Dictionary of Microbiology

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Preface

In preparing the Dictionary of Microbiology we have attempted to produce a compact source of readily-available and up-to-date information for undergraduates and postgraduates in microbiology and for those studying—or otherwise engaged in—any of the wide range of subjects and disciplines for which some knowledge of microbiology is necessary. The Dictionary deals with terms, concepts, techniques, tests, and other topics, and covers over one thousand microbial taxa; the entries—which range from short definitions to descriptions and concise reviews—relate to microbiology (pure and applied), biochemistry, immunology, and genetics, and to the microbiological aspects of allied subjects such as medicine, veterinary science, and plant pathology.

We would like to acknowledge the cooperation of Mr T. F. Lawrence of Baird & Tatlock (London) Ltd. in connection with the line drawing of the Series 225 autoclave; we are also indebted to Carl Zeiss, Oberkochen, West Germany, for the line drawing of the light microscope, and to N. V. Philips' Gloeilampenfabrieken, Eindhoven, Netherlands, for the line drawing of the electron microscope.

Paul Singleton
Diana Sainsbury
London, January 1978.

Notes for the User

Alphabetization. Entries are arranged in alphabetical order on a 'nothing before something' principle—i.e. a space (between words, or between a letter and a word) precedes a letter. For example:

blast disease	**h mutants**	**R factors**
blast transformation	**HAA**	**R mutant**
Blastocladiales	**hadacidin**	**rabies**

Subscripts, superscripts, and numbers affect the order of entries *only* if there is no other difference between the entry headings; apostrophes are ignored for the purposes of alphabetization. For example:

C3 convertase	**ascolichen**
C_{55} lipid carrier	**Ascoli's thermoprecipitin test**
C_{27} organisms	**ascolocular**

When a hyphen connects two complete words, or connects a letter and a complete or incomplete word, the hyphen is regarded as a space. (In many such cases the hyphen is omitted by some authors.) If a hyphenated word can be written alternatively as a single, non-hyphenated word it is regarded as such for the purposes of alphabetization. For example:

C substances	**F′ donor**	**red tide**	**copper**
C-type particles	**F-duction**	**red-water fever**	**co-precipitation**
cabbage, diseases of	**F factor**	**redox potential**	**Coprinaceae**

When a Greek letter forms a *significant* part of an entry heading it is counted as a word; however, if it is a relatively minor qualification it is ignored for the purposes of alphabetization. For example:

gametothallus	**omasum**	**polyhedroses**	**prophylaxis**
***gamma* globulins**	***omega*-oxidation**	**poly-β-hydroxybutyrate**	**β-propiolactone**
***gamma* rays**	**omnivorous**	**poly(I:C)**	***Propionibacterium***
gamone	**oncogene**	**polykaryocytosis**	**propionic acid fermentation**

Certain entry headings defy any logical system of alphabetization. An example of such a heading is **T2H test**; this heading has been arbitrarily regarded as 'T H test' and hence:

T antigen
T-even phages
T2H test
T-independent antigens

Cross references. (These are indicated by SMALL CAPITAL letters.) In order to effect maximum economy of space, information given in any particular entry is seldom repeated elsewhere. In some cases a complete understanding of an entry is dependent on a knowledge of information given in other entries—which are indicated by cross references; in such cases the cross reference(s) frequently form an integral part of a sentence within the text, or may be introduced by 'see .....'. In other cases cross references may be used to link one topic with another or to extend the scope of a given topic; in such cases a cross reference is often placed within brackets and preceded by 'see also' or 'cf.'.

Certain entry headings are followed simply by (see CROSS REFERENCE); this is *not* intended to indicate that synonomy necessarily exists between the term which forms the entry heading and that to which the reader is referred—such referral signifies only that the meaning of the term is given under the heading indicated.

Numbered definitions. In a number of cases a term is used with different meanings by different authors—or it may have different meanings in different contexts; for such terms the various definitions are indicated by (1), (2), (3) etc.—though *all* the definitions which can be ascribed to the term are not necessarily included. The position in which any given definition appears in a list of definitions is *not* intended to reflect in any way the appropriateness or frequency of usage of that definition of the term.

Taxonomy. In general, the characteristics described for a given taxon apply to all subordinate taxa; thus, e.g. the distinguishing characteristics of a given family apply to all the genera within that family—though such characteristics are usually *not* repeated in the separate entries for each genus.

The taxonomic scheme used for the bacteria is based on that given in the 8th edition of *Bergey's Manual of Determinative Bacteriology* (1974). For the fungi the taxonomic scheme is based largely on 'A General Purpose Classification of the Fungi' proposed by G. C. Ainsworth in *Bibliography of Systematic Mycology* part 1 (1966) pages 1–4; the scheme adopted in the dictionary incorporates some of the suggestions given in volumes IVa and IVb of *The Fungi* (editors: G. C. Ainsworth, F. K. Sparrow, and A. S. Sussman)—both volumes published in 1973 by Academic Press. Protozoological classification is based partly on 'A Revised Classification of the Phylum Protozoa' by B. M. Honigberg *et al.* (*J. Protozool.* **11** (1) 7–20, 1964) and partly on more recent literature. A detailed classification of the algae was considered to be beyond the scope of this work; the taxa given are those currently accepted by a number of authors. In general, the animal viruses have been grouped according to the scheme given in *The Biology of Animal Viruses* by F. Fenner *et al.* (Academic Press, 2nd edition, 1974).

A

Å Ångström unit. A unit of length: 10^{-10} metres.

a_w (see WATER ACTIVITY)

A-protein (1) (of the TOBACCO MOSAIC VIRUS) Experimentally produced oligomers of protein coat subunits. (2) (of BACTERIOPHAGE Qβ and other RNA phages) A protein *maturation factor* present in the phage coat; it is distinct from other coat proteins. (cf. PROTEIN A)

A site (of a RIBOSOME) (see PROTEIN SYNTHESIS)

A-type particle (*virol.*) (see B-TYPE PARTICLE)

AAA pathway (see AMINOADIPIC ACID PATHWAY)

AAV *Adenovirus*-associated virus (see PARVOVIRUS).

ab (*immunol.*) Antibody.

abequose (3,6-dideoxy-D-galactose) A sugar which occurs e.g. in the O-specific chains of LIPOPOLYSACCHARIDES in certain serotypes of *Salmonella*. Abequose, first isolated from *S. abortus-equi*, contributes to the specificity of somatic (O) antigen 4 in group B salmonellae.

aberrations, chromosomal (see CHROMOSOME ABERRATION)

abhymenial (*mycol.*) Refers to the surface of a fruiting body which is opposite that of the hymenium, *or* may refer to any surface of a fruiting body *other than* that of the hymenium.

abiogenesis (spontaneous generation) The spontaneous formation of living organisms from non-living material; apart from its application to the evolutionary origin of life, the doctrine of abiogenesis has long since been abandoned.

ablastins (*immunol.*) Antibodies which specifically inhibit microbial reproduction by combining with homologous cell-surface antigens.

abomasum (see RUMEN)

abortive transduction (see TRANSDUCTION)

abortus Bang reaction (abortus Bang ringprobe) The MILK RING TEST.

ABR Abbreviation for *abortus Bang reaction* or *abortus Bang ringprobe*—both of which refer to the MILK RING TEST.

Absidia A genus of fungi of the ZYGOMYCETES.

absorption (*immunol.*) The removal or effective removal of particular antibodies (or antigens) from a given sample (e.g. serum) by the addition of homologous antigens (or antibodies) to that sample; the resulting antigen–antibody complex may or may not be removed from the sample.

acaricide Any chemical agent which kills members of the order Acarina (mites and ticks).

accessory pigments (in PHOTOSYNTHESIS) Pigments which harvest light energy and transfer it to the *reaction centres*. They include CAROTENOIDS, PHYCOBILIPROTEINS and certain CHLOROPHYLLS.

