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OF
BIOTECHNOLOGY**

J. Coombs

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J. Coombs

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MACMILLAN

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A

A Area in mathematical formulae or descriptions. It may be applied to parameters such as the area of a fermenter surface, a heat transfer area in a heat exchanger, area across which diffusion occurs, area of a support medium in chromatography, area of a particle surface or internal pore surface, area of leaf surface in photosynthesis, etc.

ABA See abscisic acid.

abattoir An animal slaughter-house.

abaxial Descriptive of the surface of a leaf or other lateral organ that is furthest from the apex of the axis on which it is borne. Compare adaxial.

abomasum The fourth chamber of a ruminant stomach.

abortive transduction The transfer of bacterial genes into a new host by a viral vector that is not followed by integration of the new genetic material into the genome of the recipient cell. However, the transduced genes may persist for a time in the cell as a plasmid.

abscisic acid (ABA) A plant growth substance associated with leaf senescence, fruit drop, seed and bud dormancy, some aspects of apical dominance and inhibition of flowering in long-day plants under short-day conditions.

absorbance A measure of the extent to which light is attenuated during passage through a coloured liquid or solid.

absorbent A substance used to absorb another.

absorptiometer A device used to measure the absorbance of a sample, usually a

coloured liquid. It consists of a light source, a sample cell and a photomultiplier, or other light-sensitive cell, coupled to a suitable meter or recorder. See spectrophotometer.

absorption spectrum The image recorded when electromagnetic radiation from a source emitting a continuous spectrum is passed through a substance. If the material is in the gaseous phase, bands will appear in the same position as the lines that occur in the characteristic emission spectrum of that substance. In solids or liquids, these bands are broadened and can be used to identify or quantify the material.

acceptor site The active site of an enzyme or a site on an organism, tissue or cell recognized by a biological molecule and with which it reacts in a highly specific manner.

acellular Descriptive of an organism or tissue consisting of a mass of protoplasm that is not divided into cells. An example is the multinucleate hyphae of some fungi.

acentric Descriptive of a chromosome or chromosome fragment that does not possess a centromere.

Acer pseudoplatanus The sycamore tree; a source of heterotrophic and autotrophic plant cell suspension cultures which have been widely used for research purposes.

acesulpham K A synthetic sweetener, similar to saccharin. It is about 150 times sweeter than sucrose.

acetaldehyde An intermediate in the formation of ethanol by glycolysis. It is formed by the decarboxylation of pyruvate in a reaction catalyzed by pyruvate decarboxylase.

2 acetic acid

acetic acid An organic acid; the product of some types of fermentation. It is most familiar as the active principle of vinegar.

acetic acid bacteria Bacteria of the genus *Acetobacter* or *Acetomonas* that characteristically oxidize primary alcohols and aldehydes to the corresponding acids.

acetic anhydride An acid anhydride, the product of a dehydration reaction between two molecules of acetic acid.

Acetobacter A genus of the eubacteria. These bacteria are gram-negative rods with a highly aerobic metabolism and are used in the production of acetic acid (vinegar). They are also involved in beer contamination and wine spoilage.

acetoclastic bacteria Organisms that form methane, exclusively from acetic acid in anaerobic digestion. They show very low growth rates, with doubling times of several days, and often represent the rate-limiting step in biogas production.

acetogenic bacteria Organisms that ferment fatty acids, notably propionic and butyric acids, to acetic acid. They are only able to grow in the absence of hydrogen.

acetone An important industrial solvent made by some bacteria, notably *Clostridium acetobutylicum*, as a result of fermentation.

acetone/butanol fermentation An industrial process, based on the fermentation of sugars (e.g., molasses), using *Clostridium acetobutylicum* to produce a mixture of acetone and butanol. This was the first fermentation to be carried out on a large scale using pure culture and aseptic methods. At one time, fermentation was the major source of these solvents. However, almost all plants were closed with the advent of the petrochemical industry. Interest in this process is now increasing as it may provide a means of producing cosolvents for addition to lead-free petroleum blends.

acetone powder A protein preparation formed during the isolation of enzymes. The frozen material is homogenized in acetone at below -30°C , which prevents autolysis and/or inactivation of the enzymes by inhibitory substances.

acetyl-DL-amino acid The acetylated form of an amino acid produced by treating hydrolyzed protein with acetic anhydride.

acetylcholine The acetyl ester of choline; a neurotransmitter in the central and peripheral nervous systems of vertebrates and invertebrates.

acetyl-coenzyme A (acetyl-CoA) A complex of an acetyl group with coenzyme A produced during the oxidative decarboxylation of pyruvate and during oxidation of fatty acids. It functions as the link compound between glycolysis and the TCA cycle in respiration, is an intermediate of the glyoxylate cycle, and is involved in the synthesis of a wide variety of primary and secondary products including fatty acids, some amino acids and terpenoids.

acetylene reduction test A sensitive technique used to measure the ability of an organism to fix nitrogen. It is based on the fact that the enzyme system responsible for the reduction of nitrogen gas (dinitrogen) is also capable of reducing acetylene to ethylene. Material under investigation is incubated in a closed flask in an atmosphere of acetylene. The gas phase is sampled periodically, and the constituent gases are separated by gas chromatography.

acetylmuramic acid An amino sugar derived from D-glucosamine and lactic acid. It is a component of the mucopeptides found in bacterial cell walls.

