates it is movement of air into and out of the lungs (*see also* AIR SAC; EXPIRATION; INSPIRATION; TRACHEA). The **ventilation rate** (or **respiration rate**) of an animal is the volume of air breathed per minute, i.e. *tidal volume × number of breaths per minute. It can be measured with the aid of a *respirometer.

ventilation centre The group of neurons in the *medulla oblongata of the brain that controls the process of *ventilation. The partial pressure of carbon dioxide in the blood and the pH of the blood are monitored by chemoreceptors in the arteries. These include the *carotid bodies in the carotid arteries and the **aortic bodies** in the wall of the aorta close to the heart. The ventilation centre responds to an increase in the amount of carbon dioxide in the blood by increasing the rate of breathing. Within the ventilation centre are subcentres that control inspiration (**inspiratory centre**) and expiration (**expiratory centre**).

ventral Describing the surface of a plant or animal that is nearest or next to the ground or other support, i.e. the lower surface. In bipedal animals, such as humans, it is the forward-directed (*anterior) surface. *Compare* DORSAL.

ventral root The part of a *spinal nerve

that leaves the spinal cord on the ventral side and contains motor fibres. *Compare* DORSAL ROOT. *See* SPINAL CORD.

ventricle 1. A chamber of the *heart that receives blood from an *atrium and pumps it into the arterial system. Amphibians and fish have a single ventricle, but mammals, birds, and reptiles have two, pumping deoxygenated blood to the lungs and oxygenated blood to the rest of the body, respectively. **2.** Any of the four linked fluid-filled cavities in the brain of vertebrates. One of these cavities is in the *medulla oblongata, two are in the cerebral hemispheres (*see* CEREBRUM), and the fourth is in the posterior part of the *forebrain. The ventricles contain cerebrospinal fluid filtered from the blood by the *choroid plexus.

Venturi tube A device for mixing a fine spray of liquid with a gas or measuring a flow rate of a gas. It consists of two tapered sections of pipe joined by a narrow throat. The fluid velocity in the throat is increased and the pressure is therefore reduced. By attaching manometers to the three sections of the tube, the pressure drop can be measured and the flow rate through the throat can be calculated. In a carburettor, the petrol from the float chamber is made into a fine spray by being drawn through a jet into the low pressure in the throat of a Venturi tube, where it mixes with the air being drawn into the engine. The device was invented by the Italian physicist Giovanni Venturi (1746–1822).

venule A small blood vessel that receives blood from the capillaries and transports it to a vein.

Venus The sixth largest *planet in the *solar system and the second in order from the *sun. Its mean distance from the sun is 108.21×10^6 km, its mass is 4.868 5 $\times 10^{24}$ kg (about 81% that of earth), and its equatorial diameter is 12 104 km; it has a *sidereal period of 224.7 days. Because Venus is so close to the earth, it appears as the brightest object in the sky after the sun and moon. Venus is never more than 47° from the sun and usually appears as a morning or evening 'star'. Venus is shrouded in a thick atmosphere topped with a dense layer of cloud about 20 km thick, and consisting largely of concentrated sulphuric acid, that completely obscures the surface from external view. Therefore, most of our knowledge about it comes from a series of planetary probes launched between 1961 and 2005, including the Soviet Venera 7, which in 1970 became the first spacecraft to send back data from the surface of another planet.

The atmosphere is 98% carbon dioxide and most of the remainder is nitrogen. The atmospheric pressure on the surface of Venus is about 90 times that on earth. This has meant that landers have only been able to function for an hour or less before being crushed and destroyed. Images taken by the dim sunlight reaching the surface reveal an arid landscape strewn with rocks rounded by windblown sand; radar has revealed very high mountains and plateaux, impact craters, and volcanic lava plains. The temperature on the surface of Venus soars to 750 K. This is the result of the *greenhouse effect, not proximity to the sun. Venus is unusual among the planets of the solar system because it rotates in a retrograde sense. In addition, its axial tilt is 177.3° and its period of axial rotation is the slowest of any planet so far known – 243 .01 days relative to the stars, but 116.8 days relative to the sun.

(⊕) SEE WEB LINKS
• NASA's profile of Venus
• Maps of the surface of Venus

verdigris A green patina of basic copper salts formed on copper. The composition of verdigris varies depending on the atmospheric conditions, but includes the basic carbonate $CuCO_3.Cu(OH)_2$, the basic sulphate $CuSO_4.Cu(OH)_2.H_2O$, and in some cases the basic chloride $CuCl_2.Cu(OH)_2$.

vermiculite *See* CLAY MINERALS.

vermiform appendix *See* APPENDIX.

vernalization The promotion of flowering by exposure of a plant to low temperatures. For example, winter cereals will not flower unless subjected to a period of chilling early in their development. Winter cereals are therefore sown in the autumn for flowering the following year. However, if germinating seeds are artificially vernalized they can be sown in the spring for flowering the same year.