AcCoA Acetyl-coenzyme A (see COENZYME A).

acellular (see CELLULAR)

acellular slime moulds (Myxomycetes, Myxomycetales, 'true' slime moulds) A group of eucaryotic organisms in which the stages of the life cycle include a uninucleate amoeboid cell (the *myxamoeba*) and/or a uninucleate biflagellate (heterokont) *swarm cell*, and a motile multinucleate body, the *plasmodium*. (cf. CELLULAR SLIME MOULDS) The acellular slime moulds—which are usually classified among the fungi—occur in soil and on decomposing vegetation; they feed on bacteria and on small particles of organic detritus.

The life cycle includes a vegetative (feeding) phase in which the plasmodium—a shapeless mass of multinucleate protoplasm (sometimes brightly coloured)—increases in size to several centimetres or to a metre or more; the plasmodial nuclei are diploid, and the protoplasm of the plasmodium exhibits active streaming. Under certain environmental conditions (e.g. starvation *and* darkness) the plasmodium may give rise to a dry, brittle or pliable thick-walled mass, a *sclerotium*, which is a dormant, resistant form; in e.g. *Physarum polycephalum* the sclerotium is divided, internally, into a number of multinucleate sections ('spherules'). Normally, in the presence of light, a starved plasmodium gives rise to one or more *fruiting bodies*—the form of which varies widely among species of acellular slime moulds. In *Physarum polycephalum* the fruiting body consists of a short, cell-free stalk surmounted by a lobed *sporangium*; the sporangium consists of an outer sac, the *peridium*, which contains a number of thick-walled spores—among which ramifies a system of (cellulosic and/or chitinous?) threads, the *capillitium*. Although many species form stalked fruiting bodies, some (e.g. *Lycogalia* spp.) form non-stalked sporangia (*aethelia*—*sing.*: *aethelium*). *Ceratiomyxa* spp. differ from all other slime moulds in that e.g. the spores are borne *externally* on the fruiting body, i.e. the spores are not enveloped by a peridium. Spore germination gives rise either to a uninucleate myxamoeba or to a uninucleate, biflagellate *swarm cell*—depending on species and environment; for example, germination on a moist substratum may give rise to a myxamoeba, while germination in water may give rise to a swarm cell. In either case, the

product of germination is a haploid cell; there is some evidence that meiosis occurs within the pre-formed spore. Myxamoebae may subsequently become swarm cells, and *vice versa*. The life cycle is completed when a pair of myxamoebae, or swarm cells, fuse to form a (diploid) zygote; flagella, if present, are subsequently lost. The zygote grows and develops to form the multinucleate, diploid plasmodium. Genera include *Ceratiomyxa*, *Didymium*, *Fuligo*, *Hemitrichia*, *Lycogala*, *Physarum*, and *Stemonitis*.

acentric (of a chromosome) Having no centromere.

acephaline (*protozool.*) Refers to those members of the Eugregarinida which form aseptate trophozoites.

acervulus An asexual reproductive structure formed by certain plant-pathogenic fungi (see MELANCONIALES); an acervulus is essentially a mat of plectenchymatous tissue—or of plectenchyma and plant tissue—which supports a mass of densely-packed conidiophores. Acervuli commonly develop sub-cuticularly or sub-epidermally in the plant host; when mature, the mass of conidiophores forces an opening in the overlaying layer of host tissue—thus permitting dispersal of the conidia.

Acetabularia A genus of tropical or subtropical marine algae of the division CHLOROPHYTA. The vegetative organism consists of a single cell which is differentiated to form a vertical *stalk* (axis) (up to several centimetres in height) and a branching rhizoid-like structure which anchors the organism to the substratum; the single nucleus is located in one branch of the rhizoid. The cell wall, which is frequently calcified, contains mannan as a major component. As the stalk of the alga grows, whorls of sterile hair-like appendages develop around the distal end; subsequently these appendages are shed leaving rings of scars around the stalk. The nucleus increases in size by up to twenty times but does not divide until 'gametangia' begin to develop; at this point the nucleus undergoes many mitotic divisions to form numerous diploid nuclei. The gametangia occur as a whorl of elongated sac-like structures which (depending on species) may or may not be joined to form a characteristic cup-shaped structure (the *cap*) at the distal end of the stalk. The nuclei migrate from the rhizoid to the gametangia by cytoplasmic streaming; within each gametangium a large number of (diploid) *cysts* are formed. These cysts, which may have calcified walls, are liberated into the sea. Meiosis occurs within the cysts and numerous biflagellate, haploid isogametes are liberated; pairs of gametes fuse to form zygotes which subsequently germinate to form new individuals.

Acetobacter A genus of gram-negative, obligately aerobic, chemoorganotrophic, ovoid or rod-shaped, peritrichously flagellate (or non-motile) non-sporing bacteria of uncertain taxonomic affiliation. Species occur e.g. in a variety of fermented products; typically they oxidize ethanol to acetic acid, and acetic acid to carbon dioxide ('overoxidation'). (cf. ACETOMONAS) Optimum growth temperature: about 30 °C; optimum pH about 6. (see also CARR'S MEDIUM) In a recent classification, *A. aceti*, *A. orleanensis*, *A. liquefaciens*, and the cellulose-producing *A. xylinum* have been regarded as subspecies of one of three species, *A. aceti*. (see also VINEGAR)

acetoin (acetylmethylcarbinol) 2-Keto-3-hydroxybutane. Acetoin is formed e.g. during the BUTANEDIOL FERMENTATION (see also VOGES–PROSKAUER TEST), and in the metabolism of citrate by *Leuconostoc citrovorum* (= *L. cremoris*) (see also BUTTER).

Acetomonas (syn: *Gluconobacter*) A genus of gram-negative, obligately aerobic, chemoorganotrophic, ovoid or rod-shaped, polarly flagellate (or non-motile) non-sporing bacteria of the family Pseudomonadaceae. Species occur e.g. in a variety of fermented products. *Acetomonas* oxidizes ethanol to acetic acid (cf. ACETOBACTER) and glucose to gluconate. Optimum growth temperature: about 25 °C; optimum pH about 5.5. (see also CARR'S MEDIUM)

acetone–butanol fermentation (solvent fermentation) A type of fermentation carried out under certain conditions by certain saccharolytic *Clostridium* species—e.g. *C. acetobutylicum*. Initially, glucose is fermented as in the BUTYRIC ACID FERMENTATION—acetic acid, butyric acid, CO_2 and H_2 being formed. As the acidic products accumulate and the pH of the medium drops to about 4–4.5, acetone and *n*-butanol (butyl alcohol) replace the acids as major end products (see Appendix III(d)). This fermentation has been used as an important industrial source of acetone and butanol, but has now been superceded by alternative processes.

***N*-acetyl-D-glucosamine** (*N*-acetyl-(2-amino-2-deoxy-D-glucose)) An amino sugar which occurs in a wide range of structural polysaccharides—see e.g. CHITIN; HYALURONIC ACID; LIPOPOLYSACCHARIDES; PEPTIDOGLYCAN (q.v. for formula); TEICHOIC ACIDS.

acetylmethylcarbinol (see ACETOIN)

***N*-acetylmuramic acid** The 3-*O*-D-lactyl derivative of *N*-ACETYL-D-GLUCOSAMINE: a constituent of the polysaccharide backbone of PEPTIDOGLYCAN.

***N*-acetylmuramidase** (see LYSOZYME)

***N*-acetylneuraminic acid** (see NEURAMINIC ACIDS)

achlorophyllous (of an organism) Lacking chlorophyll.

