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GLOSSARY FOR CHEMISTS OF TERMS USED IN BIOTECHNOLOGY

(IUPAC Recommendations 1992)

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Glossary for chemists of terms used in biotechnology (IUPAC Recommendations 1992)

Synopsis. The glossary contains definitions and explanatory notes, if needed, of over 230 terms frequently used in publications in the multidisciplinary field of biotechnology. The glossary was developed as a step to help facilitate communication between chemists, chemical engineers, biologists and bioengineers and to make biotechnology and its methodologies more accessible to the chemical profession. The interrelation between chemistry, chemical engineering and the burgeoning areas of molecular biology will be especially important as chemical industrial processes begin to incorporate recombinant DNA techniques, for example. The range of terms includes microbiology, genetic engineering, biochemistry, molecular biology, biochemical engineering, bioprocessing and general concepts of biotechnology.

PREFACE

This glossary is a project conceived by Commission VI.2 of the Applied Chemistry Division of IUPAC.

It is clear that major developments are happening in the biological sciences and that this "biological revolution" has and will have a substantial impact on technology in a broad context. The European Federation of Biotechnology has defined Biotechnology as the integration of natural sciences and engineering sciences in order to achieve the application of organisms, cells, parts thereof and molecular analogues for products and services. Much attention has been devoted recently to biotechnology - in the news and in the scientific literature. What has not been widely discussed is the interrelation between chemistry, chemical engineering and the burgeoning areas of molecular biology. This interrelation will be especially important as chemical industrial processes begin to incorporate recombinant DNA techniques, for example. In a wider community of chemists, an understanding of the so-called "new" biology will enhance research opportunities and communication in related fields. Frequently, the language of a given discipline creates a barrier to interactions with other disciplines. Rapid development, such as has been witnessed in the last few years in the multidisciplinary field of biotechnology, exacerbates this problem. We began to develop this glossary of terms used in biotechnology as a step to help facilitate communication between chemists, chemical engineers, biologists and bioengineers and to make biotechnology and its methodologies more accessible to the chemical profession. This is by no means the first effort to offer definitions of terms used in biotechnology. In the references that follow, we provide a list of other documents currently available. Our goal was to direct the choice of terms and the type of definitions to the general community of practising chemists and chemical engineers. Chemical professionals are certainly already familiar with amino acids, but the definition of an endonuclease would elude many of them. Nonetheless, an endonuclease is a biocatalyst that uses (as all molecules must!) thermodynamic and kinetic principles familiar to them. Understanding the mechanisms of this class of enzymes is a specific example of a goal that would be greatly appreciated by biotechnologists to whom these enzymes are critical tools. If it were possible to optimize the performance of such a tool or, better yet, to design a desired endonuclease, many technological goals could be more readily achieved.

This glossary is not encyclopedic. We offer a selection of terms that seemed to us to be the most apt starting point. Future revisions of this work will include more terms. We welcome suggestions for future revised editions.

ALPHABETICAL ENTRIES

In most cases, definitions given here are specific for areas of biotechnology. If a more general definition already exists in previously published IUPAC documents, or a definition related to other areas of chemistry, reference is given to the IUPAC Compendium of Chemical Terminology ('Gold Book') in the 'see also Gold Book' form. Underlined terms within individual definitions or explanatory notes refer to other entries where relevant information is available.

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Activator (see Effector)

Active site (enzyme catalysis, see also Gold Book)

The region of a functional protein where a substrate is specifically bound and undergoes a reaction.

Active transport

The carriage of a solute across a biological membrane from low to high concentration which requires the expenditure of (metabolic) energy.

Aerobe

An organism that needs oxygen for respiration and hence for growth.

Aerobic conditions

Conditions for growth or metabolism in which the organism is sufficiently supplied with oxygen.

Affinity chromatography

A selective separation technique by which a compound (e.g., an antibody) is immobilized on a polymeric matrix and used to bind selectively other compounds.

Following removal of the unattached components, the bound compound is displaced by changing the concentration of protons, salts, or cofactors in the eluent.

