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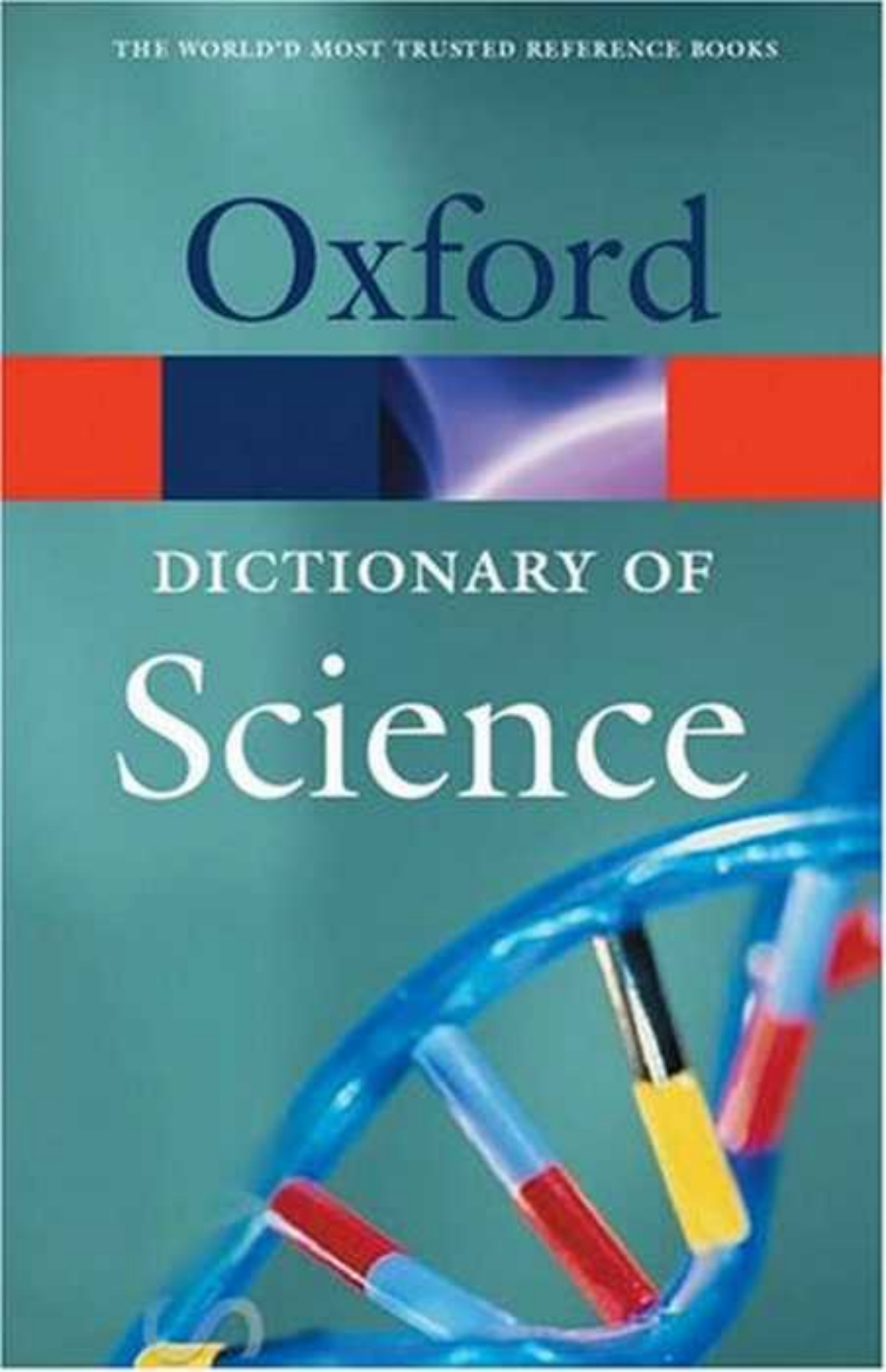
DICTIONARY OF Science



A Dictionary of

Science

FIFTH EDITION

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Preface

This fifth edition of *A Dictionary of Science*, like its predecessors, aims to provide school and first-year university students with accurate explanations of any unfamiliar words they might come across in the course of their studies, in their own or adjacent disciplines. For example, students of the physical sciences will find all they are likely to need to know about the life sciences, and vice versa. The dictionary is also designed to provide non-scientists with a useful reference source to explain the scientific terms that they may encounter in their work or in their general reading.

At this level the dictionary provides full coverage of terms, concepts, and laws relating to physics, chemistry, biology, biochemistry, palaeontology, and the earth sciences. There is also coverage of key terms in astronomy, cosmology, mathematics, biotechnology, and computer technology. In addition, the dictionary includes:

- over 160 short biographical entries on the most important scientists in the history of the subject
- ten features (each of one or two pages) on concepts of special significance in modern science
- ten chronologies showing the development of selected concepts, fields of study, and industries
- eight Appendices, including the periodic table, tables of SI units and conversion tables to and from other systems of units, summary classifications of the plant and animal kingdoms, and useful websites.

For this fifth edition over 300 new entries have been added to the text, incorporating recent advances in all the major fields and increased coverage of climatology, seismology, and computing.

In compiling the dictionary, the contributors and editors have made every effort to make the entries as concise and comprehensible as possible, always bearing in mind the needs of the readers. Particular features of the book are its lack of unnecessary scientific jargon and its extensive network of cross-references. An asterisk placed before a word used in an entry indicates that this word can be looked up in the dictionary and will provide further explanation or clarification. However, not every word that is defined in the dictionary has an asterisk placed before it when it is used in an entry. Some entries simply refer the reader to another entry, indicating either that they are synonyms or abbreviations or that they are most conveniently explained in one of the dictionary's longer articles. Synonyms and abbreviations are usually placed within brackets immediately after the headword. Terms that are explained within an entry are highlighted by being printed in boldface type. Where appropriate, the entries have been supplemented by fully labelled line-drawings or tables *in situ*.

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aa *See* LAVA.

AAS *See* ATOMIC ABSORPTION SPECTROSCOPY.

ab- A prefix attached to the name of a practical electrical unit to provide a name for a unit in the electromagnetic system of units (*see* ELECTROMAGNETIC UNITS), e.g. abampere, abcoulomb, abvolt. The prefix is an abbreviation of the word 'absolute' as this system is also known as the **absolute system**. *Compare* STAT-. In modern practice both absolute and electrostatic units have been replaced by *SI units.

abdomen The posterior region of the body trunk of animals. In vertebrates it contains the stomach and intestines and the organs of excretion and reproduction. It is particularly well defined in mammals, being separated from the *thorax by the *diaphragm. In many arthropods, such as insects and spiders, it may be segmented.