Achlya A genus of fungi of the OOMYCETES.

Acholeplasmataceae A family of the Mycoplasmatales, class MOLLICUTES. Species of *Acholeplasma*, the sole genus, differ from members of the MYCOPLASMATACEAE in that they have no sterol growth requirements. *A. laidlawii* (formerly *Mycoplasma laidlawii*) is a pigmented saprophytic or parasitic organism.

achromatic objective (achromat) An objective lens (see MICROSCOPY) in which chromatic aberration has been corrected for *two* colours and spherical aberration for *one* colour. (cf. APOCHROMATIC OBJECTIVE)

Achromobacter anitratum (see ACINETOBACTER)

Achromobacter fischeri Obsolete name for *Vibrio fischeri*.

achromycin TETRACYCLINE. (see also TETRACYCLINES)

acicular Needle-shaped.

acid-fast organisms Those organisms (e.g. *Mycobacterium* spp.) which, once effectively stained by certain procedures (e.g. ZIEHL–NEELSEN'S STAIN), cannot be decolorized by mineral acids or mixtures of acid and ethanol. While some organisms are strongly acid-fast, others tend to be decolorized on prolonged treatment with acid-alcohol. (see also AURAMINE–RHODAMINE STAIN)

acid-fast stain (see ZIEHL–NEELSEN'S STAIN and AURAMINE–RHODAMINE STAIN)

Acidaminococcus A genus of bacteria of the family VEILLONELLACEAE.

acidosis (in ruminants) (see RUMEN)

Acineta A genus of protozoans of the SUCTORIA.

Acinetobacter A genus of gram-negative, aerobic, chemoorganotrophic, asporogenous, aflagellate bacteria of the family NEISSERIACEAE; the organisms occur as saprophytes in soil and water, and may be isolated from various animals, including man—in whom they may behave as opportunist pathogens. The cells are rod-shaped (approximately 2 × 1.5 microns) during exponential growth but tend to be coccoid in the stationary phase. The organisms are oxidase-negative and catalase-positive; they are insensitive to penicillin. Intracellular granules of poly-β-hydroxybutyrate are not formed. Metabolism is oxidative (respiratory); some strains attack certain carbohydrates with acid-production. (Acid-producing strains of *A. calcoaceticus*—the type species—have appeared in the literature as e.g. *Herellea vaginicola*, *Achromobacter anitratum*, and *Acinetobacter anitratum*. Strains of *A. calcoaceticus* which do not form acid include those formerly known as *Acinetobacter lwoffi* and *Mima polymorpha*.)

Aconta A proposed taxon which includes only members of the RHODOPHYTA (red algae). (cf. CONTOPHORA)

acquired immunity (*immunol.*) (1) *Specific* IMMUNITY acquired through exposure to an ANTIGEN. (2) NON-SPECIFIC IMMUNITY such as the condition in which INTERFERONS are synthesized following effective contact with viruses or other inducers. (3) Used also (loosely) to refer to PASSIVE IMMUNITY.

Acrasiales (see CELLULAR SLIME MOULDS)

Acrasida (see CELLULAR SLIME MOULDS)

acrasin (see DICTYOSTELIUM)

Acrasina (see CELLULAR SLIME MOULDS)

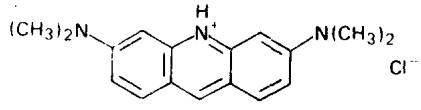
Acrasiomycetes (see CELLULAR SLIME MOULDS)

Acrasis A genus of the CELLULAR SLIME MOULDS.

acridine dyes (as antimicrobial agents) Many DYES of the *acridine* series—which include ACRIDINE ORANGE, proflavine (3,6-diaminoacridine) and ACRIFLAVINE—are bacteriostatic or bactericidal in low concentrations; such dyes appear to act by inhibiting the synthesis of nucleic acids (both DNA and RNA)—possibly by binding to the microbial DNA. A wide range of bacteria are susceptible—including gram-positive and gram-negative species. Some acridines are active against certain protozoa (e.g. *Plasmodium* spp.) and inhibit the normal replication of certain viruses.

acridine orange (*synonyms*: euchrysine; basic orange) A basic dye and FLUOROCHROME. (see also ACRIDINES (as MUTAGENS) and ACRIDINE DYES (as antimicrobial agents)) This dye can be used e.g. to demonstrate the nucleoid bodies in bacteria: in cells stained with acridine orange and viewed by fluorescence microscopy the DNA fluoresces *green* while the RNA fluoresces *orange-red*. (This differential reaction is apparently due to the fact that naturally occuring bacterial DNA is *double* stranded while the RNA is *single* stranded.)

Sub-lethal concentrations of the dye eliminate the F FACTOR in growing populations of F^+ bacterial donor cells.



Acridine orange

acridines (as MUTAGENS) Among *bacteriophages* acridine dyes are effective mutagenic agents; they cause PHASE-SHIFT MUTATIONS. A prerequisite for an acridine-induced mutation appears to be a breakage in one strand of a double-stranded nucleic acid—such as occurs during DNA replication or recombination. The mechanism of acridine-induced mutagenesis is not understood; it is usually assumed to result from the intercalation of dye molecules with the base residues of the nucleic acid.

Acridines are generally not effective mutagens in bacteria; however, compounds in

which an acridine nucleus is linked to an alkylating side chain (*ICR compounds*) induce in bacteria both insertions/deletions and point mutations.

acriflavine 3,6-Diamino-10-methylacridinium chloride: a basic yellow acridine dye and FLUOROCHROME. Acriflavine (which is soluble in water and in ethanol) has been used e.g. for the detection of smooth and rough strains of *Brucella*, for the induction of petite colonies of the yeast *Saccharomyces cerevisiae*, and as an antiseptic. (see also ACRIDINE DYES (as antimicrobial agents) and ACRIDINES (as mutagens))

acro- Prefix meaning tip, terminal, or outermost part.

acronematic Refers to a smooth *eucaryotic* FLAGELLUM which tapers to a fine point at the distal end.

acropetal (*mycol.*) (*adjective*) One of the modes in which a chain of spores may develop; in acropetal development the earliest-formed spores occupy positions in the chain nearest to the spore-bearing structure (e.g. conidiophore) while spores formed later occupy positions in the terminal or distal parts of the chain. (cf. BASIPETAL)

Actidione (*proprietary name*) (see CYCLOHEXIMIDE)

actin (see MACROTETRALIDES)

actino- A prefix signifying a ray, or rays.

Actinobacillus A genus of gram-negative, facultatively anaerobic, non-sporing bacteria of uncertain taxonomic affiliation; the cells are non-motile, pleomorphic bacilli, coccobacilli or cocci, and are usually less than 1.5 microns (maximum dimension). *A. lignieresii* is sometimes isolated from granulomatous lesions in cattle and sheep, and is the causal agent of 'wooden tongue'. (*A. muris* is now classified as *Streptobacillus moniliformis*, and *A. mallei* as *Pseudomonas mallei*.)

Actinobifida A genus of gram-positive, aerobic, thermophilic bacteria of the MICROMONOSPORACEAE; some species form *pigmented* mycelium, while all species form dichotomously-branched sporophores.

Actinobolina (*Actinobolus*) A genus of protozoans of the RHABDOPHORINA.

Actinomyces A genus of gram-positive bacteria of the ACTINOMYCETACEAE; the organisms—rods or branched filaments—are anaerobes with varying degrees of aerotolerance. Some species can be pathogenic—e.g. *A. bovis*, the causal agent of LUMPY JAW.