Agglutination

An immunochemical reaction leading to the aggregation of particulate matter such as bacteria, erythrocytes, or other cells, or synthetic particles such as plastic beads coated with antigens or antibodies.

Air-lift bioreactor

A bioreactor in which the reaction medium is kept mixed and gassed by introduction of air or another gas (mixture) at the base of a column-like reactor equipped either with a draught tube or another device (e.g., external tube) by which the reactor volume is separated into a gassed and an ungasped region thus generating a vertically circulating flow.

Algae

A heterogeneous group of aquatic photosynthetic eukaryotes and prokaryotes. Some systems of classification formerly included the Cyanobacteria (Cyanophyta) under the name Blue-Green Algae.

Allele

One of several alternate forms of a gene which occur at the same locus on homologous chromosomes and which become separated during meiosis and can be recombined following fusion of gametes.

Allosteric enzymes

Enzymes which contain regions to which small, regulatory molecules (cf., Effector) may bind in addition to and separate from substrate binding sites.

On binding the effector, the catalytic activity of the enzyme towards the substrate may be enhanced, in which case the effector is an activator, or reduced, in which case it is an inhibitor.

Anabolism

The processes of metabolism that result in the synthesis of cellular components from precursors of low molecular weight.

Anaerobe

An organism that does not need free-form oxygen for growth. Many anaerobes are even sensitive to free oxygen. Obligate (strict) anaerobes grow only in the absence of oxygen. Facultative anaerobes can grow either in the presence or in the absence of molecular oxygen.

Antibody

A protein (immunoglobulin) produced by the immune system of an organism in response to exposure to a foreign molecule (antigen) and characterized by its specific binding to a site of that molecule (antigenic determinant or epitope).

Anticodon

A sequence of three nucleotides in the anticodon-loop of a tRNA, which recognizes and binds the complementary triplet sequence (codon) of the mRNA.

Antigen

A substance that stimulates the immune system to produce a set of specific antibodies and that combines with the antibody through a specific binding site or epitope.

Archaeobacteria

A group of prokaryotes which can be subdivided into three groups (methanogenic, halophilic, thermoacidophilic), and are characterized by special constituents such as ether bonded-lipids and special coenzymes.

The archaeobacteria are members of a separate kingdom that falls in between eubacterial and eukaryotic organisms.

Autotrophic organisms

Organisms which are capable of using carbon dioxide as the sole carbon source for growth and product formation.

Organisms which use light as a source of energy are said to be photoautotrophs; those that use the energy from chemical reactions are chemoautotrophs.

Auxotrophy

The inability of an organism to synthesize a particular organic compound required for its growth.

Bacteria

Prokaryotic microorganisms, mainly unicellular (about 0.2 - 10 μm in diameter), having spherical, rodlike, spiral or filamentous bodies, and lacking membrane bound nuclei.

Bacteriophages (Phages)

Viruses that exclusively infect bacteria by insertion of their nucleic acid into the host.

Infection may cause the host cell to switch its metabolism entirely to the propagation of new bacteriophages, resulting in lysis of the host and release of new viral particles.

Balanced growth

Growth is balanced over a time interval (within the exponential phase) if, during that interval, every extensive property of the growing system increases by the same factor.

Balanced growth for an individual cell requires that each division cell is an exact replica of the previous cycle.

Base pairing

The specific association between two complementary strands of nucleic acids that results from the formation of hydrogen bonds between the base components of the nucleotides of each strand: A=T and G=C in DNA, A=U and G=C (and sometimes G=U) in RNA (the lines indicate the number of hydrogen bonds).

Single-stranded nucleic acid molecules can adopt a partially double-stranded structure through intrastrand base pairing.

Bases (Nucleotide bases)

The heterocyclic pyrimidine and purine compounds which are constituents of all nucleic acids.

Adenine (A), guanine (G) and cytosine (C) are found in both DNA and RNA, thymine (T) is found (primarily) in DNA and uracil (U) only in RNA.