A chromosome One of the chromosomes that make up the normal complement of the nucleus of a eukaryotic cell.

acid-base balance The ratio of acid to base in the blood. Blood usually contains bicarbonate and carbonic acid in the ratio of

20:1, which maintains the blood pH at 7.4. If this ratio is changed due to carbonic acid accumulation, the reabsorption of bicarbonate by the kidney is adjusted to compensate and maintain the correct ratio.

acidic Descriptive of pH lower than 7.0. Compare basic.

acidification A process in which the pH falls or acid is added to decrease the pH. In anaerobic digestion, problems may arise due to acidification following shock loading. Acid-producing bacteria are capable of faster rates of growth and metabolism than are methanogenic bacteria, which are also less tolerant of acid conditions. Hence, if the rate of acid production increases for any reason, the imbalance is enhanced as the acid producers grow faster and the acid-utilizing bacteria are inhibited. This can lead to the collapse of the biogas-producing system.

acid medium A culture medium of between pH 1 and pH 5.

acidophilous milk A product obtained by the fermentation of milk with *Lactobacillus acidophilus*.

acid protease A protein-hydrolyzing enzyme characterized by maximum activity and stability at pH 2.0–5.0. Acid proteases have low levels of basic amino acids and have a low isoelectric point. They are insensitive to sulphydryl reagents, heavy metals and metal chelators, but are inactivated at pH values above 6.0. They are widely used in the food and beverage industries. Acid proteases of commercial importance are prepared from fungal sources and are of two types: pepsin-like and rennin-like enzymes. Pepsin-like proteases are generally prepared from *Aspergillus* species, whereas rennin-like proteases are produced from *Mucor* species.

acoelomate A metazoan, such as the nematodes (threadworms), that lacks a body cavity.

aconitase An enzyme of the TCA cycle that

catalyzes the conversion of citric acid to isocitric acid via aconitic acid.

aconitic acid An intermediate of the TCA cycle that usually only occurs as an enzyme-bound intermediate associated with aconitase. However, mutant strains of *Aspergillus* may produce large quantities of this compound.

aconitine A diterpenoid alkaloid formed by *Aconitum* and *Delphinium* that is highly toxic to man.

Aconta Algae that do not have a flagellate stage in their life cycle. This is characteristic of the red algae (Rhodophyta), which are an importance source of many industrial polysaccharides including agar.

acquired immune deficiency syndrome (AIDS) A virus-mediated disease with a very high mortality rate. AIDS was first applied to a narrowly defined disease that was clinically recognizable by symptoms of Kaposi's sarcoma and *Pneumocystis carinii* pneumonia. However, it is now known to include several other life-threatening opportunistic infections. AIDS is a group of diseases secondary to a defect in cell-mediated immunity associated with a single, newly discovered and unique virus. This virus has been described as human T-cell lymphotropic virus type III, lymphadenopathy-associated virus and AIDS retrovirus. The virus appears to be a retrovirus of the subfamily Lentivirinae which has previously been found in sheep, horses and goats. The spectrum of disease associated with AIDS virus is much wider than that defined originally and includes progressive encephalopathy (degeneration of the brain). On infection, the virus infects a small number of mature T-helper lymphocytes as well as brain cells, where it is slowly replicated, in an integrated and an unintegrated form. Both types of cells form infectious virions. Treatment is difficult since the integrated virus becomes part of the genome of brain cells. The virus kills those T-helper cells in which it replicates, causing mild or profound immune deficiency according to the number of cells

4 acridine

destroyed. The blood and plasma of an infected individual are highly infectious, and the disease is spread through blood transfusions and preparations of blood clotting factors, as well as personal interaction. The virus shows antigenic drift, and antibodies when formed do not appear to affect the virus. Different isolates of the virus show a great variation in the ENV gene, which codes for the envelope glycoprotein, making it difficult to produce vaccines.

acridine A A mutagen that causes additions and deletions of base pairs, especially in plasmids and other extrachromosomal DNAs.

acridine orange Dimethylamino acridine hydrochloride; a dye used to stain nucleic acids. It fluoresces at 530 nm when intercalated into double-stranded DNA and at 640 nm when ionically bound to the phosphate backbone of single-stranded DNA or RNA.

acrocentric Descriptive of a chromosome in which the centromere is positioned towards one end.

acrylamide The monomer used in the formation of polyacrylamide gels, which are employed in electrophoretic separation of proteins and nucleic acids.

ACTH See adrenocorticotrophic hormone.