Abelian group *See* GROUP.

aberration **1.** (in optics) A defect in the image formed by a lens or curved mirror. In **chromatic aberration** the image formed by a lens (but not a mirror) has coloured fringes as a result of the different extent to which light of different colours is refracted by glass. It is corrected by using an *achromatic lens. In **spherical aberration**, the rays from the object come to a focus in slightly different positions as a result of the curvature of the lens or mirror. For a mirror receiving light strictly parallel with its axis, this can be corrected by using a parabolic surface rather than a spherical surface. Spherical aberration in lenses is minimized by making both surfaces contribute equally to the ray deviations, and can (though with reduced image brightness) be reduced by the use of diaphragms to let light pass only through the centre part of the lens. *See also* ASTIGMATISM; COMA. **2.** (in astronomy) The apparent displacement in the position of a star as a result of the earth's motion round the sun. Light appears to come from a point that is slightly displaced in the direction of the earth's motion. The angular displacement $\alpha = v/c$, where v is the earth's orbital velocity and c is the speed of light.

abiogenesis The origin of living from nonliving matter, as by *biopoiesis. *See also* SPONTANEOUS GENERATION.

abiotic factor Any of the nonliving factors that make up the **abiotic environment** in which living organisms occur. They include all the aspects of climate, geology, and atmosphere that may affect the biotic environment. *Compare* BIOTIC FACTOR.

abomasum The fourth and final chamber of the stomach of ruminants. It leads from the *omasum and empties into the small intestine. The abomasum is referred to as the 'true stomach' as it is in this chamber that protein digestion occurs, in acidic conditions. *See* RUMINANTIA.

ABO system One of the most important human *blood group systems. The system is based on the presence or absence of *antigens A and B on the surface of red blood cells and of *antibodies against these in blood serum. A person whose blood contains either or both these antibodies cannot receive a transfusion of blood containing the corresponding antigens as this would cause the red cells to clump (*see* AGGLUTINATION). The table illustrates the basis of the system: people of blood group O are described as 'universal donors' as they can give blood to those of any of the other groups. *See also* IMMUNE RESPONSE.

abscisic acid A naturally occurring plant *growth substance that appears to be involved primarily in seed maturation, stress responses (e.g. to heat and waterlogging), and in regulating closure of leaf

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Group	Antigens on red cell surface	Antibodies in serum	Blood group of people donor can receive blood from	Blood group of people donor can give blood to
A	A	anti-B	A, O	A, AB
B	B	anti-A	B, O	B, AB
AB	A and B	none	A, B, AB, O	AB
O	neither A nor B	anti-A and anti-B	O	A, B, AB, O

The ABO blood group system

pores (stomata). In seeds, it promotes the synthesis of storage protein and prevents premature germination. In leaves, abscisic acid is produced in large amounts when the plant lacks sufficient water, promoting closure of stomata and hence reducing further water losses. It was formerly believed to play a role in *abscission, hence the name.

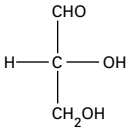
abscissa *See* CARTESIAN COORDINATES.

abscission The separation of a leaf, fruit, or other part from the body of a plant. It involves the formation of an **abscission zone**, at the base of the part, within which a layer of cells (**abscission layer**) breaks down. This process is suppressed so long as sufficient amounts of *auxin, a plant growth substance, flow from the part through the abscission zone. However, if the auxin flow declines, for example due to injury or ageing, abscission is activated and the part becomes separated.

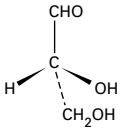
absolute **1.** Not dependent on or relative to anything else, e.g. *absolute zero. **2.** Denoting a temperature measured on an **absolute scale**, a scale of temperature based on absolute zero. The usual absolute scale now is that of thermodynamic *temperature; its unit, the kelvin, was formerly called the degree absolute (°A) and is the same size as the degree Celsius. In British engineering practice an absolute scale with Fahrenheit-size degrees has been used: this is the Rankine scale.

absolute alcohol *See* ETHANOL.

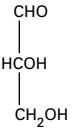
absolute configuration A way of denoting the absolute structure of an optical isomer (*see* OPTICAL ACTIVITY). Two conventions are in use: The D–L convention relates the structure of the molecule to some reference molecule. In the case of sugars and similar compounds, the dextrorotatory form of glyceraldehyde ($HOCH_2CH(OH)CHO$), 2,3-dihydroxypropanal) was used. The rule is as follows. Write the structure of this molecule down with the asymmetric carbon in the centre, the –CHO group at the top, the –OH on the right, the $–CH_2OH$ at the bottom, and the –H on the left. Now imagine that the central carbon atom is at the centre of a tetrahedron with the four groups at the corners and that the –H and –OH come out of the paper and the –CHO and $–CH_2OH$ groups go into the paper. The resulting three-dimensional structure was taken to be that of *d*-glyceraldehyde and called D-glyceraldehyde. Any compound that contains an asymmetric carbon atom having this configuration belongs to the D-series. One having the opposite configuration belongs to the L-series. It is important to note that the prefixes D- and L- do not stand for dextrorotatory and laevorotatory (they are not the same as *d*- and *l*-). In fact the arbitrary configuration assigned to D-glyceraldehyde is now known to be the correct one for the dextrorotatory form, although this was not known at the time. However, all D-compounds are not dextrorotatory. For instance, the acid obtained by oxidizing the –CHO group of glyceraldehyde is glyceric acid (1,2-dihydroxypropanoic acid). By convention, this belongs to the D-series, but it is in fact laevorotatory; i.e. its name can be written as D-glyceric acid or *l*-glyceric acid. To avoid confusion it is better to use + (for dextrorotatory) and – (for laevorotatory), as in D-(+)-glyceraldehyde and D-(–)-glyceric acid.



planar formula

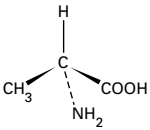


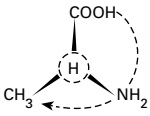
structure in 3 dimensions



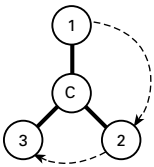
Fischer projection

D–L convention: D-(+)-glyceraldehyde (2,3-dihydroxypropanal)

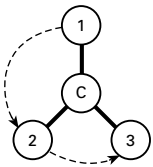




D–L convention: D-alanine (R is CH_2 in the CORN rule); the molecule is viewed with H on top



R–configuration



S–configuration

R–S system: the lowest priority group is behind the chiral carbon atom

The D–L convention can also be used with alpha amino acids (compounds with the $-NH_2$ group on the same carbon as the –COOH group). In this case the molecule is imagined as being viewed along the H–C bond between the hydrogen and the asymmetric carbon atom. If the clockwise order of the other three groups is *–COOH*, *–R*, $-NH_2$, the amino acid belongs to the D-series; otherwise it belongs to the L-series. This is known as the **CORN rule**.

The R–S convention is a convention based on priority of groups attached to the chiral carbon atom. The order of priority is I, Br, Cl, SO_3H, $OCOCH_3$, OCH_3, OH, NO_2, NH_2, $COOCH_3$, $CONH_2$, $COCH_3$, CHO, CH_2OH, C_6H_5, C_2H_5, CH_3, H, with hydrogen lowest. The molecule is viewed with the group of lowest priority behind the chiral atom. If the clockwise arrangement of the other three groups is in descending priority, the compound belongs to the R-series; if the descending order is anticlockwise it is in the S-series. D-(+)-glyceraldehyde is R-(+)-glyceraldehyde. See illustration.

absolute expansivity *See* EXPANSIVITY.

absolute humidity *See* HUMIDITY.

absolute permittivity *See* PERMITTIVITY.

absolute pitch (perfect pitch) The ability of a person to identify and reproduce a note without reference to a tuned musical instrument.

absolute temperature *See* ABSOLUTE; TEMPERATURE.

absolute value (modulus) The square root of the sum of the squares of the real numbers in a *complex number, i.e. the absolute value of the complex number $z = x + iy$ is $|z| = \sqrt{(x^2 + y^2)}$.