vernier A short auxiliary scale placed beside the main scale on a measuring instrument to enable subdivisions of the main scale to be read accurately. The vernier scale is usually calibrated so that each of its divisions is 0.9 of the main scale divisions. The zero on the vernier scale is set to the observed measurement on the main scale and

V
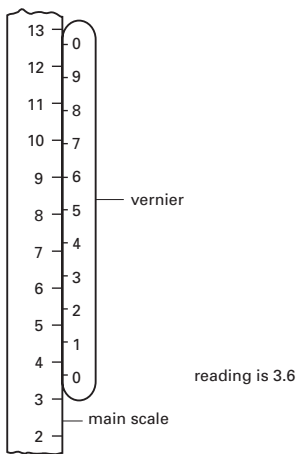
Vernier.

by noting which division on the vernier scale is exactly in line with a main scale division, the second decimal place of the measurement is obtained (see illustration). The device was invented by Pierre Vernier (1580–1637) in about 1630.

vertebra Any of the bones that make up the *vertebral column. In mammals each vertebra typically consists of a main body, or **centrum**, from which arises a **neural arch** through which the spinal cord passes, and **transverse processes** projecting from the side. In all vertebrates there are five groups of vertebrae, specialized for various functions and varying in number with the species. In humans, for example, there are 7 *cervical vertebrae, 12 *thoracic vertebrae, 5 *lumbar vertebrae, 5 fused *sacral vertebrae, and 5 fused *caudal vertebrae (forming the *coccyx).

vertebral column (backbone; **spinal column**; **spine)** A flexible bony column in vertebrates that extends down the long axis of the body and provides the main skeletal support. It also encloses and protects the *spinal cord and provides attachment for the muscles of the back. The vertebral column consists of a series of bones (*see* VERTEBRA) separated by discs of cartilage (*intervertebral discs). It articulates with the skull by means of the *atlas vertebra, with the ribs at the *thoracic vertebrae, and with the pelvic girdle at the sacrum (*see* SACRAL VERTEBRAE).

vertebrate Any one of a large group of animals comprising all those members of the subphylum *Craniata that have backbones (*see* VERTEBRAL COLUMN). Vertebrates include the fishes, amphibians, reptiles, birds, and mammals.

very high frequency (VHF) A radio frequency in the range 3×10^8– 0.3×10^8 Hz, i.e. having a wavelength in the range 1–10 m.

very long baseline interferometry (VLBI) A technique used in *radio astronomy in which radio telescopes at widely separated locations on the earth combine their observations of the same object to emulate a single radio telescope whose dish whose diameter equals the greatest separation between the participating telescopes.

very low frequency (VLF) A radio frequency in the range 3×10^4– 0.3×10^4 Hz, i.e. having a wavelength in the range 10–100 km.

Vesalius, Andreas (1514–64) Belgian physician and anatomist, who was a professor at Padua for six years before becoming a physician to the Habsburg court. He is remembered for producing in 1538–43 definitive text and anatomical drawings of the human body, which were made from actual dissections.

vesicle A small, usually fluid-filled, membrane-bound sac within the cytoplasm of a living cell. Vesicles occur, for example, as part of the *Golgi apparatus.

vessel 1. (in botany) A tube within the *xylem composed of joined *vessel elements. Vessels facilitate the efficient movement of water from the roots to the shoots and leaves of a plant. **2.** (in zoology) Any of various tubular structures through which substances are transported, especially a blood vessel or a lymphatic vessel.

vessel element A type of cell occurring within the *xylem of flowering plants, many of which, end to end, form water-conducting **vessels**. Vessel elements are frequently very broad and have side walls thickened by deposits of lignin over most of the surface area. However, the end walls are broken down to provide connections with the cells both above and below them. *Compare* TRACHEID.

vestibular apparatus The part of the inner ear that is responsible for balance. The vestibular apparatus is continuous with the cochlea. It consists of the three *semicircular canals, which detect movements of the head

(*see* AMPULLA), and the *utriculus and *sacculus, which detect the position of the head (*see* MACULA). *See* EAR.

vestigial organ Any part of an organism that has diminished in size during its evolution because the function it served decreased in importance or became totally unnecessary. Examples are the human appendix and the wings of the ostrich.

vibrio Any comma-shaped bacterium. Generally, vibrios are Gram-negative (*see* GRAM'S STAIN), motile, and aerobic. They are widely distributed in soil and water and while most feed on dead organic matter some are parasitic, e.g. *Vibrio cholerae*, the causal agent of cholera.

vicinal (vic) Designating a molecule in which two atoms or groups are linked to adjacent atoms. For example, 1,2-dichloroethane (CH_2ClCH_2Cl) is a vicinal (or vic) dihalide and can be named *vic*-dichloroethane.