Batch process

A process in which a (bio)reactor is loaded with substrates inoculated with microorganisms (or enzymes), and allowed to run to completion, usually without removing biomass and products during the process.

Bioassay

A procedure for determining the concentration or biological activity of a substance (e.g., vitamin, hormone, plant growth factor, antibiotic) by measuring its effect on an organism or tissue compared to a standard preparation.

Biocatalyst

An enzyme or enzyme complex consisting of, or derived from, an organism or cell culture, (in cell-free or whole-cell forms) that catalyzes metabolic reactions in living organisms and/or substrate conversions in various chemical reactions.

Biochemical (Biological) Oxygen Demand (BOD)

The amount of oxygen, divided by the volume of the system, taken up through the respiratory activity of microorganisms growing on the organic compounds present in the sample (e.g., water or sludge) when incubated at a specified temperature (usually 20°C) for a fixed period (usually 5 days, BOD₅).

It is a measure of that organic pollution of water which can be degraded biologically. In practice, it is usually expressed in milligrams O₂ per litre.

Biochip

An integrated circuit whose electrical and logical functions are performed by protein molecules appropriately manipulated.

Bioconversion (see Biotransformation)**Biodegradation**

The breakdown of a substance to its constituents, catalyzed by enzymes or whole microorganisms.

Bioelectronics

The application of biomolecular principles to microelectronics such as in biosensors and biochips.

Biomass

Material produced by the growth of microorganisms, plants or animals.

Biopolymers

Macromolecules (including proteins, nucleic acids and polysaccharides) formed by living organisms.

Bioreactor

An apparatus used to carry out any kind of bioprocess; examples include fermenter, or enzyme reactor.

Biosensor

A device that uses specific biochemical reactions mediated by isolated enzymes, immunosystems, tissues, organelles or whole cells to detect chemical compounds usually by electrical, thermal or optical signals.

Biosynthesis

The production of a chemical compound by a living organism(cf., Biotransformation).

Biotechnology

Biotechnology is the integration of natural sciences and engineering sciences in order to achieve the application of organisms, cells, parts thereof and molecular analogues for products and services (European Federation of Biotechnology, 1988).

Biotransformation

Any chemical conversion of substances that is mediated by living organisms or enzyme preparations derived therefrom.

Blotting

A technique used for transferring DNA, RNA, or protein from gels to a suitable binding matrix, such as nitrocellulose or nylon paper, while maintaining the same physical separation.

Bubble column

A bioreactor, in the shape of a column, in which the reaction medium is kept mixed and aerated by introduction of air into the bottom (cf., Air lift bioreactor).

Callus

An undifferentiated cluster of cells produced by plants in response to wounding and some infections.

A callus may also be formed in vitro during the first stages of plant regeneration from tissue culture or in the in vitro propagation of tissue fragments.

Catabolism

Reactions involving the oxidation of organic substrates to provide chemically available energy (e.g., ATP) and/or to generate metabolic intermediates used in subsequent anabolic reactions.

Catabolite repression

A decrease in the activity of certain auxiliary catabolic enzymes when a surplus of an (easily metabolizable) substrate is available.

Commonly this effect is caused by glucose (glucose repression), or by metabolites produced from glucose.

cdNA (see Complementary DNA)**Cell**

The smallest structural unit of living matter capable of functioning autonomously.

Cell culture

The in vitro propagation of animal or plant cells, in an artificial nutrient medium.

Cell cycle

The growth cycle of a cell from one division to the next.

In eukaryotic cells the growth cycle is divided into the following 4 phases:

G1-phase: the period of the cycle beginning after mitosis and preceding the initiation of DNA synthesis.

S-phase: discrete period of cell cycle when most DNA synthesis occurs.

G2-phase: period of cell cycle when cells contain twice the G1 complement of DNA.

M-phase: division of the cell into two (cf., Mitosis), each with one complete genome.

Chemical Oxygen Demand (COD)

A measure of the amount of oxygen, divided by the volume of the system, required to oxidize the organic (and inorganic) matter in wastewater using a chemically oxidizing agent.