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absolute zero Zero of thermodynamic *temperature (0 kelvin) and the lowest temperature theoretically attainable. It is the temperature at which the kinetic energy of atoms and molecules is minimal. It is equivalent to –273.15°C or –459.67°F. *See also* ZERO-POINT ENERGY; CRYOGENICS.

absorbed dose *See* DOSE.

absorptance Symbol α. The ratio of the radiant or luminous flux absorbed by a body to the flux falling on it. Formerly called **absorptivity**, the absorptance of a *black body is by definition 1.

absorption **1.** (in chemistry) The take up of a gas by a solid or liquid, or the take up of a liquid by a solid. Absorption differs from *adsorption in that the absorbed substance permeates the bulk of the absorbing substance. **2.** (in physics) The conversion of the energy of electromagnetic radiation, sound, streams of particles, etc., into other forms of energy on passing through a medium. A beam of light, for instance, passing through a medium, may lose intensity because of two effects: *scattering of light out of the beam, and absorption of photons by atoms or molecules in the medium. When a photon is absorbed, there is a transition to an excited state. **3.** (in biology) The movement of fluid or a dissolved substance across a plasma membrane. In many animals, for example, soluble food material is absorbed into cells lining the alimentary canal and thence into the blood. In plants, water and mineral salts are absorbed from the soil by the *roots. *See* OSMOSIS; TRANSPORT PROTEIN.

absorption coefficient **1.** (in physics) *See* LAMBERT'S LAWS. **2.** (in chemistry) The volume of a given gas, measured at standard temperature and pressure, that will dissolve in unit volume of a given liquid.

absorption indicator *See* ADSORPTION INDICATOR.

absorption spectrum *See* SPECTRUM.

absorptivity *See* ABSORPTANCE.

ABS plastic Any of a class of plastics based on acrylonitrile–butadiene–styrene copolymers.

abundance **1.** The ratio of the total mass of a specified element in the earth's crust to the total mass of the earth's crust, often expressed as a percentage. For example, the abundance of aluminium in the earth's crust is about 8%. **2.** The ratio of the number of atoms of a particular isotope of an element to the total number of atoms of all the isotopes present, often expressed as a percentage. For example, the abundance of uranium–235 in natural uranium is 0.71%. This is the **natural abundance**, i.e. the abundance as found in nature before any enrichment has taken place.

abyssal zone The lower depths of the ocean (below approximately 2000 metres), where there is effectively no light penetration. Abyssal organisms are adapted for living under high pressures in cold dark conditions. *See also* APHOTIC ZONE.

a.c. *See* ALTERNATING CURRENT.

acceleration Symbol a. The rate of increase of speed or velocity. It is measured in m s^{-2}. For a body moving linearly with constant acceleration a from a speed u to a speed v,

$$a = (v - u)/t = (v^2 - u^2)/2s$$

where t is the time taken and s the distance covered.

If the acceleration is not constant it is given by $dv/dt = d^2s/dt^2$. If the motion is not linear the vector character of displacement, velocity, and acceleration must be considered. *See also* ROTATIONAL MOTION.

acceleration of free fall Symbol g. The acceleration experienced by any massive object falling freely in the earth's gravitational field. Experimentally this is almost constant for all positions near the earth's surface, independent of the nature of the falling body (provided air resistance is eliminated). This is taken to indicate the strict proportionality of *weight (the force causing the acceleration) and *inertial mass, on the basis of *Newton's second law of motion. There is some variation of g with latitude, because of the earth's rotation and because the earth is not completely spherical. The standard value is taken as 9.806 65 m s^{-2}. The acceleration of free fall is also called the **acceleration due to gravity**.

accelerator **1.** (in physics) An apparatus for increasing the kinetic energies of charged particles, used for research in nuclear and particle physics. *See* CYCLOTRON; LINEAR ACCELERATOR; SYNCHROCYCLOTRON; SYNCHROTRON. **2.** (in chemistry) A substance that increases the rate of a chemical reaction, i.e. a catalyst.

acceptor **1.** (in chemistry and biochemistry) A compound, molecule, ion, etc., to which electrons are donated in the formation of a coordinate bond. **2.** (in biochemistry) A *receptor that binds a hormone without any apparent biological response. **3.** (in physics) A substance that is added as an impurity to a *semiconductor because of its ability to accept electrons from the valence bands, causing *p*-type conduction by the mobile positive holes left. *Compare* DONOR.

acceptor levels Energy levels of an acceptor atom in a *semiconductor, such as aluminium, in silicon. These energy levels are very near the top of the valence band, and therefore cause *p*-type conduction. *See also* ENERGY BAND.

acclimation The physiological changes occurring in an organism in response to a change in a particular environmental factor (e.g. temperature), especially under laboratory conditions. Thermal acclimation studies reveal how such properties as metabolic rate, muscle contractility, nerve conduction, and heart rate differ between cold- and warm-acclimated members of the same species. These changes occur naturally during *acclimatization and equip the organism for living in, say, cold or warm conditions.

acclimatization **1.** The progressive adaptation of an organism to any change in its natural environment that subjects it to physiological stress. **2.** The overall sum of processes by which an organism attempts to compensate for conditions that would substantially reduce the amount of oxygen delivered to its cells. *Compare* ACCLIMATION.

accommodation **1.** (in animal physiology) Focusing: the process by which the focal length of the *lens of the eye is changed so that clear images of objects at a range of distances are displayed on the retina. In humans and some other mammals accommodation is achieved by reflex adjustments in the shape of the lens brought about by relaxation and contraction of muscles within the *ciliary body. **2.** (in animal behaviour) Adjustments made by an animal's nervous or sensory systems in response to continuously changing environmental conditions.

accretion The way in which collisions with relatively slow-moving smaller objects add to the mass of a larger celestial object. The process accelerates as the increased mass strengthens the gravitational field of the larger object. For example, the planets are thought to have formed by the accretion of dust particles onto *planetesimals. Other accreting objects probably include black holes and protostars.

accretion disc A disc-shaped rotating mass formed by gravitational attraction. *See* BLACK HOLE; NEUTRON STAR; WHITE DWARF.

accumulator (secondary cell; storage battery) A type of *voltaic cell or battery that can be recharged by passing a current through it from an external d.c. supply. The charging current, which is passed in the opposite direction to that in which the cell supplies current, reverses the chemical reactions in the cell. The common types are the *lead–acid accumulator and the *nickel–iron and nickel–cadmium accumulators. *See also* SODIUM–SULPHUR CELL.

acellular Describing tissues or organisms that are not made up of separate cells but often have more than one nucleus (*see* SYNCYTIUM). Examples of acellular structures are muscle fibres. *Compare* UNICELLULAR.

acentric Describing an aberrant chromosome fragment that lacks a centromere. Such fragments are normally lost because they are unable to orientate properly during cell division.

acetaldehyde *See* ETHANAL.

acetaldol *See* ALDOL REACTION.

acetals Organic compounds formed by addition of alcohol molecules to aldehyde molecules. If one molecule of aldehyde

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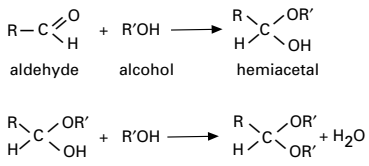
(RCHO) reacts with one molecule of alcohol (R′OH) a **hemiacetal** is formed (RCH(OH)OR′). The rings of aldose sugars are hemiacetals. Further reaction with a second alcohol molecule produces a full acetal ($RCH(OR')_2$). It is common to refer to both types of compounds simply as 'acetals'. The formation of acetals is reversible; acetals can be hydrolysed back to aldehydes in acidic solutions. In synthetic organic chemistry aldehyde groups are often converted into acetal groups to protect them before performing other reactions on different groups in the molecule. *See also* KETALS.