Victor Meyer's method A method of measuring vapour density, devised by Victor Meyer (1848–97). A weighed sample in a small tube is dropped into a heated bulb with a long neck. The sample vaporizes and displaces air, which is collected over water and the volume measured. The vapour density can then be calculated.

video camera (camcorder) A hand-held *camera used to record moving pictures on video-tape cassettes for playing back on a television set. In a video camera the standard optical lenses focus the scene to be recorded onto an electronic camera tube, as in a television camera. The electronic data so obtained are recorded on video tape within the camcorder. At the same time, sound is picked up by a microphone attached to the camcorder, and recorded as a sound track along the edge of the video tape. The contents of the tape can usually be viewed on a miniscreen in the camcorder or played back through a television screen. Modern camcorders store their data in digital rather than analogue form – the same principle as used in digital photography. The latest camcorders use DVDs or electronic memory instead of tape.

video recording The recording of films, television programmes, etc., on magnetic tape. Because the demodulated video (vision) signal can have frequencies in the megahertz range, a video tape cannot be run like a sound tape. Sound has a maximum frequency of 15–20 kHz, which means that using the same system as sound, a video tape would need to run 1000 times faster than a sound tape. As this would be impractical the signal is recorded diagonally on the tape (each diagonal line representing one line of the picture) and the tape is run slowly over a drum on which the recording and reading heads rotate at high speeds. Devices using this mechanism are available for use with domestic television sets and video cameras (camcorders).

villiaumite A mineral form of sodium fluoride, NaF.

villus A microscopic outgrowth from the surface of some tissues and organs, which serves to increase the surface area of the organ. Numerous villi line the interior of the small intestine. Their shape may vary from finger-like (in the *duodenum) to spadelike (in the *ileum). Intestinal villi are specialized for the absorption of soluble food material: each contains blood vessels and a lymph vessel (*see* LACTEAL).

   Chorionic villi occur on the chorion of the mammalian placenta, where they increase the surface area for the exchange of materials between the fetal and maternal blood.

vinyl acetate *See* ETHENYL ETHANOATE.

vinyl chloride *See* CHLOROETHENE.

vinyl group The organic group CH_2:CH–.

VIP (vasoactive intestinal peptide) A widely distributed *neuropeptide that acts as a neurotransmitter in the central and peripheral nervous systems and many other organs and tissues and also as a peptide hormone, being secreted by endocrine cells of the upper part of the small intestine in response to the entry of partially digested food from the stomach. VIP, along with *secretin, stimulates the pancreas to produce a thin watery secretion containing bicarbonate. This raises the pH in the intestine in preparation for secretion of pancreatic enzymes. VIP also inhibits gastric secretion, causes widening of blood vessals and airways, increases cardiac output, and relaxes smooth muscle.

virial equation A gas law that attempts to account for the behaviour of real gases, as opposed to an ideal gas. It takes the form

$$pV = RT + Bp + Cp^2 + Dp^3 + \ldots,$$

where *B*, *C*, and *D* are known as **virial coeffi-cients**.

virion *See* VIRUS.

viroid Any of various small naked single-stranded RNA molecules that infect plant cells and cause disease. Smaller than viruses, viroids are not enclosed in a protein coat of any kind: they generally consist of less than 400 nucleotides and do not contain any genes. The circular RNA strand undergoes extensive base pairing within itself, forming a double-stranded structure that mimics DNA and is replicated by the host cell's en-zymes. This behaviour is similar to that of certain *introns, prompting the suggestion that viroids are escaped introns. Viroids in-clude many commercially important disease agents, such as coconut cadang-cadang, cit-rus exocortis, and potato spindle tuber vi-roid.

virology The scientific study of *viruses. *See* MICROBIOLOGY.

(((⊕))) SEE WEB LINKS

• Website for All the Virology on the WWW, a major portal for virology resources via the inter-net

virtual image *See* IMAGE.

virtual reality A form of computer simu-lation in which the user has the impression of being in an artificial environment. Typi-cally, the user wears a visor into which are built two small screens, one for each eye, giving a three-dimensional view of a com-puter-generated environment. Sensors in the visor detect head movements and cause the perspective of the scene to change. It is also possible to wear special gloves (known as 'datagloves') containing sensors. These allow the user to move objects in the envi-ronment by making hand movements. Vir-tual-reality systems are used for training purposes as well as for entertainment.

virtual state The state of the **virtual par-ticles** that are exchanged between two inter-acting charged particles. These particles, called *photons, are not in the real state, i.e. directly observable; they are constructs to enable the phenomenon to be explained in terms of *quantum mechanics.

virtual work The imaginary work done when a system is subjected to infinitesimal hypothetical displacements. According to the **principle of virtual work**, the total work done by all the forces acting on a system in
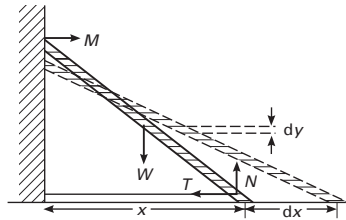
Virtual work.