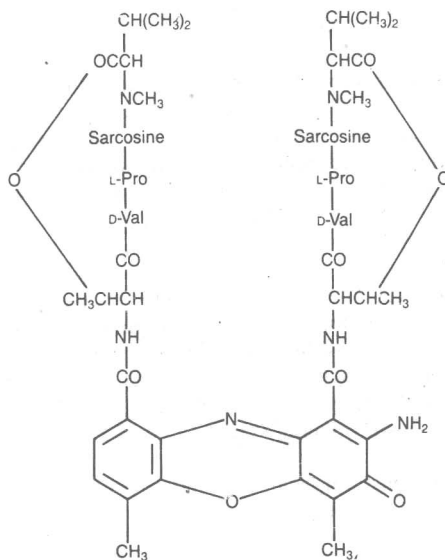
actin A protein found in contractile systems, such as muscle and flagella.

actinomorphic Descriptive of flowers that are radially symmetrical.

actinomycetes A group of rod-shaped, filamentous, gram-positive eubacteria that lack cross-walls and resemble miniature fungi (diameter less than 0.5 μm). This group includes soil organisms that display oxidative metabolism (including *Streptomyces*, *Nocardia* and *Mycobacterium*), as well as parasitic or fermentative forms which include the genus *Actinomyces*

proper. *Streptomyces* species are used for the production of antibiotics and enzymes.

actinomycin D An antibiotic derived from *Streptomyces* that suppresses the synthesis of rRNA.



Actinomycin

action potential A transitory reversal of the potential across the membrane of a nerve or muscle cell which changes from around -70 mV to about +30 mV during the passage of an impulse along the cell.

action spectrum A plot of the intensity or magnitude of a biological reaction as a function of wavelength of electromagnetic radiation. Action spectra are usually plotted over the visible and/or ultraviolet regions. The magnitude of the response will, for a photomediated or light-dependent reaction, correspond to the absorption spectrum of the compound involved. Hence the action spectrum can be used to infer a causal relationship between a given pigment or photoreceptor and a biological reaction.

activated sludge A mixture of aerobic organisms (biomass) produced in the activated sludge process of sewage or wastewater treatment.

activated sludge process A process used in sewage and wastewater treatment designed to increase the contact with high concentrations of actively growing microorganisms in the presence of sufficient dissolved oxygen so that growth of new biomass is balanced by the rate at which solids are washed from the system. The level of dissolved oxygen is maintained by agitation or air injection. The volumetric flow rate of waste sludge is kept constant, and settled solids are recycled back to the early aeration stage in order to increase contact time and maintain a high level of biological activity.

activated support A matrix material that has been treated so that the surface contains a large number of chemically reactive groups.

activation energy The energy needed to form a transition state complex. This may be illustrated considering the reaction



This reaction will only take place when molecules A and B form a transition complex AB, whose potential energy is greater than that of A + B. This transition complex can then decompose to yield the products C + D, whose potential energy is less than that of A + B since the reaction must be exogenic. The rate of reaction is proportional to the concentration of AB. The activation energy is the amount of energy required to bring all the molecules in one mole of A and B at a given temperature to the top of the energy barrier separating A and B from C and D. Enzymes increase the rate of reaction by lowering the activation energy.

activator A substance that is essential for a specific enzyme activity, but does not act as a substrate or contribute to the product. An activator may act by binding at a specific allosteric site on the enzyme.

active biomass The proportion of a cell culture that has microbiological activity.

active immunity Immunity that results from the production of antibodies within the body, rather than the introduction of antibodies by injection, for example. Active immunity gives a high resistance against subsequent infection and may be developed as a result of the disease itself or by immunization (using killed or attenuated vaccines or toxoids). The immunity takes several days up to a couple of weeks to develop, lasts for a long time (possibly for life) and can easily be reactivated by a booster injection of the required antigen. Active immunization is used as a prophylactic.

active site The region of the enzyme with which the substrate binds during catalytic conversion to a product. The basic theory of enzyme activity assumes formation of an enzyme-substrate complex through binding at the active site. Electrostatic attraction, repulsion and other intermolecular physical forces contribute to a lowering of the activation energy, thus facilitating intermolecular conversions.

active transport A biological mechanism that results in the transport of molecules across a membrane against a concentration gradient. Active transport requires metabolic energy (usually ATP or an electrochemical gradient) and may be associated with a specific carrier protein or lipoprotein molecule.

acylamino acid An amino acid to which an acyl group has been added.

Ada See zwitterionic buffer.

adaptation The fitting of an organism to its environment. It includes those processes whereby a microbial culture adapts to grow on a medium of a particular composition.

adaptive enzyme An enzyme that is formed in response to an outside stimulus during adaptation. This term is now generally obsolete and has been replaced by inducible enzyme.

adaptive value A measure of the reproduc-

tive efficiency of an organism (or genotype) compared with other organisms (or genotypes). It is also called selective value.

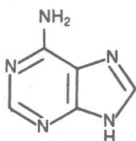
adaxial Descriptive of the surface of a leaf or other lateral organ that is closest to the apex of the axis on which it is borne. *Compare* abaxial.

additive genes Genes that interact but show no dominance, if they are alleles, or no epistasis, if they are not alleles.

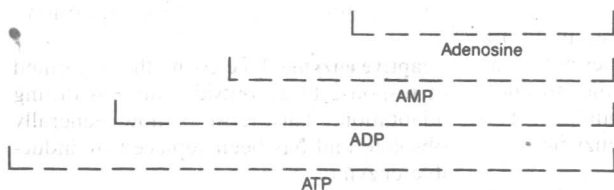
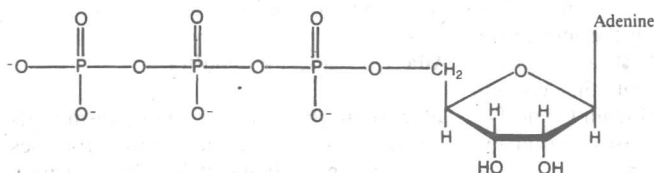
additive recombination A gene recombination that occurs by insertion of a new sequence of DNA into an existing genome without any loss of DNA from the host genome.

additive variance Genetic variance due to additive genes.

adenine (A) A purine base that is a constituent of nucleic acids and coenzymes, including NAD and FAD; a constituent of adenosine.