Formation of acetals

acetamide *See* ETHANAMIDE.

acetanilide A white crystalline primary amide of ethanoic acid, $CH_3CONHC_6H_5$; r.d. 1.2; m.p. 114.3°C; b.p. 304°C. It is made by reacting phenylamine (aniline) with excess ethanoic acid or ethanoic anhydride and is used in the manufacture of dyestuffs and rubber. The full systematic name is **N-phenylethanamide**.

acetate *See* ETHANOATE.

acetate process *See* RAYON.

acetic acid *See* ETHANOIC ACID.

acetoacetic acid *See* 3-OXOBUTANOIC ACID.

acetoacetic ester *See* ETHYL 3-OXOBUTANOATE.

acetone *See* PROPANONE; KETONE BODY.

acetylation *See* ACYLATION.

acetyl chloride *See* ETHANOYL CHLORIDE.

acetylcholine (ACh) One of the main *neurotransmitters of the vertebrate nervous system. It is released at some (**cholinergic**) nerve endings and may be excitatory or inhibitory; it initiates muscular contraction at *neuromuscular junctions. Once acetylcholine has been released it has only a transitory effect because it is rapidly broken down by the enzyme *cholinesterase.

acetylcholinesterase *See* CHOLINESTERASE.

acetyl coenzyme A (acetyl CoA) A compound formed in the mitochondria when an acetyl group (CH_3CO–), derived from the breakdown of fats, proteins, or carbohydrates (via *glycolysis), combines with the thiol group (–SH) of *coenzyme A. Acetyl CoA feeds into the energy generating *Krebs cycle and also plays a role in the synthesis and oxidation of fatty acids.

acetylene *See* ETHYNE.

acetylenes *See* ALKYNES.

acetyl group *See* ETHANOYL GROUP.

acetylide *See* CARBIDE.

achene A dry indehiscent fruit formed from a single carpel and containing a single seed. An example is the feathery achene of clematis. Variants of the achene include the *caryopsis, *cypsela, *nut, and *samara. *See also* ETAERIO.

Acheson process An industrial process for the manufacture of graphite by heating coke mixed with clay. The reaction involves the production of silicon carbide, which loses silicon at 4150°C to leave graphite. The process was patented in 1896 by the US inventor Edward Goodrich Acheson (1856–1931).

achondrite A stony meteorite that has no spherical silicate particles (chondrules) found in the meteorites called chondrites. Achondrites do not contain iron or nickel and have a coarser crystal structure than chondrites.

achromatic lens A lens that corrects for chromatic *aberration by using a combination of two lenses, made of different kinds of glass, such that their *dispersions neutralize each other although their *refractions do not. The aberration can be reduced further by using an **apochromatic lens**, which consists of three or more different kinds of glass.

acid 1. A type of compound that con-

tains hydrogen and dissociates in water to produce positive hydrogen ions. The reaction, for an acid HX, is commonly written:

$$HX \rightleftharpoons H^+ + X^-$$

In fact, the hydrogen ion (the proton) is solvated, and the complete reaction is:

$$HX + H_2O \rightleftharpoons H_3O^+ + X^-$$

The ion H_3O^+ is the **oxonium ion** (or **hydroxonium ion** or **hydronium ion**). This definition of acids comes from the **Arrhenius theory**. Such acids tend to be corrosive substances with a sharp taste, which turn litmus red and give colour changes with other *indicators. They are referred to as **protonic acids** and are classified into **strong acids**, which are almost completely dissociated in water (e.g. sulphuric acid and hydrochloric acid), and **weak acids**, which are only partially dissociated (e.g. ethanoic acid and hydrogen sulphide). The strength of an acid depends on the extent to which it dissociates, and is measured by its *dissociation constant. *See also* BASE.

2. In the **Lowry–Brønsted theory** of acids and bases (1923), the definition was extended to one in which an acid is a proton donor, and a base is a proton acceptor. For example, in

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

the HCN is an acid, in that it donates a proton to H_2O. The H_2O is acting as a base in accepting a proton. Similarly, in the reverse reaction H_3O^+ is an acid and CN^- a base. In such reactions, two species related by loss or gain of a proton are said to be **conjugate**. Thus, in the reaction above HCN is the **conjugate acid** of the base CN^-, and CN^- is the **conjugate base** of the acid HCN. Similarly, H_3O^+ is the conjugate acid of the base H_2O. An equilibrium, such as that above, is a competition for protons between an acid and its conjugate base. A strong acid has a weak conjugate base, and vice versa. Under this definition water can act as both acid and base. Thus in

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

the H_2O is the conjugate acid of OH^-. The definition also extends the idea of acid–base reaction to solvents other than water. For instance, liquid ammonia, like water, has a high dielectric constant and is a good ionizing solvent. Equilibria of the type

$$NH_3 + Na^+Cl^- \rightleftharpoons Na^+NH_2^- + HCl$$

can be studied, in which NH_3 and HCl are acids and NH_2^- and Cl^- are their conjugate bases.

3. A further extension of the idea of acids and bases was made in the **Lewis theory** (G. N. Lewis, 1923). In this, a **Lewis acid** is a compound or atom that can accept a pair of electrons and a **Lewis base** is one that can donate an electron pair. This definition encompasses 'traditional' acid–base reactions. In

$$HCl + NaOH \rightarrow NaCl + H_2O$$

the reaction is essentially

$$H^+ + :OH^- \rightarrow H:OH$$

i.e. donation of an electron pair by OH^-. But it also includes reactions that do not involve ions, e.g.