equilibrium is zero. This principle can be used to determine the forces acting on a sys-tem in equilibrium. For example, the illus-tration shows a ladder leaning against a wall, with the bottom of the ladder attached to the wall by a horizontal weightless string. The tension, *T*, in the string can be calculated by assuming that infinitesimal movement d*x* and d*y* take place as shown. Then by apply-ing the principle of virtual work, $Tdx + Wdy = 0$. As d*x* and d*y* can be calculated from the geometry, *T* can be found.

virulence The disease-producing ability of a microorganism. *See also* PATHOGEN.

virus 1. (in microbiology) A particle that is too small to be seen with a light microscope or to be trapped by filters but is capable of independent metabolism and reproduction within a living cell. Outside its host cell a virus is completely inert. A mature virus (a **virion**) ranges in size from 20 to 400 nm in diameter. It consists of a core of nucleic acid (DNA or RNA) surrounded by a protein coat (**capsid**). Some bear an outer envelope (**en-veloped viruses**). Inside its host cell the virus initiates the synthesis of viral proteins and undergoes replication. The new virions are released when the host cell disintegrates. Viruses are parasites of animals, plants, and some bacteria (*see* BACTERIOPHAGE). Viral dis-eases of animals include the common cold, influenza, smallpox, AIDS, herpes, hepa-titis, polio, and rabies (*see* ADENOVIRUS; AR-BOVIRUS; HERPESVIRUS; HIV; MYXOVIRUS; PA-POVAVIRUS; PICORNAVIRUS; POXVIRUS); some viruses are also implicated in the develop-ment of cancer (*see* RETROVIRUS). Plant viral diseases include various forms of yellowing and blistering of leaves and stems (*see* TO-BACCO MOSAIC VIRUS). *Antiviral drugs are ef-fective against certain viral diseases and *vaccines (if available) provide protection against others. **2.** (in computing) A computer program that can replicate itself and be

transferred from one computer to another without the user being aware of it. Viruses are often designed to destroy or damage the data on the user's computer. They generally spread by exchange of floppy disks or by telephone links.

visceral Relating to the internal organs (the **viscera**) that lie in the coelomic cavities of animals, i.e. in the thoracic and abdominal cavities of mammals. *Compare* SOMATIC.

viscoelasticity The property of certain materials of exhibiting both viscous behaviour when subject to shear flow and elastic properties when deformed. Some complex polymers exhibit this behaviour.

viscometer An instrument for measuring the viscosity of a fluid. In the **Ostwald viscometer**, used for liquids, a bulb in a capillary tube is filled with the liquid and the time taken for the meniscus to reach a mark on the capillary, below the bulb, is a measure of the viscosity. The **falling-sphere viscometer**, based on *Stokes' law, enables the speed of fall of a ball falling through a sample of the fluid to be measured. Various other devices are used to measure viscosity.

viscose Cellulose xanthate, the sticky brown liquid formed by adding carbon disulphide and sodium hydroxide to cellulose from wood pulp. It is forced through spinnarets into an acid bath, which reforms cellulose fibres as rayon (artificial silk).

viscose process *See* RAYON.

viscosity A measure of the resistance to flow that a fluid offers when it is subjected to shear stress. For a *Newtonian fluid, the force, F, needed to maintain a velocity gradient, $\mathrm{d}v/\mathrm{d}x$, between adjacent planes of a fluid of area A is given by: $F = \eta A(\mathrm{d}v/\mathrm{d}x)$, where η is a constant, the coefficient of viscosity. In *SI units it has the unit pascal second (in the c.g.s. system it is measured in *poise). Non-Newtonian fluids, such as clays, do not conform to this simple model. *See also* KINEMATIC VISCOSITY.

(⊕) SEE WEB LINKS
• Values of viscosities of liquids at the NPL website

visible spectrum The *spectrum of electromagnetic radiations to which the human eye is sensitive. *See* COLOUR.

vision The sense that enables perception of objects in the environment by means of the *eyes.

visual acuity Sharpness of vision: the ability of the eye to distinguish between objects that lie close together. This hinges on the ability of the eye to focus incoming light to form a sharp image on the retina. Visual acuity depends on the *cone cells, which are most densely packed in the *fovea, close to the centre of the retina, and are therefore in the optimum position to receive focused light. In addition, each cone cell synapses with a single nerve cell and is thus able to send a separate signal, via the optic nerve fibres, to the brain.

visual binary *See* BINARY STARS.

visual-display unit (VDU) The part of a *computer system or word processor on which text or diagrams are displayed. It consists of a *cathode-ray tube and usually has its own input keyboard attached.

visual purple *See* RHODOPSIN.

vital capacity The total amount of air that can be exhaled after maximum inspiration. The vital capacity of an average human is about 4.5 litres; in trained male athletes it can be 6 litres or more. However, some air always remains in the lungs (*see* RESIDUAL VOLUME).