Actinomycetaceae A family of non-sporing, non-motile, non-acid fast, gram-positive bacteria of the ACTINOMYCETALES; species form readily-fragmenting filaments but do not form mycelium. The family includes aerobic, facultatively anaerobic, and anaerobic species. Genera include ACTINOMYCES, BIFIDOBACTERIUM and *Rothia*.

Actinomycetales (the actinomycetes*) An order of bacteria in which species form branching filaments and/or true mycelium; species are found e.g. in the soil—thermophilic species occurring in decaying vegetation and compost. The organisms differ from fungi e.g. in that they are procaryotic, have bacterial-type cell walls, and are inhibited by antibacterial agents; hyphae (when formed) are thin—commonly 1 micron or less in diameter, maximum about 2 microns—and flagella (when formed) are of the simple bacterial type. The organisms are gram-positive or gram-variable, the former sometimes becoming gram-negative in ageing cultures; some species are ACID FAST. Members of the Actinomycetales are chemo-organotrophs; substances attacked by various species include agar, cellulose, chitin, paraffins, and rubber. The majority are saprophytes, but some species are pathogenic for man, animals or plants; diseases incited by various species include JOHNE'S DISEASE, LUMPY JAW, TUBERCULOSIS, and common scab of POTATO. Most species of the Actinomycetales are aerobic, and some produce spores. Some species (Frankiaceae) form nitrogen fixing associations with higher plants (see ROOT NODULES). Many synthesize important ANTIBIOTICS, e.g. ERYTHROMYCIN, STREPTOMYCIN.

Eight families are distinguished: ACTINOMYCETACEAE, ACTINOPLANACEAE, DERMATOPHILACEAE, Frankiaceae, MICROMONOSPORACEAE, MYCOBACTERIACEAE, NOCARDIACEAE, and STREPTOMYCETACEAE. The chemical nature of the cell wall is a taxonomically-important feature among members of the Actinomycetales. Thus, four cell wall types have been distinguished: Type I species contain LL-2,6-diaminopimelic acid (LL-DAP) and glycine, Type II contain *meso*-DAP and glycine, Type III contain *meso*-DAP, and Type IV contain *meso*-DAP, arabinose and galactose. *The term 'actinomycetes' is often used in a sense which excludes members of the Mycobacteriaceae.

actinomycetes (see ACTINOMYCETALES)

actinomycins A group of ANTIBIOTICS produced by *Streptomyces* spp; each contains a substituted phenoxazone ring system (a red *chromophore* group) linked to two cyclic peptides—each incorporating a lactone bond. The principal member of the group is *actinomycin D* (= actinomycin C_1) which has two identical pentapeptide lactones. The actinomycins are extremely toxic to many types of cell—although certain organisms (e.g. some gram-negative bacilli) exhibit resistance; such

resistance is presumably due to the impermeability of these organisms to the drug. Actinomycins also exhibit antitumour activity. The actinomycins inhibit DNA-directed RNA synthesis (and thus, eventually and indirectly, PROTEIN SYNTHESIS). Specifically they bind to *double-stranded* helical DNA—thus probably preventing the movement of RNA polymerase along the DNA template, i.e. chain *elongation* is prevented. (DNA replication may also be inhibited by considerably higher concentrations.) Actinomycin D is a useful biochemical tool in the study of nucleic acid synthesis.

actinomycosis Any disease, of man or other animals, in which the causal agent is a member of the ACTINOMYCETALES (excluding the genus *Mycobacterium*); examples include LUMPY JAW (*Actinomyces bovis*) and some cases of MADURA FOOT (*Nocardia, Streptomyces*).

Actinophrys sol (see HELIOZOANS)

Actinoplanaceae A family of mycelium-forming, non-acid fast bacteria of the ACTINOMYCETALES. The organisms are gram-positive, obligately-aerobic chemo-organotrophs which occur e.g. in humus-rich soils; spores—which are motile or non-motile, according to species—are formed in closed sacs (*sporangia*) at the tips of branched or unbranched aerial hyphae. The size and shape of the sporangia (and spores) depend on species; each sporangium may contain several to many hundreds of spores.

Actinosphaerium (see HELIOZOANS)

actins (see MACROTETRALIDES)

activated sludge process (see SEWAGE TREATMENT)

activation (of bacterial spores) (see SPORES (bacterial))

active bud (see LIPOMYCES)

active immunity *Specific* IMMUNITY afforded by the body's own immunological defence mechanisms following exposure to antigen. (cf. PASSIVE IMMUNITY)

active immunization (see IMMUNIZATION)

active transport (see TRANSPORT)

acute (*adjective*) (of diseases) Refers to any disease which has a rapid onset and which persists for a relatively short period of time (e.g. days, weeks) terminating either in recovery or death. Examples of acute diseases include CHOLERA and bovine ANTHRAX. The term is also used to denote an exceptionally severe or painful condition. (cf. CHRONIC)

acute-phase serum Serum derived from blood taken from a patient in the acute phase of a disease.

Acytostelium A genus of the CELLULAR SLIME MOULDS.

α-adamantanamine (amantadine) A polycyclic compound which inhibits certain VIRUSES in tissue culture (e.g. some influenza viruses). Adamantanamine is believed to act at some stage during the penetration of the host cell by the virus; it appears not to prevent adsorption of the virus to the cell surface. Adamantanamine hydrochloride has been used clinically in the prophylaxis and treatment of influenza caused by the A2 strain of INFLUENZA VIRUS—A/Singapore/1/57(H2N2); it is more effective as a prophylactic than as a therapeutic agent. (see also ANTIVIRAL AGENTS)

Adansonian taxonomy A method of classifying organisms proposed by Michel Adanson in the 18th Century. Relationships between organisms are defined by the *number* of characteristics which each organism has in common with those organisms with which it is compared—the same degree of importance being attached to all characteristics used in the comparison. (This contrasts with other systems of classification in which certain characteristics are considered to be of greater significance than others.) The modern application of this concept has been termed NUMERICAL TAXONOMY.

adaptation (*microbiol.*) Change(s) in an organism, or population of organisms, through which the organism(s) become more suited to the prevailing environmental conditions. (a) *Genetic adaptation* involves mutation and selection: in a given population, those organisms which are genetically more suited to the existing environment thrive and become numerically dominant. This results from the selection of preexisting mutants which arise, spontaneously, in any population of viable organisms. (b) *Non-genetic* (*phenotypic*) *adaptation* occurs independently of genotype. An organism which adapts non-genetically undergoes a change in metabolic activity, e.g. by enzyme induction or repression—see OPERON. (see also DIAUXIE)

Adeleina (Adeleorina) (*protozool.*) A sub-order of protozoans of the EUCOCCIDIA; species are distinguished from those of the other sub-orders by the occurrence of SYZYGY.

adenosine-5′-monophosphate (AMP) (biosynthesis of) (see Appendix V(a))

adenosine-5′-triphosphate (see ATP)

Adenovirus A genus of VIRUSES whose hosts include a variety of vertebrates—including man (and other primates), bovines, rodents, and fowl. The icosahedral *Adenovirus* virion is 70–80 nm in diameter; the capsid consists of 252 capsomeres and encloses a genome of linear double-stranded DNA. Each PENTON carries a projecting protein *fibre* which terminates in a distal knob. (Two such fibres, per penton, occur in the CELO virus—an avian strain.) The *Adenovirus* virion is non-enveloped and is ether-resistant. Human strains of *Adenovirus* share a common antigen. Many

adenoviruses agglutinate the erythrocytes of the rat and/or rhesus monkey. Adenoviruses are assembled within the *nucleus* of a host cell; they can be cultivated readily in certain tissue cultures—e.g. those prepared from human amnion, human embryonic kidney, HeLa, HEp-2 (for human strains) and chick embryo kidney (for avian strains). Cytopathic effects (CPE) in tissue cultures typically include rounding of cells and the clumping of cells to form grape-like clusters. In man, adenoviruses are associated with e.g. some instances of acute respiratory tract infection and conjunctival disease, and with latent infections of the lymphoid tissues; some human strains of *Adenovirus*—and the CELO virus—can induce tumours in newborn rodents.