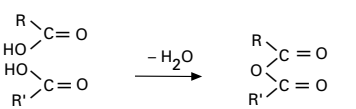
$$H_3N: + BCl_3 \rightarrow H_3NBCl_3$$

in which NH_3 is the base (donor) and BCl_3 the acid (acceptor). The Lewis theory establishes a relationship between acid–base reactions and *oxidation–reduction reactions. *See also* AQUA ACID; HYDROXOACID; OXOACID.

acid anhydrides (acyl anhydrides) Compounds that react with water to form an acid. For example, carbon dioxide reacts with water to give carbonic acid:

$$CO_2(g) + H_2O(aq) \rightleftharpoons H_2CO_3(aq)$$

A particular group of acid anhydrides are anhydrides of carboxylic acids. They have a general formula of the type R.CO.O.CO.R′, where R and R′ are alkyl or aryl groups. For example, the compound ethanoic anhydride ($CH_3.CO.O.CO.CH_3$) is the acid anhydride of ethanoic (acetic) acid. Organic acid anhydrides can be produced by dehydrating acids (or mixtures of acids). They are usually made by react-



carboxylic acids acid anhydride

Formation of a carboxylic acid anhydride

ing an acyl halide with the sodium salt of the acid. They react readily with water, alcohols, phenols, and amines and are used in *acylation reactions.

acid–base balance The regulation of the concentrations of acids and bases in blood and other body fluids so that the pH remains within a physiologically acceptable range. This is achieved by the presence of natural *buffer systems, such as the haemoglobin, hydrogencarbonate ions, and carbonic acid in mammalian blood. By acting in conjunction, these effectively mop up excess acids and bases and therefore prevent any large shifts in blood pH. The acid–base balance is also influenced by the selective removal of certain ions by the kidneys and the rate of removal of carbon dioxide from the lungs.

acid–base indicator *See* INDICATOR.

acid dissociation constant *See* DISSOCIATION.

acid dye *See* DYES.

acid halides *See* ACYL HALIDES.

acidic **1.** Describing a compound that is an acid. **2.** Describing a solution that has an excess of hydrogen ions. **3.** Describing a compound that forms an acid when dissolved in water. Carbon dioxide, for example, is an acidic oxide.

acidic hydrogen (acid hydrogen) A hydrogen atom in an *acid that forms a positive ion when the acid dissociates. For instance, in methanoic acid

$$HCOOH \rightleftharpoons H^+ + HCOO^-$$

the hydrogen atom on the carboxylate group is the acidic hydrogen (the one bound directly to the carbon atom does not dissociate).

acidic stains *See* STAINING.

acidimetry Volumetric analysis using standard solutions of acids to determine the amount of base present.

acidity constant *See* DISSOCIATION.

acid rain Precipitation having a pH value of less than about 5.0, which has adverse effects on the fauna and flora on which it falls. Rainwater typically has a pH value of 5.6, due to the presence of dissolved carbon dioxide (forming carbonic acid). Acid rain results from the emission into the atmosphere of various pollutant gases, in particular sulphur dioxide and various oxides of nitrogen, which originate from the burning of fossil fuels and from car exhaust fumes, respectively. These gases dissolve in atmospheric water to form sulphuric and nitric acids in rain, snow, or hail (**wet deposition**). Alternatively, the pollutants are deposited as gases or minute particles (**dry deposition**). Both types of acid deposition affect plant growth – by damaging the leaves and impairing photosynthesis and by increasing the acidity of the soil, which results in the leaching of essential nutrients. This acid pollution of the soil also leads to acidification of water draining from the soil into lakes and rivers, which become unable to support fish life. Lichens are particularly sensitive to changes in pH and can be used as indicators of acid pollution (*see* INDICATOR SPECIES).

acid rock A low-density igneous rock containing a preponderance (more than 65%) of light-coloured *silicate minerals. Examples include granite and rhyolite.

acid salt A salt of a polybasic acid (i.e. an acid having two or more acidic hydrogens) in which not all the hydrogen atoms have been replaced by positive ions. For example, the dibasic acid carbonic acid (H_2CO_3) forms acid salts (hydrogencarbonates) containing the ion HCO_3^-. Some salts of monobasic acids are also known as acid salts. For instance, the compound potassium hydrogendifluoride, KHF_2, contains the ion $[F...H–F]^-$, in which there is hydrogen bonding between the fluoride ion F^- and a hydrogen fluoride molecule.

acid value A measure of the amount of free acid present in a fat, equal to the number of milligrams of potassium hydroxide needed to neutralize this acid. Fresh fats contain glycerides of fatty acids and very little free acid, but the glycerides decompose slowly with time and the acid value increases.

acinus The smallest unit of a multilobular gland, such as the pancreas. Each acinus in the pancreas is made up of a hollow cluster of **acinar cells**, which produce the digestive enzymes secreted in pancreatic juice. Minute ducts from the

pancreatic acini eventually drain into the pancreatic duct.

acoustics **1.** The study of sound and sound waves. **2.** The characteristics of a building, especially an auditorium, with regard to its ability to enable speech and music to be heard clearly within it. For this purpose there should be no obtrusive echoes or resonances and the reverberation time should be near the optimum for the hall. Echoes are reduced by avoiding sweeping curved surfaces that could focus the sound and by breaking up large plane surfaces or covering them with sound-absorbing materials. Resonance is avoided by avoiding simple ratios for the main dimensions of the room, so that no one wavelength of sound is a factor of more than one of them. If the reverberation time is too long, speech will sound indistinct and music will be badly articulated, with one note persisting during the next. However, if it is too short, music sounds dead. It is long in a bare room with hard walls, and can be deliberately reduced by carpets, soft furnishings and sound-absorbent ('acoustic') felt. Reverberation times tend to be reduced by the presence of an audience and this must be taken into account in the design of the building.

acoustoelectronic devices (electro-acoustic devices) Devices in which electronic signals are converted into acoustic waves. Acoustoelectronic devices are used in constructing *delay lines and also in converting digital data from computers for transmission by telephone lines.

acquired characteristics Features that are developed during the lifetime of an individual, e.g. the enlarged arm muscles of a tennis player. Such characteristics are not genetically controlled and cannot be passed on to the next generation. *See also* LAMARCKISM; NEO-LAMARCKISM.

acquired immune deficiency syndrome *See* AIDS.

Acrilan A trade name for a synthetic fibre. *See* ACRYLIC RESINS.

acrolein *See* PROPENAL.

acromegaly A chronic condition developing in adulthood due to overproduction of (or oversensitivity to) *growth hormone, usually caused by a tumour in the pituitary gland. This leads to a gradual enlargement of the bones, causing characteristic coarsening of the facial features and large hands and feet.

acrosome *See* SPERMATOZOON.

acrylamide An inert gel (polyacrylamide) employed as a medium in *electrophoresis. It is used particularly in the separation of macromolecules, such as nucleic acids and proteins.

acrylate *See* PROPENOATE.

acrylic acid *See* PROPENOIC ACID.

acrylic resins Synthetic resins made by polymerizing esters or other derivatives of acrylic acid (propenoic acid). Examples are poly(propenonitrile) (e.g. **Acrilan**), and poly(methyl 2-methylpropenoate) (polymethylmethacrylate, e.g. **Perspex**).

acrylonitrile *See* PROPENONITRILE.