vital staining A technique in which a harmless dye is used to stain living tissue for microscopical observation. The stain may be injected into a living animal and the stained tissue removed and examined (**intravital staining**) or the living tissue may be removed directly and subsequently stained (**supravital staining**). Microscopic organisms, such as protozoa, may be completely immersed in the dye solution. Vital stains include trypan blue, vital red, and Janus green, the latter being especially suitable for observing mitochondria.

vitamin One of a number of organic compounds required by living organisms in relatively small amounts to maintain normal health. There are some 14 generally recognized major vitamins: the water-soluble *vitamin B complex (containing 9) and *vitamin C and the fat-soluble *vitamin A, *vitamin D, *vitamin E, and *vitamin K. Most B vitamins and vitamin C occur in plants, animals, and microorganisms; they function typically as *coenzymes. Vitamins A, D, E, and K occur only in animals, especially vertebrates, and perform a variety of metabolic roles. Animals are unable to manufacture many vitamins themselves and must have

V

adequate amounts in the diet. Foods may contain vitamin precursors (called **provita-mins**) that are chemically changed to the actual vitamin on entering the body. Many vitamins are destroyed by light and heat, e.g. during cooking. See Chronology.

( ) **SEE WEB LINKS**
• Information and advice on vitamins and minerals from the UK Food Standards Agency

vitamin A (retinol) A fat-soluble vitamin that cannot be synthesized by mammals and other vertebrates and must be provided in the diet. Green plants contain precursors of the vitamin, notably carotenes, that are converted to vitamin A in the intestinal wall and liver. The aldehyde derivative of vitamin A, **retinal**, is a constituent of the visual pigment *rhodopsin. Deficiency affects the eyes, causing night blindness, xerophthalmia, and eventually total blindness. Vitamin A is also important in maintaining the integrity of epidermal and mucosal surfaces, which act as barriers against infection.

( ) **SEE WEB LINKS**
• Information about IUPAC nomenclature

vitamin B complex A group of water-soluble vitamins that characteristically serve as components of *coenzymes. Plants and many microorganisms can manufacture B vitamins but dietary sources are essential for most animals. Heat and light tend to destroy B vitamins.

Vitamin B_1 (**thiamine**) is a precursor of the coenzyme thiamine pyrophosphate, which functions in the Krebs cycle and carbohydrate metabolism. Deficiency leads to *beriberi in humans and to polyneuritis in birds. Good sources include wholegrain or fortified cereals, beans, peas, and nuts.

Vitamin B_2 (**riboflavin**) occurs in green vegetables, yeast, liver, and milk. It is a constituent of the coenzymes *FAD and FMN, which have an important role in the metabolism of all major nutrients as well as in the oxidative phosphorylation reactions of the *electron transport chain. Deficiency of B_2 causes inflammation of the tongue and lips, mouth sores, and conjunctivitis.

Vitamin B_6 (**pyridoxine**) is widely distributed in cereal grains, yeast, liver, milk, etc. It is a constituent of a coenzyme (pyridoxal phosphate) involved in amino acid metabolism. Deficiency can cause anaemia, dermatitis, and fatigue.

Vitamin B_{12} (**cyanocobalamin** or **cobalamin**) is manufactured only by microorgan-isms and natural sources are entirely of animal origin. Liver is especially rich in it. One form of B_{12} functions as a coenzyme in a number of reactions, including the oxidation of fatty acids and the synthesis of DNA. It also works in conjunction with *folic acid (another B vitamin) in the synthesis of the amino acid methionine and it is required for normal production of red blood cells. Vitamin B_{12} can only be absorbed from the gut in the presence of a glycoprotein called **intrinsic factor**; lack of this factor or deficiency of B_{12} results in pernicious anaemia.

Other vitamins in the B complex include *nicotinic acid, *pantothenic acid, *biotin, and *lipoic acid. *See also* CHOLINE; INOSITOL.

( ) **SEE WEB LINKS**
• Information about IUPAC nomenclature

vitamin C (ascorbic acid) A colourless crystalline water-soluble vitamin found especially in citrus fruits and green vegetables. Most organisms synthesize it from glucose, but humans and other primates and various other species must obtain it from their diet. It functions as a scavenger of free radicals; deficiency leads to *scurvy. Vitamin C is readily destroyed by heat and light.

( ) **SEE WEB LINKS**
• Information about IUPAC nomenclature

vitamin D A fat-soluble vitamin occurring in the form of two steroid derivatives: **vitamin D_2** (**ergocalciferol**, or **calciferol**), found in yeast; and **vitamin D_3** (**cholecalciferol**), which occurs in animals. Vitamin D_2 is formed from a steroid by the action of ultraviolet light and D_3 is produced by the action of sunlight on a cholesterol derivative in the skin. Fish-liver oils are the major dietary source. The active form of vitamin D (**calcitriol**) is manufactured in the kidneys in response to the secretion of *parathyroid hormone, which occurs when blood calcium levels are low. It causes increased uptake of calcium from the gut, which increases the supply of calcium for bone synthesis. Vitamin D deficiency causes *rickets in growing animals and osteomalacia in mature animals. Both conditions are characterized by weak deformed bones.