Adenine



Adenosine nucleotides

adenosine A nucleoside comprising adenine linked to D-ribose through a β -glycosidic bond. Phosphorylated forms of adenosine (AMP, ADP and ATP) are the major compounds involved in energy transfer in biological systems.

adenosine diphosphate (ADP) A nucleotide consisting of adenine, D-ribose and two phosphate groups. ADP is important in biological energy metabolism. *See* oxidative phosphorylation, phosphorylation, photophosphorylation.

adenosine monophosphate (AMP) A nucleotide comprising adenine and D-ribose and one phosphate group. Addition of one or two further phosphate groups leads to the formation of ADP or ATP, respectively. *See* cyclic adenosine monophosphate.

adenosine triphosphate (ATP) A nucleotide consisting of adenine, D-ribose and three phosphate groups. Two of the phosphates are linked by pyrophosphate bonds, hydrolysis of which results in a large change in free energy. ATP is important in biological energy metabolism, being produced by phosphorylation reactions in respiration and photosynthesis. Energy stored in ATP is used in the synthesis of other molecules through linked reactions.

adenovirus A class of naked icosahedral viruses that contain double-stranded DNA associated with up to 12 different types of protein molecule. Adenoviruses cause acute respiratory diseases in man.

adenyl cyclase An enzyme that catalyzes the formation of cyclic AMP from ATP.

adenylic acid A synonym for AMP. *See* adenosine monophosphate.

ADH Antidiuretic hormone. *See* vasopressin.

adipic acid A six-carbon dicarboxylic acid used in the production of nylon.

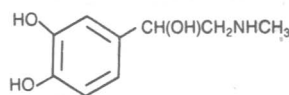
adipose tissue Fatty tissue consisting of aggregated cells containing large amounts of fats. In mammalian cells, the cell contents are often displaced by a single large fat droplet, particularly in subcutaneous cells, the mesentery and the mediastinum. Adipose tissue provides an energy store, protection against damage of sensitive internal organs and thermal insulation.

adjuvant A substance that is not antigenic but, when mixed with an antigen, enhances antibody production. Adjuvants are used therapeutically since they help to produce antibody against small amounts of antigen and to prolong the period of antibody production. Adjuvants work by inducing an inflammatory response that leads to a local influx of antibody-forming cells.

ADP *See* adenosine diphosphate.

adrenal glands A pair of compound endocrine glands situated along the anterior or superior surface of each kidney in mammals. The adrenals are divided into two regions: an outer cortex, which has an embryonic origin as lateral mesoderm; an inner medulla, which develops from the neural crest. The cortex secretes several steroid hormones collectively known as corticosteroids. The medulla secretes the catecholamines adrenaline and noradrenaline.

adrenaline A catecholamine hormone, also known as epinephrine, secreted by the mammalian adrenal medulla. Its secretion is stimulated by the sympathetic nervous system under conditions of stress. Adrenaline stimulates blood flow to skeletal muscle and increases blood glucose levels.



Adrenaline

adrenergic Descriptive of a nerve fibre or nerve ending that releases adrenaline or noradrenaline as a neurotransmitter.

adrenocorticotrophic hormone (ACTH) A polypeptide hormone, comprising 39 amino acid, secreted in mammals by the pars distalis of the pituitary gland. ACTH stimulates the production of corticosteroid hormones by the adrenal cortex and of melanin by pigment cells. Its secretion is regulated by a hypothalamic hormone known as corticotrophin-releasing factor and by vasopressin, as well as by feedback mechanisms in which corticosteroids modulate the activity of the pituitary and hypothalamus.

adsorption (1) In physical chemistry, the adhesion of molecules to solids. This process forms the basis of adsorption chromatography, which is used to purify proteins and other macromolecules, as well as some methods of cell or enzyme immobilization. (2) In microbiology, the process whereby bacteriophage attach to specific receptors on the host cell prior to injection of their nucleic acid upon infection.

adventitious Descriptive of a structure that has arisen in an uncharacteristic position.