ACTH (adrenocorticotrophic hormone; corticotrophin) A hormone, produced by the anterior *pituitary gland, that controls secretion of certain hormones (the *corticosteroids) by the adrenal glands. Its secretion, which is controlled by corticotrophin-releasing hormone and occurs in short bursts every few hours, is increased by stress.

actin A contractile protein found in muscle tissue, in which it occurs in the form of filaments (called thin filaments). Each thin filament consists of two chains of globular actin molecules, around which is twisted a strand of *tropomyosin and interspersed *troponin. Units of muscle fibre (*see* SARCOMERE) consist of actin and *myosin filaments, which interact to bring about muscle contraction. Actin is also found in the microfilaments that form part of the *cytoskeleton of all cells.

actinic radiation Electromagnetic radiation that is capable of initiating a chemical reaction. The term is used especially of ultraviolet radiation and also to denote radiation that will affect a photographic emulsion.

actinides *See* ACTINOIDS.

actinium Symbol Ac. A silvery radioactive metallic element belonging to

group 3 (formerly IIIA) of the periodic table; a.n. 89; mass number of most stable isotope 227 (half-life 21.7 years); m.p. 1050 ± 50°C; b.p. 3200°C (estimated). Actinium–227 occurs in natural uranium to an extent of about 0.715%. Actinium–228 (half-life 6.13 hours) also occurs in nature. There are 22 other artificial isotopes, all radioactive and all with very short half-lives. Its chemistry is similar to that of lanthanum. Its main use is as a source of alpha particles. The element was discovered by A. Debierne in 1899.

actinium series *See* RADIOACTIVE SERIES.

Actinobacteria (Actinomycetes; Actinomycota) A phylum of Gram-positive mostly anaerobic nonmotile bacteria. Many species are fungus-like, with filamentous cells producing reproductive spores on aerial branches similar to the spores of certain moulds. The phylum includes bacteria of the genera *Actinomyces*, some species of which cause disease in animals (including humans); and *Streptomyces*, which are a source of many important antibiotics (including streptomycin).

actinoid contraction A smooth decrease in atomic or ionic radius with increasing proton number found in the *actinoids.

actinoids (actinides) A series of elements in the *periodic table, generally considered to range in atomic number from thorium (90) to lawrencium (103) inclusive. The actinoids all have two outer *s*-electrons (a $7s^2$ configuration), follow actinium, and are classified together by the fact that increasing proton number corresponds to filling of the 5*f* level. In fact, because the 5*f* and 6*d* levels are close in energy the filling of the 5*f* orbitals is not smooth. The outer electron configurations are as follows:
89 actinium (Ac) $6d^17s^2$
90 thorium (Th) $6d^27s^2$
91 protactinium (Pa) $5f^26d^17s^2$
92 uranium (Ur) $5f^36d7s^2$
93 neptunium (Np) $5f^57s^2$ (or $5f^46d^17s^2$)
94 plutonium (Pu) $5f^67s^2$
95 americium (Am) $5f^77s^2$
96 curium (Cm) $5f^76d^1s^2$
97 berkelium (Bk) $5f^86d7s^2$ (or $5f^97s^2$)
98 californium (Cf) $5f^{10}7s^2$
99 einsteinium (Es) $5f^{11}7s^2$
100 fermium (Fm) $5f^{12}7s^2$
101 mendelevium (Md) $5f^{13}7s^2$
102 nobelium (Nb) $5f^{14}7s^2$
103 lawrencium (Lw) $5f^{14}6d^1s^2$

The first four members (Ac to Ur) occur naturally. All are radioactive and this makes investigation difficult because of self-heating, short lifetimes, safety precautions, etc. Like the *lanthanoids, the actinoids show a smooth decrease in atomic and ionic radius with increasing proton number. The lighter members of the series (up to americium) have *f*-electrons that can participate in bonding, unlike the lanthanoids. Consequently, these elements resemble the transition metals in forming coordination complexes and displaying variable valency. As a result of increased nuclear charge, the heavier members (curium to lawrencium) tend not to use their inner *f*-electrons in forming bonds and resemble the lanthanoids in forming compounds containing the M^{3+} ion. The reason for this is pulling of these inner electrons towards the centre of the atom by the increased nuclear charge. Note that actinium itself does not have a 5*f* electron, but it is usually classified with the actinoids because of its chemical similarities. *See also* TRANSITION ELEMENTS.

actinometer Any of various instruments for measuring the intensity of electromagnetic radiation. Recent actinometers use the *photoelectric effect but earlier instruments depended either on the fluorescence produced by the radiation on a screen or on the amount of chemical change induced in some suitable substance.

actinomorphy *See* RADIAL SYMMETRY.

Actinomycetes *See* ACTINOBACTERIA.

action at a distance The direct interaction between bodies that are not in physical contact with each other. The concept involves the assumption that the interactions are instantaneous. This assumption is not consistent with the special theory of *relativity, which states that nothing (including interactions) can travel through space faster than the *speed of light in a vacuum. For this reason it is more logical to describe interactions be-

tween bodies by *quantum field theories or by the exchange of virtual particles (*see* VIRTUAL STATE) rather than theories based on action at a distance.

action potential The change in electrical potential that occurs across a plasma membrane during the passage of a nerve *impulse. As an impulse travels in a wavelike manner along the *axon of a nerve, it causes a localized and transient switch in electric potential across the membrane from –60 mV (millivolts; the *resting potential) to +45 mV. The change in electric potential is caused by an influx of sodium ions. Nervous stimulation of a muscle fibre has a similar effect.

action spectrum A graphical plot of the efficiency of electromagnetic radiation in producing a photochemical reaction against the wavelength of the radiation used. For example, the action spectrum for photosynthesis using light shows a peak in the region 670–700 nm. This corresponds to a maximum absorption in the absorption *spectrum of chlorophylls in this region.

activated adsorption Adsorption that involves an activation energy. This occurs in certain cases of chemisorption.

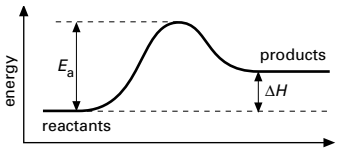
activated alumina *See* ALUMINIUM HYDROXIDE.

activated charcoal *See* CHARCOAL.

activated complex The association of atoms of highest energy formed in the *transition state of a chemical reaction.

activation analysis An analytical technique that can be used to detect most elements when present in a sample in milligram quantities (or less). In **neutron activation analysis** the sample is exposed to a flux of thermal neutrons in a nuclear reactor. Some of these neutrons are captured by nuclides in the sample to form nuclides of the same atomic number but a higher mass number. These newly formed nuclides emit gamma radiation, which can be used to identify the element present by means of a gamma-ray spectrometer. Activation analysis has also been employed using high-energy charged particles, such as protons or alpha particles.

activation energy Symbol E_a. The minimum energy required for a chemical reaction to take place. In a reaction, the reactant molecules come together and chemical bonds are stretched, broken, and formed in producing the products. During this process the energy of the system increases to a maximum, then decreases to the energy of the products (see illustration). The activation energy is the difference between the maximum energy and the energy of the reactants; i.e. it is the energy barrier that has to be overcome for the reaction to proceed. The activation energy determines the way in which the rate of the reaction varies with temperature (*see* ARRHENIUS EQUATION). It is usual to express activation energies in joules per mole of reactants.