( ) **SEE WEB LINKS**
• Information about IUPAC nomenclature

vitamin E (tocopherol) A fat-soluble vitamin, consisting of several closely related compounds, that is the main *antioxidant of cell membranes and other lipid-rich tissue

VITAMINS

1897 Dutch physician Christiaan Eijkman (1858–1930) cures beriberi in chickens with diet of whole rice.

1906–07 British biochemist Sir Frederick Hopkins demonstrates existence of accessory dietary elements essential for growth.

1912 Polish-born US biochemist Casimir Funk (1884–1967) extracts antiberiberi factor (an amine) from rice husks and coins the term 'vitamine' (vital amine; later changed to 'vitamin').

1913 US biochemist Elmer McCollum (1879–1967) discovers and names vitamin A (retinol) and names antiberiberi factor vitamin B.

1920 McCollum names antirachitic factor vitamin D.

1922 US embryologist Herbert Evans (1882–1971) discovers vitamin E (tocopherol).

1926 German chemist Adolf Windaus (1876–1959) discovers that ergosterol is converted to vitamin D in the presence of sunlight.

1931 German chemist Paul Karrer (1889–1971) determines the structure of (and synthesizes) vitamin A.

1932 Hungarian-born US biochemist Albert Szent-Györgyi (1893–1986) and US biochemist Charles King (1896–1986) independently isolate vitamin C (ascorbic acid).

1933 Polish-born Swiss chemist Tadeus Reichstein (1897–1996) and British chemist Walter Haworth (1883–1950) independently synthesize vitamin C.
US chemist Roger Williams (1893–1988) discovers the B vitamin pantothenic acid.

1934 Danish biochemist Carl Dam (1895–1976) discovers vitamin K.

1935 Karrer and Austrian-born German chemist Richard Kuhn (1900–67) independently synthesize vitamin B_2 (riboflavin).

1937 US chemist Robert Williams (1886–1965) synthesizes vitamin B_1 (thamine).

1938 Karrer synthesizes vitamin E.
Kuhn isolates and synthesizes vitamin B_6 (pyridoxine).

1939 Dam and Karrer isolate vitamin K.

1940 Szent-Györgyi and US biochemist Vincent Du Vigneaud (1901–78) discover 'vitamin H' (the B vitamin biotin).
Roger Williams determines the structure of pantothenic acid.
US biochemist Edward Doisey synthesizes vitamin K.

1948 US biochemist Karl Folkers (1906–97) isolates vitamin B_{12} (cyanocobalamin).

1956 British chemist Dorothy Hodgkin (1910–94) determines the structure of vitamin B_{12}.

1971 US chemist Robert Woodward (1917–79) and Swiss chemist Albert Eschenmoser (1925–   ) synthesize vitamin B_{12}.

V

components. Deficiency leads to a range of disorders in different species, including muscular dystrophy, liver damage, and infertility. Good sources are cereal grains and green vegetables.

(⊕) SEE WEB LINKS
• Information about IUPAC nomenclature

vitamin K Any of several related fat-soluble compounds, including vitamins K_1 (**phylloquinone**) and K_2 (**menaquinone**), that act as coenzymes in the synthesis of several proteins (including prothrombin) necessary for blood clotting. Deficiency of vitamin K, which leads to extensive bleeding, is rare because a form of the vitamin is manufactured by intestinal bacteria. Green vegetables and egg yolk are good sources.

vitelline membrane See EGG MEMBRANE.

vitreous Having a glasslike appearance or structure.

vitreous humour The colourless jelly that fills the space between the lens and the retina of the vertebrate eye.

vitriol (oil of vitriol) An old name for sulphuric acid. As a result, hydrated iron(II) (ferrous) sulphate was known as **green vitriol**, and hydrated copper(II) (cupric) sulphate as **blue vitriol**.

viviparity **1.** (in zoology) A form of reproduction in animals in which the developing embryo obtains its nourishment directly from the mother via a *placenta or by other means. Viviparity occurs in some insects and other arthropods, in certain fishes, amphibians, and reptiles, and in the majority of mammals. *Compare* OVIPARITY; OVOVIVIPARITY. **2.** (in botany) **a.** A form of *asexual reproduction in certain plants, such as the onion, in which the flower develops into a budlike structure that forms a new plant when detached from the parent. **b.** The development of young plants on the inflorescence of the parent plant, as seen in certain grasses and the spider plant.

vocal cords A pair of elastic membranes that project into the *larynx in air-breathing vertebrates. Vocal sounds are produced when expelled air passing through the larynx vibrates the cords. The pitch of the sound produced depends on the tension of the cords, which is controlled by muscles and cartilages in the larynx.