In practice, it is usually expressed in milligrams O₂ per litre.

Chemostat

A bioreactor in which constant growth conditions for microorganisms are maintained over prolonged periods of time by supplying the reactor with a continuous input of nutrients and continuous removal of medium.

Chromosome

A self-replicating structure consisting of DNA complexed with various proteins and involved in the storage and transmission of genetic information; the physical structure that contains genes (cf., Plasmid).

Eukaryotic cells have a characteristic number of chromosomes per cell (cf., Ploidy) and contain DNA as linear duplexes. The chromosomes of bacteria consist of double-stranded, circular DNA molecules.

Clone

(1) A population of genetically identical cells produced from a common ancestor.

(2) Sometimes, "clone" is also used for a number of recombinant DNA molecules all carrying the same inserted sequence.

Codon

The sequence of three consecutive nucleotides that occurs in mRNA which directs the incorporation of a specific amino acid into a protein and includes also the starting or termination signals of protein synthesis.

Coenzymes (Cosubstrates)

Dissociable, low-molecular weight, non-proteinaceous organic compounds (often nucleotides) participating in enzymic reactions as acceptor or donor of chemical groups or electrons.

Cofactors

Organic molecules (cf., Coenzymes) or ions (usually metal ions) that are required by an enzyme for its activity.

They may be attached either loosely or tightly (prosthetic group) to the enzyme.

A cofactor binds with its associated protein (apoenzyme), which is functionally inactive, to form the active enzyme (holoenzyme).

Communities (Consortia, Syntrophic associations, Synergistic associations)

Naturally occurring groups of different (micro)organisms inhabiting a common environment, interacting with each other, especially through food relationships and relatively independent of other groups. Communities may be of varying sizes, and larger communities may contain smaller ones.

Competent cells

Bacterial cells able to take up exogenous high molecular weight DNA (cf., Transformation).

Competency changes with the physiological status and can also be generated by treating the cells with various compounds e.g., calcium salts.

Complementary DNA (cDNA)

A single-stranded DNA molecule with a nucleotide sequence that is complementary to an RNA molecule; cDNA is formed by the action of the enzyme reverse transcriptase on an RNA template. After conversion to the double-stranded form, cDNA is used for molecular cloning or for hybridization studies.

Conjugation (gene technology, see also G.B.)

The contact-dependent transfer of a part or all of its genome from one bacterial cell (donor) to another (recipient).

Constitutive enzymes

Enzymes which are produced constitutively by the cell under all physiological conditions.

Therefore, they are not controlled by induction or repression.

Continuous process

Method of cultivation in which nutrients are supplied and components of culture medium are removed continuously at volumetrically equal rates (cf., Chemostat) maintaining the cells in a condition of stable multiplication and constant growth rate.

Cooperativity

Interaction between the substrate binding sites of an allosteric enzyme.

Binding of a substrate molecule to one binding site changes the affinity of the binding sites on the other subunits (cf., Allosteric enzymes) to the substrate by induction of a conformation change at the other binding sites. Cooperative enzymes typically display a sigmoid (S-shaped) plot of the reaction rate against substrate concentration.

Copy number

The number of copies of a plasmid or a gene within a cell.

Cross-flow filtration

Method of operating a filtration device where retained fluid is circulated over the membrane (filter) surface thus preventing undue build-up of filtered material on membrane (filter).

Crossing over

The usually reciprocal exchange of genetic material between chromosomes; part of natural genetic recombination.

Cytochromes

Conjugated proteins containing haem as the prosthetic group and associated with electron transport and with redox processes. The terminal electron transport chain of oxidative respiration contains at least five different cytochromes.

Cytoplasm

The part of protoplasm in a cell outside of and surrounding the nucleus.

Denaturation

The process of partial or total alteration of the native structure of a macromolecule resulting from the loss of tertiary or tertiary and secondary structure that is a consequence of the disruption of stabilizing weak bonds.

Denaturation can occur when proteins and nucleic acids are subjected to elevated temperature or to extremes of pH, or to non-physiological concentrations of salt, organic solvents, urea or other chemical agents.