Reaction profile (for an endothermic reaction)

activator **1.** A type of *transcription factor that enhances the transcription of a gene by binding to a region of DNA called an **enhancer**. *Compare* REPRESSOR. **2.** A substance that – by binding to an allosteric site on an enzyme (*see* INHIBITION) – enables the active site of the enzyme to bind to the substrate. **3.** Any compound that potentiates the activity of a drug or other foreign substance in the body.

active device **1.** An electronic component, such as a transistor, that is capable of amplification. **2.** An artificial *satellite that receives information and retransmits it after amplification. **3.** A radar device that emits microwave radiation and provides information about a distant body by receiving a reflection of this radiation. *Compare* PASSIVE DEVICE.

active immunity *Immunity acquired due to the body's response to a foreign antigen.

active mass *See* MASS ACTION.

active site **(active centre)** **1.** A site on the surface of a catalyst at which activity occurs. **2.** The site on the surface of an

a

*enzyme molecule that binds and acts on the substrate molecule. The properties of an active site are determined by the three-dimensional arrangement of the polypeptide chains of the enzyme and their constituent amino acids. These govern the nature of the interaction that takes place and hence the degree of substrate specificity and susceptibility to *inhibition.

active transport The movement of substances through membranes in living cells, often against a *concentration gradient: a process requiring metabolic energy. Organic molecules and inorganic ions are transported into and out of both cells and their organelles. The substance binds to a *transport protein embedded in the membrane, which carries it through the membrane and releases it on the opposite side. Active transport serves chiefly to maintain the normal balance of ions in cells, especially the concentration gradients of sodium and potassium ions crucial to the activity of nerve and muscle cells. *Compare* FACILITATED DIFFUSION.

activity **1.** Symbol *a*. A thermodynamic function used in place of concentration in equilibrium constants for reactions involving nonideal gases and solutions. For example, in a reaction

$$A \rightleftharpoons B + C$$

the true equilibrium constant is given by

$$K = a_B a_C / a_A$$

where a_A, a_B, and a_C are the activities of the components, which function as concentrations (or pressures) corrected for nonideal behaviour. **Activity coefficients** (symbol γ) are defined for gases by $\gamma = a/p$ (where p is pressure) and for solutions by $\gamma = aX$ (where X is the mole fraction). Thus, the equilibrium constant of a gas reaction has the form

$$K_p = \gamma_B p_B \gamma_C p_C / \gamma_A p_A$$

The equilibrium constant of a reaction in solution is

$$K_c = \gamma_B X_B \gamma_C X_C / \gamma_A X_A$$

The activity coefficients thus act as correction factors for the pressures or concentrations. *See also* FUGACITY.
2. Symbol *A*. The number of atoms of a radioactive substance that disintegrate per unit time. The **specific activity** (*a*) is the activity per unit mass of a pure radioisotope. *See* RADIATION UNITS.

activity series *See* ELECTROMOTIVE SERIES.

acyclic Describing a compound that does not have a ring in its molecules.

acyclovir (acycloguanosine) A drug used to treat cold sores, shingles, genital blisters, or other lesions caused by herpesvirus infection. It is an analogue of the base guanine and acts by interfering with DNA replication of the virus.

acyl anhydrides *See* ACID ANHYDRIDES.

acylation The process of introducing an acyl group (RCO–) into a compound. The usual method is to react an alcohol with an acyl halide or a carboxylic acid anhydride; e.g.

$$RCOCl + R'OH \rightarrow RCOOR' + HCl$$

The introduction of an acetyl group (CH_3CO–) is **acetylation**, a process used for protecting –OH groups in organic synthesis.

acyl fission The breaking of the carbon–oxygen bond in an acyl group. It occurs in the hydrolysis of an *ester to produce an alcohol and a carboxylic acid.

acylglycerol *See* GLYCERIDE.

acyl group A group of the type RCO–, where R is an organic group. An example is the acetyl group CH_3CO–.

acyl halides (acid halides) Organic compounds containing the group –CO.X, where X is a halogen atom (see formula). Acyl chlorides, for instance, have the general formula RCOCl. The group RCO– is the **acyl group**. In systematic chemical nomenclature acyl-halide names end in the suffix *-oyl*; for example, ethanoyl chloride, CH_3COCl. Acyl halides react readily with water, alcohols, phenols, and amines and are used in *acylation reactions. They are made by replacing the –OH group in a carboxylic acid by a halogen using a halogenating agent such as PCl_5.

Acyl halide: X is a halogen atom

Ada A high-level computer programming language developed in the late 1970s for the US military. It was originally employed in missile control systems and is now used in various other real-time applications. Ada was named after Augusta Ada Lovelace (1815–52), the mathematician daughter of Lord Byron, who worked with Charles *Babbage on his mechanical computer, the 'analytical engine'.

Adams, John Couch (1819–92) British astronomer who became professor of astronomy and geometry at Cambridge University in 1858. He is best known for his prediction (1845) of the existence and position of the planet *Neptune, worked out independently the following year by Urbain Leverrier (1811–77). The planet was discovered in 1846 by Johann Galle (1812–1910), using Leverrier's figures. Adams's priority was not acknowledged.

adaptation **1.** (in evolution) Any change in the structure or functioning of an organism that makes it better suited to its environment. *Natural selection of inheritable adaptations ultimately leads to the development of new species. Increasing adaptation of a species to a particular environment tends to diminish its ability to adapt to any sudden change in that environment. **2.** (in physiology) The alteration in the degree of sensitivity (either an increase or a decrease) of a sense organ to suit conditions more extreme than normally encountered. An example is the adjustment of the eye to vision in very bright or very dim light.

adaptive radiation (divergent evolution) The evolution from one species of animals or plants of a number of different forms. As the original population increases in size it spreads out from its centre of origin to exploit new habitats and food sources. In time this results in a number of populations each adapted to its particular habitat: eventually these populations will differ from each other sufficiently to become new species. A good example of this process is the evolution of the Australian marsupials into species adapted as carnivores, herbivores, burrowers, fliers, etc. On a smaller scale, the adaptive radiation of the Galapagos finches provided Darwin with crucial evidence for his theory of evolution (*see* DARWIN'S FINCHES).

addition polymerization *See* POLYMERIZATION.

addition reaction A chemical reaction in which one molecule adds to another. Addition reactions occur with unsaturated compounds containing double or triple bonds, and may be *electrophilic or *nucleophilic. An example of electrophilic addition is the reaction of hydrogen chloride with an alkene, e.g.

$$HCl + CH_2{:}CH_2 \rightarrow CH_3CH_2Cl$$

An example of nucleophilic addition is the addition of hydrogen cyanide across the carbonyl bond in aldehydes to form *cyanohydrins. **Addition–elimination** reactions are ones in which the addition is followed by elimination of another molecule (*see* CONDENSATION REACTION).

additive A substance added to another substance or material to improve its properties in some way. Additives are often present in small amounts and are used for a variety of purposes, as in preventing corrosion, stabilizing polymers, etc. **Food additives** are used to enhance the taste and colour of foods and improve their texture and keeping qualities. *See* FOOD PRESERVATION.

additive process *See* COLOUR.

adduct A compound formed by an addition reaction. The term is used particularly for compounds formed by coordination between a Lewis acid (acceptor) and a Lewis base (donor). *See* ACID.

adenine A *purine derivative. It is one of the major component bases of *nucleotides and the nucleic acids *DNA and *RNA.

adenosine A nucleoside comprising one adenine molecule linked to a D-ribose sugar molecule. The phosphate-ester derivatives of adenosine, AMP, ADP, and *ATP, are of fundamental biological importance as carriers of chemical energy.

adenosine diphosphate (ADP) *See* ATP.

adenosine monophosphate (AMP) *See* ATP.

adenosine triphosphate *See* ATP.

a

adenovirus One of a group of DNA-containing viruses found in rodents, fowl, cattle, monkeys, and humans. In humans they produce acute respiratory-tract infections with symptoms resembling those of the common cold. They are also implicated in the formation of tumours (*see* ONCOGENIC).

adenylate cyclase The enzyme that catalyses the formation of *cyclic AMP. It is bound to the inner surface of the plasma membrane. Many hormones and other chemical messengers exert their physiological effects by increased synthesis of cyclic AMP through the activation of adenylate cyclase. The hormone binds to a receptor on the outer surface of the plasma membrane, which then activates adenylate cyclase on the inner surface via *G protein.