Voice over Internet Protocol See VoIP.

void A large region of space at the centre of a collection of galaxy superclusters; there are hardly any galaxies in the void itself, indeed there is little evidence of any matter at all. Empty 'corridors' connect voids, rather like the holes in a piece of sponge, making them part of the large-scale structure of the universe.

VoIP Voice over Internet Protocol: the use of an IP network, in particular the Internet, to carry verbal conversations. This has been a major growth area in recent years, with several companies offering services that not only allow conversations between their members but also connect to the global telephone network. Indeed, many traditional telephone providers now use VoIP internally. Implementing conversations in real time imposes special constraints because they are particularly sensitive to any delay or lost data. For example, the scope for using buffering to assemble an incoming message from data packets that might arrive out of order, be delayed, be lost and require retransmission, etc., is severely limited. There are currently (2008) two main standards used to implement VoIP: the ITU's **H323** and the IETF's **SIP**.

(⊕) SEE WEB LINKS
• The H323 specification
• The SIP specification

volcano A fissure or vent in the earth's surface, connected to a magma source in the earth's interior by a conduit or series of fractures, from which solid, molten, and gaseous material is ejected. The resultant geological structure, also called volcano, can take a number of forms. **Central volcanoes**, which have a circular vent or number of vents, may be composite volcanoes or stratovolcanoes, comprising alternate layers of tephra (fragmental material including ash) and lava (e.g. Vesuvius, Italy), or (where only solid material is ejected) steep-sided cinder cones. **Shield volcanoes** are large structures with gentle slopes (e.g. the islands of Hawaii). **Fissure volcanoes** are linear fractures in the earth's surface where fluid material is emitted and, on land, spreads over large areas (e.g. volcanoes in Iceland). A number of types of volcanic eruption are recognized: Hawaiian, which are generally quiet with fluid lava erupted freely from fissures or pits, and – with increasing viscocity of magma – Strombolian, Vulcanian, Vesuvian, Plinian, and Peléean, which are more explosive. An ex-

ceptionally large form is the **supervolcano**, in which magma rises to form a vast reservoir in the earth's crust and builds in pressure over time before erupting in devastating explosions. The last supervolcano to erupt was Toba Caldera in Sumatra, 74 000 years ago. The *caldera of Yellowstone National Park is one of the largest in the world. Volcanoes occur principally along constructive or destructive plate margins (*see* PLATE TECTONICS) but some volcanic activity occurs away from the margins.

volcanology (vulcanology) The scientific study of volcanism, i.e. the processes by which magma and associated gases rise from the earth's interior and are emitted from the surface, and the resultant structures (*see* VOLCANO).

volt Symbol V. The SI unit of electric potential, potential difference, or e.m.f. defined as the difference of potential between two points on a conductor carrying a constant current of one ampere when the power dissipated between the points is one watt. It is named after Alessandro Volta.

Volta, Alessandro Giuseppe Antonio Anastasio (1745–1827) Italian physicist. In 1774 he began teaching in Como and in that year invented the *electrophorus. He moved to Pavia University in 1778. In 1800 he made the *voltaic cell, thus providing the first practical source of electric current (*see also* GALVANI, LUIGI). The SI unit of voltage is named after him.

voltage Symbol V. An e.m.f. or potential difference expressed in volts.

voltage divider (potential divider; potentiometer) A resistor or a chain of resis-
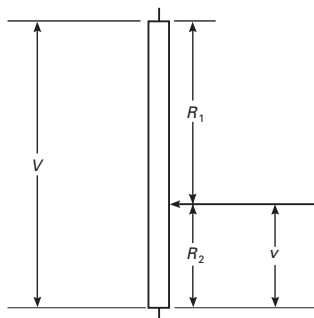
Voltage divider.

tors connected in series that can be tapped at one or more points to obtain a known fraction of the total voltage across the whole resistor or chain. In the illustration, V is the total voltage across the divider and v is required voltage, then

$$v/V = R_2/(R_1 + R_2).$$

voltaic cell (galvanic cell) A device that produces an e.m.f. as a result of chemical reactions that take place within it. These reactions occur at the surfaces of two electrodes, each of which dips into an electrolyte. The first voltaic cell, devised by Alessandro Volta (1745–1827), had electrodes of two different metals dipping into brine. *See* PRIMARY CELL; SECONDARY CELL.

voltaic pile An early form of battery, devised by Alessandro Volta, consisting of a number of flat *voltaic cells joined in series. The liquid electrolyte was absorbed into paper or leather discs.

voltameter (coulometer) **1.** An electrolytic cell formerly used to measure quantity of electric charge. The increase in mass (m) of the cathode of the cell as a result of the deposition on it of a metal from a solution of its salt enables the charge (Q) to be determined from the relationship $Q = m/z$, where z is the electrochemical equivalent of the metal. **2.** Any other type of electrolytic cell used for measurement.