AE *See* amino ethyl group.

aeration (1) The introduction of air (or oxygen) into aerobic fermentation reactions. (2) The introduction of any gas, such as carbon dioxide, into a liquid.

aerator An apparatus used for aerating a liquid.

aerobe An organism that requires oxygen for respiration and hence growth.

aerobic bacteria *See* aerobe.

aerobic reactor A fermenter or bioreactor that is fitted with an aeration system for the culture of aerobic organisms.

aerobic respiration The overall process in which carbohydrates are completely oxidized to carbon dioxide and water using molecular oxygen. In the initial stage (glycolysis), which is common to both aerobic and anaerobic respiration, glucose phosphate is degraded to pyruvate. Pyruvate is then converted to acetyl-CoA, which enters the TCA cycle by combining with oxaloacetic acid to form citric acid. Citric acid is then metabolized to reform the acceptor molecule oxaloacetic acid in a cyclic process. This results in the release of two molecules of carbon dioxide and the passage of hydrogen atoms and their electron equivalents to an intermediate electron transport chain which ends with the formation of water from molecular oxygen. During passage through the series of redox couples that constitute the intermediate electron transport chain energy is conserved in the form of ATP.

aerobic waste treatment A biological process in which aerobic microorganisms are grown on wastewater as a means of lowering the biochemical oxygen demand. Rapidly growing organisms use carbon compounds as a source of material for cell growth and metabolic energy, generating cell biomass and carbon dioxide. *See* activated sludge process, algal oxidation pond, deep shaft system, trickle filter.

aerogel A rigid, preformed matrix containing pores into which a solvent has been introduced. Because it is not a gel in the true sense the matrix will form aerogels in any solvent. Examples include porous glass beads and titanium spherules. Aerogels are used in chromatography for gel filtration or

as carriers for ion exchangers, or xerogel materials.

aerosol (1) A system consisting of fine droplets or colloidal particles dispersed in a gas. (2) A fine suspension of water droplets containing infectious organisms.

afferent Descriptive of a nerve or neurone that transmits information from peripheral receptors to the central nervous system. *Compare* efferent.

affinity A natural attraction towards a compound or object. The term is used in relation to the specific interaction that occurs between an enzyme and its substrate, or an antigen and an antibody, which can be exploited in techniques such as immunoassay, affinity labelling and affinity chromatography.

affinity chromatography A chromatographic technique that depends on the specific affinity of one molecule for another. For instance enzymes may be isolated by binding an analogue of their normal substrate to an inert matrix. If a solution of mixed proteins is passed through a column packed with such a matrix, the required enzyme will be retained or retarded due to its affinity for the bound substrate. The protein is then retrieved by eluting the column using a suitable solution with a pH or ionic concentration such that the affinity is reduced. The technique is also used to purify antibodies (especially monoclonal antibodies) by passing them through a column packed with a similar matrix to which a suitable antigen has been complexed.

affinity-isolated antibody A highly purified antibody prepared using an affinity column containing a matrix to which the antigen for the required product has been bound.

affinity labelling A method of labelling nucleic acids for use as probes without employing radioactive materials. A group that does not impair the ability to hybridize with complementary sequences is coupled to the probe. Following hybridization the

affinity-labelled duplex is reacted with a signal molecule which contains a binding site for the affinity label. Signal molecules include fluorescent antibodies, enzymes that produce colour changes and chemiluminescent catalysts. For instance biotin can be chemically attached to the nucleotides of the probe DNA. Biotin is complexed by the protein avidin which may be labelled with a fluorescent marker. The sensitivity of the method can be increased by the addition of lengths of biotinylated nucleotides to the probes.

affinity precipitation A system in which a precipitate is formed as a result of a reaction between two types of molecules through binding at a specific interaction site (e.g., enzyme and substrate, antibody and antigen).

aflatoxins A group of highly toxic and often carcinogenic substances produced by the moulds *Aspergillus flavus* and *A. parasiticus* during their growth on foodstuffs or animal feeds. There is a potential hazard to health from consuming even very small amounts of these toxins (the LD₅₀ may be less than 0.35 mg/kg body weight). The toxigenic *Aspergillus* species are widely distributed in nature and the likelihood of contamination is high, especially in grains and oilseed residues that are poorly dried or stored in damp conditions. The feeding of contaminated materials to cows can lead to contaminated milk. More than a dozen forms of aflatoxin have been identified. Chemically the aflatoxins are substituted coumarins, B1 being the most toxic and carcinogenic.

agammaglobulinaemia A condition in which individuals suffer from a congenital lack of gamma-globulin and form little or no antibodies. Such subjects are thus highly susceptible to repeated bacterial infections.

agamospermy Any type of apomixis other than vegetative propagation.

agar A complex polysaccharide produced by red algae, especially *Gelidium* and

Gracilaria species. It contains the polysaccharides agarose and agarpectin. Agar is used in food manufacture and as a matrix for the culture of microorganisms. It is particularly suitable for the latter purpose since very few bacteria produce enzymes capable of liquefying the gel.

agarpectin A polymer similar to agarose, but containing D-glucuronic acid and small amounts of other sugars including sulphate esters.

agarose A polysaccharide gum obtained from seaweed composed of alternating (1,3)-linked D-galactose and (1,4)-linked 3,6-anhydro-L-galactose residues, as well as small amounts of D-xylose. Some of the D-galactose units are methylated at C-6. Agarose is used as a gel medium in chromatography or electrophoresis. It has a molecular fractionation range that extends into the region of viruses and microparticles.

agarose gel electrophoresis A separation technique using agarose gel as the stationary phase. Agarose gel electrophoresis is important in gene manipulation and sequencing, since it can separate DNA molecules on the basis of their molecular weights. The bands on the gel are detected using ethidium bromide so that levels as low as 0.5 mg DNA can be detected by examination in ultraviolet light.