adjuvant (*immunol.*) Any substance which, when administered with (or before) an antigen, heightens, or affects *qualitatively*, the immune response to that antigen. Adjuvants are commonly administered with the object of increasing the *immunogenicity* of an antigen in order to stimulate a higher rate of antibody formation (or a more vigorous response in cell-mediated immunity) in respect of that antigen. Examples of adjuvants include aluminium hydroxide gel, certain alums, and water-in-oil emulsions. (see also FREUND'S ADJUVANT)

adnate (*mycol.*) In an agaric: refers to a gill the lower edge of which does not appreciably curve upwards or downwards as it approaches the stipe (to which it is attached).

adnexed (*mycol.*) In an agaric: refers to a gill the lower edge of which curves upwards as it approaches the stipe (to which it is narrowly attached).

adonitol Synonym of *ribitol*, a reduction product of ribose.

adoptive immunity Synonym of PASSIVE IMMUNITY.

adoral zone of membranelles (see AZM)

adsorption (*immunol.*) *Non-specific* adherence of substances (in solution or suspension) to cells or other forms of particulate matter. (cf. ABSORPTION) (see also BOYDEN PROCEDURE)

aecidiospores (aeciospores) (see RUSTS (1))

aecidium (*pl.* aecidia) An *aecium*—see RUSTS (1)

aeciospores (see RUSTS (1))

aecium (see RUSTS (1))

Aedes aegypti A species of mosquito (order Diptera, suborder Orthorrhapha, family Culicidae); one of the vectors of YELLOW FEVER. *A. simpsoni* and *Haemagogus* spp are among the other (mosquito) vectors of this disease.

aequihymeniiferous (aequihymenial) (see GILLS)

aerial mycelium (*bacteriol.*) In certain actinomycetes: that part of the mycelium which projects above the level of the medium (cf. SUBSTRATE MYCELIUM).

Aerobacter An obsolete bacterial genus; many of the organisms previously referred to as *Aerobacter* spp. are currently classified as species of *Klebsiella* or *Enterobacter*.

aerobe Any organism which grows in the *presence* of air or oxygen; a *strict* aerobe grows *only* under such conditions. (see also FACULTATIVE; cf. ANAEROBE)

aerobic (*adjective*) (1) (of an environment) Refers to an environment in which the partial pressure of oxygen is similar to that which occurs under normal atmospheric conditions (cf. ANAEROBIC and MICROAEROPHILIC). (2) (of organisms) See: AEROBE (see also FACULTATIVE).

Aerococcus A genus of the STREPTOCOCCACEAE.

aerogenic (*adjective*) Refers to those organisms which form gas (as well as other metabolic by-products) from particular substrates.

Aeromonas A genus of gram-negative, oxidase-positive, catalase-positive bacteria of the VIBRIONACEAE; the cells may be round-ended rods (approx. 1–4 × 0.5–1 microns) or short filaments. A single polar flagellum is usually present. All species are insensitive to O/129 (cf. *Vibrio*), all liquefy gelatin, and none produce acid from inositol (cf. *Plesiomonas*). Some strains form acid from glucose. Most strains fail to grow in media containing 7.5% NaCl. Growth occurs on common bacteriological media (e.g. nutrient agar); optimal growth temperature : 20–30 °C.

aerotaxis A particular form of CHEMOTAXIS in which a (motile) organism migrates along a concentration gradient to a location where the concentration of oxygen is optimal.

aerotolerant (*adjective*) Refers to an ANAEROBE which can (i) survive, but not grow, in the presence of oxygen (i.e. an aerotolerant OBLIGATE anaerobe), or (ii) grow, at sub-optimal rates, under aerobic conditions. (cf. MICROAEROPHILIC)

aeruginocins (pyocins) BACTERIOCINS produced by *Pseudomonas aeruginosa*.

aesculin The 6-β-D-glucosyl derivative of 6,7-dihydroxycoumarin. Aesculin is hydrolysed e.g. by certain streptococci (e.g. many strains of group D) to yield 6,7-dihydroxycoumarin—which gives a brown coloration with soluble ferric salts. (see also AESCULIN BROTH)

aesculin broth and agar *Broth*: PEPTONE WATER containing 0.1% AESCULIN and 0.05% ferric citrate sterilized at 115 °C/10 minutes. *Agar*: the broth gelled by 2% agar.

aethelium (see ACELLULAR SLIME MOULDS)

aetiology (*American*: etiology) The study of *causation*; the aetiological agent of an infectious disease is that organism which incites or causes the disease.

affinity (*immunol.*) The strength with which an

antibody binds to a simple, monovalent hapten or to one determinant of an antigen; factors which effect the strength of binding include the size (area) of the combining site, the closeness of fit, and the nature and strength of the intermolecular forces (e.g. van der Waals' forces). (cf. AVIDITY)

affinity labelling A technique used to identify the precise location of the COMBINING SITE of an antibody. In one form of affinity labelling the antibody is allowed to combine with an homologous HAPTEN (the 'affinity label') which, on subsequent irradiation, forms a covalent bond with the antibody; the point of attachment of the hapten to the antibody (i.e. the combining site) is then determined by chemical analysis following separation of the heavy and light chains. (In this particular method the (aromatic) hapten carries an azide side-chain which, on irradiation with u.v. light, forms the highly reactive *nitrene* group which readily combines (non-specifically) with any of a wide variety of organic groups.)

aflatoxins A range of low-M.Wt. compounds (M.Wt. in the region of 350) produced by strains of *Aspergillus flavus* and *A. parasiticus*; the aflatoxin molecule contains a coumarin-bifuran nucleus. Aflatoxins are toxic and carcinogenic for a range of animals. Aflatoxin-contaminated foodstuffs (particularly cereals and peanuts) have caused outbreaks of food-intoxication among cattle, pigs, etc. In England, in the 1960s, a high incidence of fatal aflatoxin poisoning among turkey poults (*turkey X disease*) was traced to a contaminated groundnut feed; symptoms of turkey X disease include lack of appetite and general weakness, and necrotic liver lesions are found *post mortem*.

Aflatoxins are soluble in organic solvents; some are fluorescent. (see also FOOD POISONING (fungal))

ag (*immunol.*) Antigen.

agar A complex sulphated galactan which is widely used (in *gel* form) as a base for many kinds of solid and semi-solid microbiological MEDIUM. Agar contains two main components: *agarose* and *agaropectin*. Agarose consists of linear chains of alternating residues of 1,3-linked β-D-galactose and 1,4-linked 3,6-anhydro-L-galactose. The structure of agaropectin has not been determined; it may consist of a mixture of polysaccharides and contains D-galactose, 3,6-anhydro-L-galactose, and mono-esterified sulphuric acid.

An agar gel is a translucent or transparent jelly-like substance formed when a mixture of agar and water is heated to above 100 °C and subsequently cooled; gelling occurs at about 45 °C. Agar media usually contain 1.5% to 2% w/v agar in water—though *semi-solid* agar contains 0.5% or less. *Stiff* agars contain e.g. 8% w/v agar. (The above concentrations refer to Japanese agars; when using New Zealand agar the above quantities should be halved to give gels of similar strengths.) Sterile gels are prepared by autoclaving (see AUTOCLAVE) a suspension of agar in water; the addition of nutrients and other substances, prior or subsequent to autoclaving, enables the gel to support the growth of particular types of microorganism (see e.g. NUTRIENT AGAR). Various agar-based media are used e.g. for the selective culture of particular organisms and for the display of particular cultural features (e.g. colony form) which assist in the identification of microorganisms. *Blood agar* is made by mixing 5–10% (v/v) citrated or defibrinated blood with molten agar (at about 50 °C) and allowing it to set. Culturing on blood agar allows the detection of bacterial *haemolysin* production; since a given microbial haemolysin may be active only against the erythrocytes of particular species (e.g. horse, sheep) the choice of blood is important. (see also CHOCOLATE AGAR) *Ion-free agar* is a refined form of agar used e.g. in *immunoelectrophoresis*.