voltmeter An instrument used to measure voltage. *Moving-coil instruments are widely used for this purpose; generally a galvanometer is used in series with a resistor of high values (sometimes called a **multiplier**). To measure an alternating potential difference a rectifier must be included in the circuit. A moving-iron instrument can be used for either d.c. or a.c. without a rectifier. *Cathode-ray oscilloscopes are also used as voltmeters. The electronic **digital voltmeter** displays the value of the voltage in digits. The input is repeatedly sampled by the voltmeter and the instantaneous values are displayed.

volume Symbol V. The space occupied by a body or mass of fluid.

volumetric analysis A method of quantitative analysis using measurement of volumes. For gases, the main technique is in reacting or absorbing gases in graduated containers over mercury, and measuring the

V

volume changes. For liquids, it involves *titrations.

voluntary (in biology) Controlled by conscious thought. *See* VOLUNTARY MUSCLE. *Compare* INVOLUNTARY.

voluntary muscle (skeletal, striped, *or* **striated muscle)** Muscle that is under the control of the will and is generally attached to the skeleton. An individual muscle consists of bundles of long **muscle fibres**, each containing many nuclei, the whole muscle being covered with a strong connective tissue sheath (**epimysium**) and attached at each end to a bone by inextensible *tendons. Each fibre contains smaller fibres (**myofibrils**) having alternate light and dark bands, which contain protein filaments responsible for the muscle's contractile ability and give the muscle its typical striped appearance under the microscope. The functional unit of a myofibril is the *sarcomere. See illustration.

   The end of the muscle that is attached to a nonmoving bone is called the **origin** of the muscle; the end attached to a moving bone is the **insertion**. As a muscle contracts it becomes shorter and fatter, moving one bone closer to the other. Since a muscle cannot expand, another muscle (the **extensor**) is required to move the bone in the opposite direction and stretch the first muscle (known as the **flexor**). The flexor and extensor are described as **antagonistic muscles**. See illustration.

von Baeyer nomenclature A system of naming polycyclic compounds originally introduced by Adolf von Baeyer in 1900 and since extended.

(⊕) **SEE WEB LINKS**

• Information about the IUPAC system

von Laue, Max *See* LAUE, MAX THEODOR FELIX VON.

vortex dynamics The branch of fluid mechanics that is concerned with the dynamics of **vortices**, i.e. fluid which is rotating. There are many applications of vortex dynamics in engineering, atmospheric dynamics, and oceanography. Familiar examples of vortex dynamics include hurricanes and tornadoes. Vortex dynamics is also important in quantum liquids, such as superfluids.

vortex pinning The fixing in space of a vortex so that it does not 'slip'. In some prac-
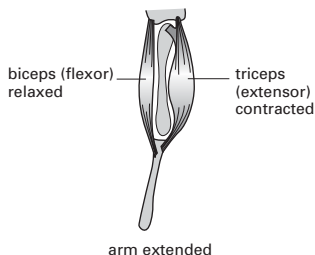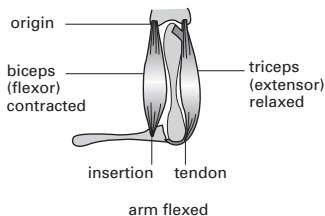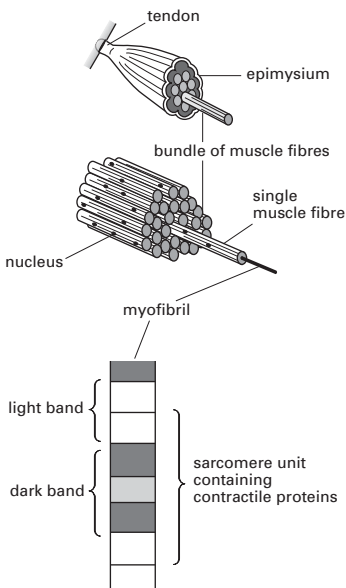
Voluntary muscle. Structure and action of a voluntary muscle.

tical applications of *superconductivity vortex pinning is desirable.

V-series *See* NERVE AGENTS.

vulcanite (ebonite) A hard black insulating material made by the vulcanization of rubber with a high proportion of sulphur (up to 30%).

vulcanization A process for hardening rubber by heating it with sulphur or sulphur compounds.

vulcanology *See* VOLCANOLOGY.

vulva The female external genitalia, comprising in women two pairs of fleshy folds of tissue, the labia (*see* LABIUM); the *clitoris; and the vaginal opening.

VX A highly toxic colourless oily liquid, $C_{11}H_{26}NO_2PS$; r.d. 1.01; m.p. –50°C; b.p. 298°C. It is an organophosphorus compound and is probably one of the most toxic of all *nerve agents. VX was discovered in 1952 at the Porton Down research station in Wiltshire. VX is the best known of the V-series of nerve agents (the V denotes very high persistence in the environment). Other, lesser known, members of the series include VG and VM, which are both organophosphorus compounds related to VX.

V