Denitrification

The reduction of nitrates to nitrites, dinitrogen oxide (nitrous oxide) or di-nitrogen catalyzed by microorganisms, e.g. facultative aerobic soil bacteria under anaerobic conditions.

Deoxyribonucleic acids (DNA)

High molecular weight, linear polymers, composed of nucleotides containing deoxyribose and linked by phosphodiester bonds; DNA contains the genetic information of organisms.

The double-stranded form consists of a double helix of two complementary chains that run in opposite directions and are held together by hydrogen bonds between pairs of the complementary nucleotides and Hoogsteen (stacking) forces.

Dilution rate D (h^{-1} , d^{-1})

The ratio of the ingoing volume flow rate (dV/dt) and the culture volume (V).

In continuous fermentation, a measure of the rate at which the existing medium is replaced with fresh medium; D is the reciprocal of the hydraulic retention time (HRT).

DNA (see Deoxyribonucleic acids)

DNA probe

A short sequence of DNA labelled isotopically or chemically that is used for the detection of a complementary nucleotide sequence.

Doubling time t_p (min, h)

The time required for a cell population to double either the number of cells or the active cell mass.

Downstream processing

All kinds of processes necessary for the separation and purification of biomass or products after the conversion of materials in the bioreactor.

Effector

A small molecule which increases (activator) or decreases (inhibitor) the activity of an (allosteric) protein by binding to the protein at the regulatory site (which is different from the substrate-binding catalytic site).

Endoenzymes

Enzymes that cut internal bonds of a polymer.

Endonucleases are able to cleave phosphodiester bonds within a nucleic acid chain by hydrolysis either randomly or at specific base sequences (cf., Restriction enzymes).

Enzymes

Macromolecules, mostly of protein nature, that function as (bio)catalysts by increasing the reaction rates.

In general, an enzyme catalyzes only one reaction type (reaction specificity) and operates on only one type of substrate (substrate specificity). Substrate molecules are attacked at the same site (regiospecificity) and only one or preferentially one of the enantiomers of chiral substrates or of racemic mixtures is attacked (stereospecificity).

Enzyme induction

The process whereby an (inducible) enzyme is synthesized in response to a specific molecule (cf., Inducer).

The inducer molecule (often a substrate that needs the catalytic activity of the inducible enzyme for its metabolism) combines with a repressor and thereby prevents the blocking of an operator by the repressor.

Enzyme repression

The mode by which the synthesis of an enzyme is prevented by repressor molecules.

In many cases, the end product of a synthesis chain (e.g., an amino acid) acts as a feed-back corepressor by combining with an intracellular aporepressor protein, so that this complex is able to block the function of an operator. As a result, the whole operon is prevented from being transcribed into mRNA, and the expression of all enzymes necessary for the synthesis of the end product amino acid is abolished.

Epigenetic

Descriptive term for processes that change the phenotype without altering the genotype.

Epitope

Any part of a molecule that acts as an antigenic determinant. A macromolecule can contain many different epitopes each capable of stimulating production of a different specific antibody.

Eukaryotes

Organisms whose cells have their genetic material packed in a membrane-surrounded, structurally discrete nucleus and with well developed cell organelles.

Eukaryotes include all organisms except archaeobacteria and eubacteria (cf., Prokaryotes).

Exoenzymes

Enzymes that cleave monomers (sometimes also di- or oligomers) from one end of a polymer chain.

Exonucleases are able to cleave nucleotides, one by one, from either the 5'- or the 3'- (or both) ends of nucleic acids.

Exon

A section of DNA which carries the coding sequence for a protein or part of it. Exons are separated by intervening, non-coding sequences (cf., Intron).

In eukaryotes most genes consist of a number of exons.

Exponential growth (phase)

The phase of cell growth in which the number of cells (or the cell mass) increases exponentially with time and in which the specific growth rate has a time-independent constant value.

Expression

(1) The cellular production of the protein encoded by a particular gene.