Agar is produced by certain species of the Rhodophyta (red algae)—e.g. *Gelidium*. (The term 'agar' derives from the Malay 'agar-agar' which refers to certain edible seaweeds.) The ability to degrade agar is confined to a few organisms—including certain strains of *Streptomyces coelicolor*, certain marine vibrios, and marine species of *Cytophaga*.

agar gel diffusion (see GEL DIFFUSION)

agar plate (see PLATE)

agaric (1) Any fungus of the order AGARICALES. (2) Any *gill-bearing* member of the Agaricales—particularly those species which are mushroom-shaped (as opposed to species which are non-stipitate or which have a laterally situated stipe).

Agaricaceae A family of fungi of the order AGARICALES. Constituent species form fruiting bodies in which the gills are free or almost free from the stipe, in which an annulus is typically present, and in which the basidiospores (which *lack* an apical germ pore) are dark chocolate brown or of a similar *dark* coloration; the stipe separates cleanly from the cap. A UNIVERSAL VEIL is not formed. The genera include e.g. AGARICUS.

Agaricales An order of fungi of the sub-class HOLOBASIDIOMYCETIDAE. Constituent species form well-developed fruiting bodies which are typically gymnocarpic* and in which the hymenium occurs on the surfaces of GILLS (lamellae), lines the tubules of porous tissue (which is *easily* detached from the remainder of the pileus—cf. APHYLLOPHORALES), or (exceptionally) covers a smooth hymenophore; the holobasidia bear small, inconspicuous

sterigmata. The basidiocarp is typically 'mushroom-shaped'—i.e. consists of a discoid, convex, conical, or umbonate pileus, with radially arranged gills on the underside, supported on a thin or stout stipe; the stipe is typically central but may be eccentric or lateral, or may be absent—according to species. The fruiting body is fleshy in the great majority of species; species which form tough or leathery fruiting bodies do not form porous hymenophores. Members of the Agaricales are typically saprophytic fungi which occur principally on soil and wood. The families of the order include e.g. AGARICACEAE, AMANITACEAE, BOLETACEAE, COPRINACEAE, HYGROPHORACEAE, Lepiotaceae, Paxillaceae, RUSSULACEAE, Strophariaceae, TRICHOLOMATACEAE. *The order now includes a number of species whose fruiting bodies are essentially angiocarpic or 'semiangiocarpic'; during at least certain stages, the fruiting bodies of these organisms—*Secotium* and other 'secotioid gasteromycetes'—develop in a manner analogous to that of the agarics. Thus, e.g. the early stages of fruiting body development in *Secotium agaricoides* correspond closely with those in *Agaricus*; however, in the mature fruiting body of *S. agaricoides* only remnants of the gill tissue may remain, and the statismospores are released into the unopened peridium—which subsequently disintegrates.

Agaricus A genus of fungi of the family AGARICACEAE; the organisms include a number of edible species (see MUSHROOM)—though some species are reported to be poisonous. The spores are dark chocolate brown; the gills are pinkish when immature.

agaropectin A component of AGAR.

agarophyte (agarphyte) Any AGAR-producing seaweed.

agarose A component of AGAR.

agglutination (*immunol.*) The formation of visible clumps of *particulate* antigens (e.g. bacteria, red blood cells) following the linkage of the antigen particles by specific antibodies (or other factors which have agglutinating properties—e.g. LECTINS). (cf. PRECIPITATION; see also HAEMAGGLUTINATION and PASSIVE AGGLUTINATION) Agglutinated particles may form a mat or reticulum over a relatively large area of the bottom of the test tube in which agglutination has occurred; by contrast, non-agglutinated particles form a smaller, dense button in the control tube.

agglutinin (*immunol.*) Any substance, usually an ANTIBODY, which brings about the AGGLUTINATION of *particulate* antigens, e.g. bacteria. (see also LECTINS)

agglutinogen (*immunol.*) The antigen which stimulates the production of a particular agglutinin.

aggressins Diffusible substances or cellular components produced by certain pathogenic microorganisms; aggressins promote the invasiveness of a pathogen. An aggressin may e.g. protect a pathogen from phagocytosis, or it may enable the pathogen to resist intracellular digestion within a phagocyte.

aglycon The non-sugar portion of a glycoside.

Agonomycetes (*Mycelia Sterilia*) A class of fungi within the sub-division DEUTEROMYCOTINA. Constituent species were originally distinguished from those of other classes in that they appeared not to produce reproductive structures of any kind (either sexual or asexual); however, since the inception of the *Mycelia Sterilia*, a number of species have been found to have an ascomycete or basidiomycete sexual stage. Constituent species include a number of plant pathogens—e.g. species of RHIZOCTONIA and SCLEROTIUM.

agranulocyte Any white blood cell which has a non-granular cytoplasm, e.g. a *lymphocyte*.

Agrobacterium A genus of gram-negative, aerobic, non-sporing, rod-shaped bacteria of the family Rhizobiaceae. Cells have either several (peritrichous) flagella or a single (commonly non-polar) flagellum. *Agrobacterium* species (all chemoorganotrophs) are found in the soil; most strains can initiate plant GALLS. (The type species, *A. tumefaciens*, causes CROWN GALL.) Growth on nutrient media is non-pigmented; in the presence of carbohydrates it is often highly mucoid. The temperature optimum is about 25 °C and the pH range wide. *Agrobacterium* spp do not fix nitrogen (cf. *Rhizobium*).

AHG (*immunol.*) Anti-human globulin—an antibody against human globulin.

air bladders, vesicles (see PNEUMATOCYSTS)

Ajellomyces dermatitidis (see BLASTOMYCES DERMATITIDIS)

akinete (1) In blue-green algae: a thick-walled spore, commonly larger than a vegetative cell, which is rich in food reserves; akinetes are often formed adjacent to heterocysts. An akinete is appreciably resistant to desiccation; it germinates to form a *hormogonium*. (2) (*mycol.*) A non-motile spore or resting cell.

alamethicin A cyclic polypeptide which shows ANTIBIOTIC activity against gram-positive bacteria, apparently by acting as an IONOPHORE.

alanine (biosynthesis of) (see Appendix IV(b))

alastrim (amaas) (see SMALLPOX)

alazopeptin (see 6-DIAZO-5-OXO-L-NORLEUCINE)

albamycin Synonym of NOVOBIOCIN.