agglutination The formation of clumps or flocs of microorganisms or cells, such as erythrocytes, due to the interaction of antigens on the cell surface with antibodies to form bridges linking the antigen determinants. Agglutination reactions are used in the identification of blood groups, bacteria, animal cell culture lines, etc.

agglutinin A substance (antibody) that causes agglutination.

agglutinogen An antigen present in a bacterium that causes production of an agglutinin when injected into an animal.

aggregation The clumping or flocculation

of individual organisms or cells to form groups.

aging The biochemical and genetical changes that lead to the gradual senescence and death of a cell or organism.

agitation The mixing by shaking or other violent irregular action or motion.

aglycone A molecule containing a nucleophilic atom (usually oxygen present in an alcohol, phenol or organic acid) that replaces the hydroxyl group on the anomeric carbon atom (C-1 of aldoses or C-2 of ketoses) in the formation of glycosides. S-Glycosides and N-glycosides are also formed.

agonist A competitive substance in any reaction.

agranulocyte A white blood cell that does not contain distinct cytoplasmic granules. Such cells include lymphocytes and monocytes.

agricultural alcohol Ethanol that has been produced by fermentation of a raw material derived from agriculture. The main sources of agricultural alcohol are sugar cane, maize, grapes, molasses, potatoes, spoilt fruit, wheat, cassava and rice.

agricultural wastes Products of agriculture that are not utilized by the established routes as food, animal feed, bedding, building materials, etc. These wastes can be divided into three groups: (1) woody or fibrous wastes such as straw, bagasse, wood wastes, etc.; (2) manures and other products of animal husbandry; (3) solid waste from food-processing operations.

agricultural waste utilization A number of biological or fermentation processes are employed: the production of compost or silage; the production of methane by anaerobic digestion; the production of fuel alcohol (ethanol) and other solvents by yeast or bacterial fermentation; the production of glucose and fructose syrups using enzyme methods; the production of

single cell protein, using fungi or bacteria, as an animal feed or human food. Most agricultural wastes contain high levels of cellulose, hemicellulose and lignin, which are not easily broken down. There are two approaches that can be used. The first is to treat the material with acid, solvents or other chemicals, or cellulolytic enzymes, after grinding or disruption by steam explosion. This produces a sugar syrup which can then be fermented by conventional yeasts. The alternative is the development of specific strains of organisms that can grow on and/or ferment lignocellulose directly. Direct conversion is best carried out using thermophilic organisms.

agriculture The cultivation of land to produce crops. In a broad sense, agriculture includes horticulture, forestry and the raising of farm animals.

Agrobacterium A genus of bacteria that includes *A. tumefaciens*, which is responsible for the production of crown gall tumours in gymnosperms and dicotyledonous plants. The disease is caused by a DNA plasmid (tumour-inducing or Ti plasmid). This is capable of independent replication within the cells of the plant host in the absence of the bacterium. The morphology of the tumours produced on infection varies depending on the bacterial strain and the plant species involved. The exact morphology depends on the extent to which the hormone system of the host plant is disrupted. Some tumours are undifferentiated, whereas others produce viable teratomatic plants. The plant cells of the tumour show two new properties: their growth is independent of phytohormones or plant growth substances; they contain one or more of the unusual guanido acids known as opines. The most common of these opines are octopine and nopaline. Crown gall tumours continue to synthesize opines in tissue culture, and plants regenerated from nopaline-containing tissue continue to synthesize nopaline. The ability of the tumours to synthesize opines is a property conferred on the cells by the bacteria which can use the opines as

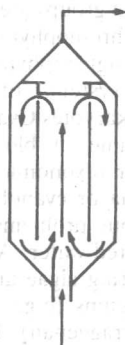
their sole nitrogen source. The bacteria do not penetrate the plant cells that are converted to tumour cells, rather they penetrate the intercellular spaces and attach to the wall of healthy plant cells. The genetic information specifying bacterial utilization of opines and their synthesis by plants is borne on the Ti plasmids. Since these plasmids are capable of replicating in plant cells, they are widely regarded as suitable for use as DNA vectors in gene manipulation of plants. See plant cloning vehicle.

agrochemicals Crop-protection chemicals, which may be synthetic, semisynthetic or natural products, that are used to increase crop yields. Agrochemicals include pesticides, herbicides and fungicides.

AIDS See acquired immune deficiency syndrome.

air filter A device for cleaning air by removing fine particles. Air filters are used either to keep infective or contaminating particles out of an area (e.g., a clean room) or a bioreactor, or to prevent the escape in a ventilation stream of pathogens or genetically manipulated organisms from a containment facility or fermenter.

air lift fermentation A process in which the cell suspension is kept mixed and aerated by introduction of air at the base of a central draught tube. This results in the vertical circulation of liquid. Large-scale air lift fermenters are used in the industrial production of single cell protein.



Air lift

air monitoring The measuring of the quality of an air stream. It is used to detect biological or non-biological materials, with the objective of preventing contamination and/or maintaining asepsis. Air may be monitored by collecting particles on ultrafilters and exposing these to nutrients so that trapped cells are recognized and counted on the basis of the colonies formed.

air sterilization The removal of contaminating organisms from air prior to its use as the source of oxygen and/or for mixing cultures. Air sterilization processes are required to remove organisms with dimensions as small as 0.5 μm from very large volumes of air. Heat generation during air compression is of value in killing some organisms, but in general it is necessary to filter the air using fibrous, sintered or acetylated polyvinyl alcohol sheet filters.