The process includes transcription of DNA, processing of the resulting mRNA product and its translation into an active protein.

(2) A recombinant gene inserted into a host cell by means of a vector is said to be expressed if the synthesis of the encoded protein can be demonstrated.

Extremophiles

Organisms which require extreme physico-chemical conditions for their optimum growth and proliferation.

Extremophilic microorganisms are e.g., thermophiles or psychrophiles, halophiles, alkalophiles or acidophiles, osmophiles and barophiles, based on their growth at extremes of temperature, salt concentration, pH, osmolarity, or pressure, respectively.

Fed batch process

A process during which one or more nutrients are supplied to the (bio)reactor, usually without removing biomass and products (cf., Batch process).

Feed-back inhibition (End product inhibition)

A metabolic control mechanism in which the end product of a biochemical sequence is able to inhibit the activity of an early enzyme in the sequence, thereby controlling the metabolic flux through this pathway.

As an example, isoleucine controls its own synthesis by inhibiting threonine deaminase; adenosine 5'-triphosphate (ATP) and citrate control glycolysis by inhibiting phosphofructokinase.

Fermentation

(1) In metabolism, the dehydrogenating degradation of organic substance by organisms or cells under anaerobic conditions in which electrons are transferred to metabolites which accumulate and are excreted in reduced form.

Fermentation is only possible, if the organism is able to gain energy by this process.

(2) In microbiology, the process in which cells (microorganisms, plant or animal cells) are cultured in a bioreactor in liquid or solid medium to convert organic substances into biomass (growth) or into products.

Fermenter

A bioreactor which enables optimal fermentation conditions to be maintained, allowing addition of nutrients, removal of products, and insertion of measuring and/or control probes as well as other necessary equipment (e.g., for heating, cooling, aeration, agitation, sterilization, etc.) under sterile conditions.

Frame-shift mutation

A point mutation involving either the deletion or insertion of a nucleotide in a gene.

By the frame-shift mutation, the normal reading frame used when decoding the nucleotide triplets in the gene is altered to another reading frame.

Fungi

A group of non-photosynthetic unicellular and multicellular eukaryotic microorganisms.

Fungi are used (1) in the production of a wide range of materials of commercial importance and (2) for the breakdown of organic materials, such as in composting and sewage disposal.

Fusion

The amalgamation of two distinct cells or macromolecules into a single integrated unit.

Gene (Cistron)

Structurally, a basic unit of hereditary material; an ordered sequence of nucleotide bases that encodes one polypeptide chain (via mRNA). The gene includes, however, regions preceding and following the coding region (leader and trailer) as well as (in eukaryotes) intervening sequences (introns) between individual coding segments (exons).

Functionally, the gene is defined by the cis-trans test that determines whether independent mutations of the same phenotype occur within a single gene or in several genes involved in the same function.

Gene amplification

An increase in the number of copies of a specific gene in an organism.

This can lead to the production of a corresponding protein at elevated levels.

Gene library

A collection of cloned DNA fragments from a variety of species.

Gene manipulation

The use of in vitro techniques to produce DNA molecules containing novel combinations of genes or altered sequences, and the insertion of these into vectors that can be used for their incorporation into host organisms or cells in which they are capable of continued propagation of the modified genes.

Generation time t_g

The average time required by a cell for the completion of one cell cycle.

Genetic code

The set of rules which governs the relationship between the linear order of the nucleotides in an mRNA molecule and the sequence of the amino acids in the protein which it encodes.

The genetic code is a triplet code, nearly universal. It is not overlapping: a mutation which alters only a single nucleotide in a gene can change only one amino acid in the encoded protein. It is degenerate: It assigns each of the 20 amino acids to one or more of 61 of the 64 possible nucleotide triplets (cf., Codon) that can be constructed from four nucleotides. The remaining three triplets are used to signal the termination of a genetic message.

Genetics

The study of the nature, transfer and expression of heritable information, that controls the development of living organisms, and the distribution of this information during reproduction and growth.