ADH *See* ANTIDIURETIC HORMONE.

adhesive A substance used for joining surfaces together. Adhesives are generally colloidal solutions, which set to gels. There are many types including animal glues (based on collagen), vegetable mucilages, and synthetic resins (e.g. *epoxy resins).

adiabatic approximation An approximation used in *quantum mechanics when the time dependence of parameters such as the inter-nuclear distance between atoms in a molecule is slowly varying. This approximation means that the solution of the *Schrödinger equation at one time goes continuously over to the solution at a later time. This approximation was formulated by Max Born and the Soviet physicist Vladimir Alexandrovich Fock (1898–1974) in 1928. The *Born–Oppenheimer approximation is an example of the adiabatic approximation.

adiabatic demagnetization A technique for cooling a paramagnetic salt, such as potassium chrome alum, to a temperature near *absolute zero. The salt is placed between the poles of an electromagnet and the heat produced during magnetization is removed by liquid helium. The salt is then isolated thermally from the surroundings and the field is switched off; the salt is demagnetized adiabatically and its temperature falls. This is because the demagnetized state, being less ordered, involves more energy than the magnetized state. The extra energy can come only from the internal, or thermal, energy of the substance. It is possible to obtain temperatures as low as 0.005 K in this way.

adiabatic process Any process that occurs without heat entering or leaving a system. In general, an adiabatic change involves a fall or rise in temperature of the system. For example, if a gas expands under adiabatic conditions, its temperature falls (work is done against the retreating walls of the container). The **adiabatic equation** describes the relationship between the pressure (p) of an ideal gas and its volume (V), i.e. $pV^{\gamma} = K$, where γ is the ratio of the principal specific *heat capacities of the gas and K is a constant.

adipic acid *See* HEXANEDIOIC ACID.

adipose tissue A body tissue comprising cells containing *fat and oil. It is found chiefly below the skin (*see* SUBCUTANEOUS TISSUE) and around major organs (such as the kidneys and heart), acting as an energy reserve, providing insulation and protection, and generating heat. *See* BROWN FAT; THERMOGENESIS.

admittance Symbol Y. The reciprocal of *impedance. It is measured in siemens.

adolescence The period in human development that occurs during the teenage years, between the end of childhood and the start of adulthood, and is characterized by various physical and emotional changes associated with development of the reproductive system. It starts at **puberty**, when the reproductive organs begin to function, and is marked by the start of menstruation (*see* MENSTRUAL CYCLE) in females and the appearance of the *secondary sexual characteristics in both sexes. In males the secondary sexual characteristics are controlled by the hormone testosterone and include deepening of the voice due to larynx enlargement, the appearance of facial and pubic hair, rapid growth of the skeleton and muscle, and an increase in *sebaceous gland secretions. In females the secondary sexual characteristics are controlled by oestrogens and include growth of the breasts,

broadening of the pelvis, redistribution of fat in the body, and appearance of pubic hair.

ADP *See* ATP.

adrenal cortex The outer layer of the *adrenal gland, in which several steroid hormones, the *corticosteroids, are produced.

adrenal glands A pair of endocrine glands situated immediately above the kidneys (hence they are also known as the **suprarenal glands**). The inner portion of the adrenals, the **medulla**, secretes the hormones *adrenaline and *noradrenaline; the outer **cortex** secretes small amounts of sex hormones (*androgens and *oestrogens) and various *corticosteroids, which have a wide range of effects on the body. *See also* ACTH.

adrenaline (epinephrine) A hormone, produced by the medulla of the *adrenal glands, that increases heart activity, improves the power and prolongs the action of muscles, and increases the rate and depth of breathing to prepare the body for 'fright, flight, or fight'. At the same time it inhibits digestion and excretion. Similar effects are produced by stimulation of the *sympathetic nervous system. Adrenaline can be administered by injection to relieve bronchial asthma and reduce blood loss during surgery by constricting blood vessels.

adrenal medulla The inner part of the *adrenal gland, in which *adrenaline is produced.

adrenergic **1.** Describing a cell (especially a neuron) or a cell receptor that is stimulated by *adrenaline, *noradrenaline, or related substances. *See* ADRENOCEPTOR. **2.** Describing a nerve fibre or neuron that releases adrenaline or noradrenaline when stimulated. *Compare* CHOLINERGIC.

adrenoceptor (adrenoreceptor; adrenergic receptor) Any cell receptor that binds and is activated by the catecholamines adrenaline or noradrenaline. Adrenoceptors are therefore crucial in mediating the effects of catecholamines as neurotransmitters or hormones. There are two principal types of adrenoceptor, alpha (α) and beta (β). The **alpha adrenoceptors** fall into two main subtypes: α_1-adrenoceptors, which mediate the contraction of smooth muscle and hence cause constriction of blood vessels; and α_2-adrenoceptors, which occur, for example, in presynaptic neurons at certain nerve synapses, where they inhibit release of noradrenaline from the neuron. The **beta adrenoceptors** also have two main subtypes: β_1-adrenoceptors, which stimulate cardiac muscle causing a faster and stronger heartbeat; and β_2-adrenoceptors, which mediate relaxation of smooth muscle in blood vessels, bronchi, the uterus, bladder, and other organs. Activation of β_2-adrenoceptors thus causes widening of the airways (bronchodilation) and blood vessels (vasodilation). *See also* BETA BLOCKER.

adrenocorticotrophic hormone *See* ACTH.

Adrian, Edgar Douglas, Baron (1889–1977) British neurophysiologist, who became a professor at Cambridge in 1937, where he remained until his retirement. He is best known for his work on nerve impulses, establishing that messages are conveyed by changes in the frequency of the impulses. He shared the 1932 Nobel Prize for physiology or medicine with Sir Charles *Sherrington for this work.

ADSL (asymmetric digital subscriber line) A mechanism by which *broadband communication via the Internet can be made available via pre-existing telephone lines, while allowing simultaneous use of the line for normal telephone calls. Data communication via ADSL is asymmetric in that upstream (transmitting) communication is slower than downstream (receiving) communication, typically half as fast. Commonly available downstream data rates in the UK are 512 Kbps, 1 Mbps, and 2 Mbps. Faster rates are available in other countries. ADSL coexists with standard telephone operation on the same line by the use of band separation filters at each telephone socket.

adsorbate A substance that is adsorbed on a surface.

adsorbent A substance on the surface of which a substance is adsorbed.