Ala An abbreviation for the amino acid alanine used in protein sequences and elsewhere.

alanine (Ala) One of the 20 common amino acids found in proteins.

Alanine $\text{CH}_3\text{CH}(\text{NH}_2)\text{COOH}$

alanine production Alanine is produced by direct fermentation, using a medium based on glucose or molasses, and bacteria such as *Corynebacterium*, *Brevibacterium*, *Arthrobacter*, *Microbacterium* or *Pseudomonas*. Alanine is also produced from aspartic acid using cultures of *Pseudomonas* or *Xanthomonas* with a high level of L-aspartic- β -decarboxylase activity.

albumen The water-soluble protein of egg white. It comprises a number of conjugated proteins, such as ovalbumin which contains a carbohydrate prosthetic group.

albumin One of a group of simple proteins soluble in water and coagulated by heat. Serum albumins occur in the blood.

Alcaligenes A genus of eubacteria. The bacteria are gram-negative rods, some of

which are facultative anaerobes. These organisms may cause spoilage of milk, resulting in slimy milk or ropiness.

alcohol (1) The substance present in alcoholic beverages (i.e. ethyl alcohol or ethanol). (2) A class of chemical compounds having the general formula ROH, where R represents an alkyl group. The lowest molecular weight alcohol is methanol. Alcohols are widely used as industrial solvents and as precursors for the synthesis of various acids, esters, aldehydes and polymers including acetic acid, ethyl acetate, ethyl ether and polyethylene, respectively. Alcohols may also be used in internal combustion engines as fuels, octane enhancers or cosolvents in petroleum blends.

alcohol dehydrogenase An enzyme that catalyzes the conversion of acetaldehyde to ethanol.

alcoholic fermentation An anaerobic metabolic process that occurs in certain yeasts, bacteria and fungi. Glucose is degraded to pyruvic acid by glycolysis with subsequent production of carbon dioxide and (alcohol) ethanol. This is the major route of production of potable, agricultural and fuel alcohols. Yeast-based alcoholic fermentations form the basis of large-scale fuel alcohol production (e.g., in Brazil over 11 billion litres are produced per year from sugar cane), as well as the formation of beers, wines and spirits.

alcohol production The production of ethanol by fermentation is mainly carried out using yeasts grown on sugar-containing substrates, which may be directly expressed juice or obtained by hydrolysis of starch. Such alcohol production can be divided into the production of alcoholic beverages for direct consumption (beers or wines), the production of alcoholic beverages for consumption following distillation to increase the alcohol content (spirits such as gin, whisky, vodka, brandy, etc.) or the production of alcohol for use as a chemical feedstock, fuel additive or fuel in its own right.

aldehyde A compound of the general formula RCHO, where R is an alkyl group. Aldehydes yield alcohols when reduced and acids when oxidized.

aldolase An enzyme that catalyzes the reversible conversion of fructose biphosphate to one molecule of glyceraldehyde phosphate and one molecule of dihydroxyacetone phosphate. It is an enzyme of glycolysis.

aldonic acid A compound produced from an aldose sugar oxidized at the C-1 position.

aldose A monosaccharide that contains an aldehyde group. *Compare* ketose.

aldo sugar *See* aldose.

alduronic acid A compound produced from an aldose oxidized at the C-6 position.

ale A top-fermented beer; a beer produced using the yeast *Saccharomyces cerevisiae* which rises to the surface of the fermentation where it is recovered by skimming. Several types of ales are made which are distinguished on the basis of their colour and body. Pale ale has a low colour and a high level of hop bitterness. Mild ale (brown ale) is darker and sweeter. Stout is a very dark ale, full-bodied, with a low level of hop bitterness.

algae Undifferentiated aquatic plants lacking true roots, stems or leaves that contain chlorophyll a and other characteristic pigments. The main groups are the eukaryotic Rhodophyta, Chromophyta, Chrysophyta, Phaeophyta, Euglenophyta and Chlorophyta. Some systems of classification include the prokaryotes Cyanophyta under the general name of blue-green algae. However, other taxonomic systems place them as bacteria or cyanobacteria. Algae can cause serious problems due to overgrowth in polluted water. A wide range of naturally occurring algae are used for the production of gums (e.g., agar, agarose, alginate and carrageenan). These gums are employed in microbial culture, food pro-

ducts, chromatography and electrophoresis. Algae may be cultured as a source of fish food, pigments, lipids and other chemicals (including hydrocarbons) or single cell protein. Some nitrogen-fixing blue-green algae are cultured as organic fertilizers, in the production of paddy rice.

algal biomass Cultures of algae such as *Chlorella*, *Spirulina* and *Scenedesmus* grown as a source of animal feed or food. See single cell protein (algal).

algal oxidation pond A large, shallow, confined stretch of water or a lagoon, which may cover several hectares, used for the treatment of wastewaters. Organic material and minerals are removed and converted into cell biomass by the combined action of bacteria and photosynthetic microalgae. Oxygen produced in photosynthesis keeps the system aerobic, whereas carbon dioxide formed by bacterial respiration provides carbon for the algal growth. The system is restricted to areas that have continual high sunshine and is suitable for areas of flat land close to the source of wastewaters.