Albert's stain A stain used for the demonstration of METACHROMATIC GRANULES; Albert's stain is used e.g. as an aid to the identification of

Corynebacterium diphtheriae. Two solutions are used: (a) Albert's stain: toluidine blue (0.15 g) and MALACHITE GREEN (0.2 g) are dissolved in 95% ethanol (2 ml); this is added to 1% glacial acetic acid (100 ml) and the whole filtered after standing for 24 hours. (b) LUGOL'S IODINE. The smear is stained with Albert's stain for 3–5 minutes, washed in tap water, and blotted dry; Lugol's iodine is applied and left for 1 minute, and the smear is subsequently washed and blotted dry. Granules stain darkly (or black); cytoplasm stains pale green.

albomycin (see SIDEROMYCINS)

Albugo A genus of fungi within the class OOMYCETES; *Albugo* spp. are obligate parasites and pathogens of a range of higher plants—e.g. cabbage, horse-radish, mustard. *A. candida* (economically the most important species) forms a well-developed, branched, aseptate mycelium within the tissues of the host; the (*inter*cellular) mycelium abstracts nutrients from the host by means of spherical haustoria. Asexual reproduction involves the formation of chains of multinucleate sporangia which develop, basipetally, on short club-shaped sporangiophores beneath the epidermis of the host plant; the compacted masses of sporangia appear as white 'blisters' on the surface of the host plant. When mature, the sporangia form a loose powdery mass which, on rupture of the host's epidermis, is dispersed by wind and rain. On germination, each sporangium produces a number of zoospores. Sexual reproduction is initiated when parts of the intercellular thallus differentiate to form an oogonium and an adjacent antheridium; subsequently, a fertilization tube is established between the two gametangia, and plasmogamy and karyogamy precede the development of a thick-walled oospore. Meiosis occurs within the oospore. On germination an oospore liberates a number of biflagellate zoospores.

albumen The white of an egg. (cf. ALBUMINS)

albumins A class of proteins. (cf. ALBUMEN)

Alcaligenes (*Alkaligenes*) A genus of gram-negative, aerobic, non-fermentative, chemoorganotrophic*, non-sporing bacteria of uncertain taxonomic position; *Alcaligenes* spp. are common in the mammalian intestine and in soil and aquatic environments. The cells are rod-shaped or coccoid, maximum size about 1.2 × 2.5 microns; they are sparsely flagellated. Growth occurs e.g. on nutrient agar at pH7, 37 °C. *Alcaligenes* spp. may oxidize glucose but do not form acid in glucose peptone water; they are oxidase positive. GC ratio: 58–70%. **A. eutrophus* can grow chemoautotrophically when provided with hydrogen, oxygen, and carbon dioxide.

alcoholic fermentation (ethanol fermentation) A type of fermentation carried out by a range of fungi—e.g. yeasts (including *Saccharomyces*) and species of *Aspergillus*, *Fusarium*, and *Mucor*. In the alcoholic fermentation glucose is converted to ethanol and carbon dioxide; small amounts of other compounds (e.g. glycerol) may be formed. Initially, glucose is converted to pyruvate *via* the EMBDEN–MEYERHOF–PARNAS PATHWAY. Subsequently pyruvate is decarboxylated to acetaldehyde in a reaction catalysed by pyruvate decarboxylase and thiamine pyrophosphate; the acetaldehyde is reduced to ethanol by a NAD-dependent alcohol dehydrogenase—resulting in the reoxidation of the $NADH_2$ formed during the EMP pathway. Alcoholic fermentation by *Saccharomyces* spp. has been used in the commercial production of ethanol. (cf. ZYMOMONAS; see also BREWING; CIDER; WINEMAKING; GLYCEROL, MICROBIAL PRODUCTION OF)

alcohols (as antimicrobial agents) Under appropriate conditions, alcohols may be rapidly bactericidal, fungicidal, or virucidal (to certain viruses); they are virtually without effect on spores. The mechanism of antimicrobial activity may involve the denaturation of structural or enzymic proteins and/or a solubilizing effect on the lipids of the bacterial or fungal CELL MEMBRANE or on those of the ENVELOPE of certain viruses (e.g. influenza viruses). The antimicrobial activity of alcohols increases with molecular weight and with chain length up to about C8 or C10; above this, insolubility becomes an important factor. Activity decreases in the order: primary → *iso*-primary → secondary → tertiary. Penetration tends to be poor and alcohols are unsuitable for use in the presence of organic matter. *Ethanol* exerts maximum antimicrobial activity at 60–95% (by volume) in an ethanol–water mixture. *Isopropyl alcohol* ($CH_3.CHOH.CH_3$) is less volatile and somewhat more effective than ethanol; it is used primarily as a skin antiseptic. *Phenoxyethanol* (Phenoxetol) and *benzyl alcohol* are used as preservatives in pharmaceutical preparations. The activity of benzyl alcohol is improved by halogenation: 2,4-dichlorobenzyl alcohol is used as a skin antiseptic. *Ethylene glycol*, *propylene glycol*, and *trimethylene glycol* (dihydric alcohols) have been used, in aerosol form, for the disinfection of air; a relative humidity of some 60% is required. *Glycerol* (a trihydric alcohol) is bacteriostatic at concentrations above 50%; it has been used as a preservative in vaccines. (see also DISINFECTANTS and STERILIZATION)

Alectoria A genus of fruticose LICHENS in which the phycobiont is *Trebouxia*; the thallus may be attached to the substratum by a holdfast. Apothecia are rarely formed. Species include e.g.:

A. fuscescens. The thallus is brown to black, glossy, filamentous, branching, pendulous or entangled, and may reach 20 centimetres in length; small greenish-white soralia are generally present. *A. fuscescens* occurs on trees, fences, and occasionally on rocks.

Aleuria A genus of fungi of the order PEZIZALES; the organisms form sessile or stipitate, discoid or cup-shaped, minute or conspicuous apothecia in which the hymenium may be red, orange, or yellow.

aleuriospore (*mycol.*) A type of spore which is liberated from the sporophore by breakage of the latter close to its junction with the spore.

alexin (1) (*immunol.*) A historical term for COMPLEMENT. (2) (*plant pathol.*) (see PHYTOALEXINS)

algae An heterogenous group of *eucaryotic*, photosynthetic, unicellular and multicellular organisms. (cf. BLUE-GREEN ALGAE and PROCHLOROPHYTA) Algae resemble higher plants e.g. in that oxygen is evolved during PHOTOSYNTHESIS (cf. RHODOSPIRILLALES) and in that algal photosynthetic pigments invariably include CHLOROPHYLL *a*; the multicellular algae differ from vascular plants e.g. in that they lack the specialized conducting systems characteristic of the latter—though phloem (but not xylem) occurs in some of the larger seaweeds. Algae differ from bryophytes (mosses, liverworts) e.g. in that the algal reproductive structure, when formed, lacks the peripheral envelope of sterile cells found in analogous structures in every bryophyte—though see Charophyta, below. Some organisms have characteristics intermediate between those of algae and PROTOZOA. The aquatic algae occur in fresh, brackish, and/or marine waters—according to species—where they are of major ecological importance as primary producers (see also PLANKTON); terrestrial algae occur e.g. on damp soil, on ice and snow (the 'cryoflora'), on rocks, tree-trunks etc., and as the phycobionts of LICHENS. Apart from their ecological significance, algae are useful to man e.g. as sources of AGAR, ALGINIC ACID, CARRAGEENAN, FUNORAN, and FURCELLARAN; iodine (as iodide) has been extracted from the ash of burnt seaweed. (see also DIATOMACEOUS EARTH and MICROORGANISMS AS FOOD) A few algae are pathogenic—see e.g. RED RUST.

Algae are classified on the basis of their pigments, type of food reserve material, type and arrangement of flagella, CHLOROPLAST ultrastructure, and CELL WALL composition. The algal divisions are BACILLARIOPHYTA, CHAROPHYTA, CHLOROPHYTA, CHRYSOPHYTA, Cryptophyta, DINOPHYTA, EUGLENOPHYTA, HAPTOPHYTA, PHAEOPHYTA, Prasinophyta, RHODOPHYTA and XANTHOPHYTA. (Some authors divide the algae into a number of *classes* which correspond with the above divisions—e.g. Bacillariophyceae, Charophyceae, etc.)

According to species algae range in size from unicellular organisms (several microns in diameter) to the largest seaweeds (some 50 or more metres in length). Unicellular species occur in most of the algal divisions; none occurs in the Phaeophyta. In certain unicellular species (e.g. the amoeboid alga *Rhizochrysis*) the thallus (i.e. algal body) is naked—i.e. it lacks a cell wall; in many other unicellular algae (e.g. *Chlamydomonas*, *Chlorella*)—and in all multicellular algae—a cell wall is present (see CELL WALL (algal) for details). The multicellular algae exhibit great diversity of form. Examples of common morphological types include (a) the branched or unbranched *filament*—i.e. one or more chains of cells which form a thread-like or ribbon-like thallus (e.g. *Cladophora*, *Spirogyra*); (b) the *parenchymatous* thallus—i.e. a sheet of cells one or more cells thick (e.g. *Ulva*), or a tubular arrangement of cells (e.g. *Enteromorpha*); (c) the SIPHONACEOUS thallus. Some multicellular algae exhibit considerable differentiation; thus, e.g. in certain seaweeds (e.g. *Laminaria* spp.) the thallus includes root-like, stem-like, and leaf-like structures (the *holdfast*, *stipe*, and *lamina* (*blade*) respectively) and a conducting system, the *phloem*. (see also PNEUMATOCYST) (Some differentiation also occurs e.g. in the *unicellular* alga ACETABULARIA.) In the multicellular algae meristematic tissue may occur in apical, intercalary, and/or diffuse regions—according to species and to the stage of development. Algae may be non-motile (e.g. *Chorella*, *Scenedesmus*, members of the Rhodophyta) or motile (e.g. *Chlamydomonas*, *Euglena*, *Ochromonas*, *Volvox*); according to species, flagellate vegetative cells (and gametes) may have one, two or more flagella of equal or unequal length. (see also *diatoms* under MOTILITY) Some algae exhibit colonial organization—see COENOBIUM, PALMELLOID STAGE, and TETRASPORAL COLONY.

Although normally photosynthetic a number of algae can grow, in the dark, on certain organic substrates e.g. glucose and/or acetate—i.e. they behave as facultative chemoorganotrophs; such algae include species of *Chlamydomonas*, *Chlorella*, *Nitzschia*, and *Scenedesmus*. (Facultative chemoorganotrophy could be important to algae under conditions of low light intensity.) Chemoorganotrophy has not been demonstrated e.g. in members of the Phaeophyta. Under certain conditions some algae (e.g. *Scenedesmus* spp, *Ulva* spp.) carry out PHOTOREDUCTION.

Asexual reproduction. In some filamentous and colonial algae (e.g. *Spirogyra*, *Synura*) asexual reproduction occurs by fragmentation—a process referred to by some authors as *vegetative* reproduction. Some of the many modes of asexual reproduction are given in the entries CHLAMYDOMONAS, CHLORELLA, SCENEDESMUS, VAUCHERIA, and VOLVOX.

Sexual reproduction. For some examples of modes of sexual reproduction see ACETABULARIA, CHLAMYDOMONAS, SPIROGYRA, and VOLVOX. In members of the Charophyta sexual reproduction is strictly oogamous; according to species a given thallus may contain the gametangia of one or both sexes. This group is characterized by a complex multicellular male gametangium which is enclosed by an envelope of sterile cells (*shield cells*); such a structure is atypical of the algae, and it has been argued by some authors that members of the Charophyta should be excluded from the algae on this basis. AUTOGAMY can occur in certain diatoms. Sexual reproduction has not been observed in members of the Euglenophyta or e.g. in *Chlorella* and *Pleurococcus* or certain genera of the Bacillariophyta.

Many algae exhibit an ALTERNATION OF GENERATIONS; such algae may produce sporophytes and gametophytes which are morphologically similar (e.g. *Ectocarpus*, *Ulva*) or morphologically dissimilar (e.g. *Laminaria*). The vegetative cells of certain algae (e.g. *Chlamydomonas*, *Chlorella*, and many other green algae) are haploid; the *siphonaceous* green algae and e.g. all diatoms have diploid vegetative cells.

algicides Chemical agents which (selectively) kill algae. Algicides are used e.g. to inhibit algal growth in swimming pools (e.g. copper sulphate, DICHLONE) and in reservoirs (see BLOOM) and as components of the anti-fouling paints used on ships' hulls (e.g. THIURAM DISULPHIDE and tributyltin oxide, $(C_4H_9)_3Sn.O.Sn(C_4H_9)_3$).

alginic acid A complex polysaccharide which contains β-(1 → 4)-linked D-mannuronic acid residues and α-(1 → 4)-linked L-guluronic acid residues. Alginates are associated with the cell wall in members of the Phaeophyta. Alginic acid is insoluble in water, but certain alginates (e.g. sodium alginate) are readily soluble; gels are formed in the presence of calcium ions. Alginates have a wide range of industrial uses, e.g. in cosmetics, pharmaceuticals, and as emulsifiers or thickeners in foodstuffs. Certain bacteria (e.g. *Nocardia* spp.) can degrade alginates. (see also SWABS)

aliphatic hydrocarbons (microbial utilization of) A wide range of microorganisms can use aliphatic hydrocarbons as substrates for growth. Straight-chain paraffins (*n*-alkanes) appear to be the most widely used, but branched-chain paraffins (alkyl-alkanes) and unsaturated hydrocarbons (alkenes) can also be used by some organisms; in general, long-chain hydrocarbons (e.g. C_{10}) are more readily utilized than are short-chain hydrocarbons. (see also METHANE (microbial utilization of)) Microorganisms which can degrade aliphatic hydrocarbons include e.g. certain species of the bacteria *Actinomyces*, *Corynebacterium*, *Mycobacterium*, *Nocardia*, *Pseudomonas*, of the yeasts *Candida*, *Debaromyces*, *Hansenula*, *Pichia*, and *Torulopsis*, and of the filamentous fungi *Aspergillus*, *Botrytis*, *Cladosporium*, *Fusarium*, *Helminthosporium*, and *Penicillium*. Hydrocarbon metabolism is a strictly aerobic process and appears to occur most commonly by *omega-oxidation*: a terminal methyl group of the hydrocarbon is oxidized—in a reaction involving a mono-oxygenase—to form a primary alcohol. (In *Pseudomonas* spp, for example, the *omega*-oxidation enzyme system is complex and involves a mono-oxygenase (hydroxylase), the iron–sulphur protein *rubredoxin*, and an FAD-containing $NADH_2$-rubredoxin oxidoreductase.) The alcohol is oxidized to the corresponding fatty acid which can undergo degradation by *beta*-oxidation. Occasionally *both* ends of a hydrocarbon substrate are oxidized—resulting in the formation of a dicarboxylic acid; subterminal oxidation may also occur. Unsaturated hydrocarbons may be metabolised in the same way(s) as saturated hydrocarbons, but may also be oxidized at the double bond; this results in the formation of a diol—sometimes (at least) with the prior formation of an epoxide.

Hydrocarbon-utilizing organisms can cause spoilage of a number of hydrocarbon-containing materials; thus, e.g. microbial growth in jet aircraft fuels results in the formation of sludge and may lead to the corrosion of fuel tanks etc. Growth of such organisms tends to occur at a hydrocarbon–water interface. The commercial exploitation of hydrocarbon-utilizing microorganisms is being attempted e.g. in the production of *single-cell protein* (see MICROORGANISMS AS FOOD). Ethane-utilizing organisms have been used in oil prospecting; ethane associated with oil deposits may diffuse to the surface and allow localized growth of these organisms in the soil.

Alkalescens-Dispar group Non-motile members of the ENTEROBACTERIACEAE which ferment glucose anaerogenically, and in which lactose fermentation is delayed or absent: the organisms are otherwise similar to the typical form of *Escherichia coli*, and they are now regarded as variants of *E. coli*.