alginate An anionic polysaccharide; an acetylated polymer of mannuronic acid and guluronic acid. It is extracted on a commercial basis from brown seaweed. Microbial alginates are produced by a number of organisms including *Azotobacter vinelandii* and *Pseudomonas aeruginosa*. Alginates form viscous gels in the presence of calcium ions. Various grades of viscosity are available commercially. These differ in their ratios of guluronic acid to mannuronic acid. Alginates are used widely in food products, in textile printing and for the immobilization of microorganisms.

alginic acid See alginate.

alimentary canal The passage in animals, which extends from the mouth to the anus, through which foodstuffs pass to be broken down and absorbed into the body. The alimentary canal shows a great diversity of morphology and biochemical specialization to suit a wide variety of diets.

A line An inbred male sterile line used in the production of plant hybrids.

aliphatic Descriptive of organic molecules that occur as open chains, such as the paraffins or olefins.

aliquot A small sample of substance in solution of exact known volume.

alkaline Descriptive of a pH greater than 8.0.

alkaline hydrolysis A chemical hydrolysis carried out using an alkali such as sodium hydroxide.

alkaline medium A culture medium with a pH of between 8 and 10.

alkaloid A nitrogen-containing compound. Alkaloids differ widely in chemical structure and are classified on the basis of the type of heterocyclic group they contain: purine, pyrimidine, quinoline, isoquinoline, pyridine, reduced pyridine and indole. Most alkaloids are produced by plants and many have potent pharmacological activities. Alkaloids can act as analgesics (morphine), stimulants (caffeine, nicotine), muscle relaxants (strychnine), opiates (opium), vasoconstrictors (scopolamine), anaesthetics (cocaine), tranquillizers (reserpine), psychedelic agents (psilocybin).

alkanes Saturated aliphatic hydrocarbons, components of oil. Normal (straight chain) n-alkanes containing more than nine carbon atoms are readily metabolized by a variety of microorganisms through beta-oxidation to produce C_2 compounds. As the degree of branching increases their metabolism becomes more difficult and takes much longer. Their use as feedstock for the production of single cell protein (SCP) has been widely investigated and several large-scale plants for SCP production from alkanes have been built. Concern about possible toxic constituents and costs have led to closure of the largest plant.

alkenes Chemical compounds containing

only carbon and hydrogen, and having at least one unsaturated (double) $>C=C<$ bond. This makes them chemically reactive. A common alkene used in commercial processes is ethene (ethylene), which is employed in the manufacture of polyethylene. Although in most instances polyethylene is produced from fossil fuel-based raw materials, a number of plants have been built that use fermentation ethanol as raw material.

alkylation The replacement of a hydrogen atom in an organic compound by an alkyl group.

alkyl group A univalent group or radical derived from an aliphatic hydrocarbon by removal of a hydrogen atom.

allele One of two or more genes which occur at the same locus on homologous chromosomes and which become separated during meiosis and recombined following fusion of the gametes. When present in pairs, one (the dominant) is expressed in preference to the other (the recessive). *See* heteroallele.

allelic exclusion The failure of one of the two allelic forms of a gene to be expressed in a diploid cell. This effect differs from normal genetic dominance, since the repressed allele may be expressed in other cells of the same organism.

allelomorph The characteristic produced by an allele.

allelopathy An interaction between two organisms in which the growth or reproduction of one is suppressed by chemicals released into the environment by the other.

allergen A substance that causes an allergic response.

allergy A hypersensitivity to food products, pollen, proteins, etc. that are normally harmless. The symptoms in response to an allergen are oedema and inflammation. Common allergies are hay fever, asthma and hives. Allergies may also

develop following an insect bite or sting, or inoculation. In all cases, the mechanism is similar. The individual is sensitized by exposure to an antigen and a period of time then elapses for antibody production to take place. Subsequently, when the individual is again exposed to a fairly large amount of the same antigen, the antibody-antigen reaction results in damage.

allopatric Descriptive of populations or species that inhabit separate geographic regions. *Compare* sympatric.

allopolyploid Descriptive of an organism exhibiting polyploidy due to the addition of chromosome sets from two different species.

all-or-none Descriptive of a response that can be expressed in terms of either of two distinct states: no response or a maximal response, irrespective of the magnitude of the stimulus. A stimulus causing such a response usually produces no effect until a threshold value is reached.

allosteric effector A compound that induces a conformational change in a protein, which changes its catalytic activity, by binding at a specific recognition site. The effector molecule may be a normal substrate for the reaction. If it can also function as a substrate, the position of the binding site that causes the conformation change differs from the position of the substrate binding site.

allosteric enzyme An enzyme that shows unusual kinetic properties in response to changes in substrate concentration and/or in response to the action of allosteric effectors that are not substrates. If the rate of reaction is plotted as a function of substrate concentration for such enzymes, the result will be a sigmoid curve rather than the usual right-angled hyperbola. Addition of the appropriate allosteric effector may cause a change in the kinetic profile to the usual hyperbolic form.

allosteric inhibitor A compound that reduces the activity of an enzyme by