Genome

The complete set of chromosomal and extrachromosomal genes of an organism, a cell, an organelle or a virus; the complete DNA component of an organism.

Genotype

The genetic constitution of an organism as revealed by genetic or molecular analysis, i.e. the complete set of genes, both dominant and recessive, possessed by a particular cell or organism.

Genus

A taxonomic category of organisms that includes groups of closely related species that have an obvious series of characteristics in common.

Gram stain

A set of two stains that are used to stain (crystal violet and iodine) and counterstain (fuchsin) bacteria.

Gram-negative bacteria are completely decolorized after treating the stained bacteria with ethanol or acetone and can be visualized by the counterstain. They have a complex cell wall in which the peptidoglycan layer is covered by lipopolysaccharides in an outer membrane structure.

Gram-positive bacteria resist decolorization by ethanol or acetone, they retain the initial Gram stain. They have a cell wall consisting predominantly of peptidoglycan not overlaid by an outer membrane.

Growth rate (h^{-1} , d^{-1})

The measure of the rate of growth or multiplication of an organism or a culture, usually expressed as specific growth rate (the increase of mass or cell number per time unit referred to the unit of mass, $d\ln X/dt$).

Halophiles

Organisms which require a minimum concentration of sodium chloride in their environment (cf., Extremophiles).

Hapten

A low-molecular weight molecule which contains an antigenic determinant but which is not itself antigenic unless complexed with an antigenic carrier.

Examples of haptens are dinitrophenols, phosphorylcholine and dextran.

Heterotrophic organisms

Descriptive of organisms which are not able to synthesize cell components from carbon dioxide as sole carbon source.

Heterotrophic organisms use preformed oxidizable organic substrates such as glucose as carbon and energy sources.

Histones

A class of basic proteins associated with DNA in the chromosomes of eukaryotic cells forming the nucleosome as the basic subunit of chromatin.

They contain an unusually large proportion of the basic amino acids arginine and lysine.

Host

A cell whose metabolism is used for growth and reproduction of a virus, plasmid or other form of foreign DNA.

Host-vector system

A compatible combination of host (e.g., Bacteria) and vector (e.g., Plasmid) that allows propagation of DNA.

Hybridization

(1) The formation of stable duplexes of two DNA and/or RNA (complementary) strands via Watson-Crick base pairing used for locating or identifying nucleotide sequences and to establish the effective transfer of nucleic acid material to a new host.

(2) The formation of a novel diploid organism either by sexual processes or by protoplast fusion.

Hybridoma

A hybrid cell line resulting from the fusion of a specific antibody-producing spleen cell (lymphocyte) with a myeloma cell, which has the growth characteristics of the myeloma component and the antibody-secreting characteristics of the lymphocyte, and will multiply to become a source of pure monoclonal antibody.

Hydrolases (Enzyme Classification, Class No. 3)

Enzymes that catalyze the cleavage of C-O, C-N, C-C and other bonds by reactions involving the addition or removal of water.

Immobilization

The technique used for the physical or chemical fixation of cells, organelles, enzymes, or other proteins (e.g., Monoclonal antibodies) onto a solid support, into a solid matrix or retained by a membrane, in order to increase their stability and make possible their repeated or continued use.

The principle is also used for affinity chromatography.

Immunization

The administration of an antigen to an animal in order to stimulate the production of antibodies by that organism. Also, the administration of antigens, antibodies or lymphocytes to an animal to generate the corresponding active, passive or adaptive immunity.

Immunoassay

A ligand-binding assay that uses a specific antigen or antibody, capable of binding to the analyte, to identify and quantify substances.

The antibody can be linked to a radioisotope (radioimmunoassay, RIA), or to an enzyme which catalyzes an easily monitored reaction (enzyme-linked immunosorbent assay, ELISA), or to a highly fluorescent compound by which the location of an antigen can be visualized (immunofluorescence).

Immunogen

A substance that elicits a cellular immune response and/or antibody production (cf., Antigen).

Immunoglobulin (Ig)

A protein of the globulin-type found in serum or other body fluids that possesses antibody activity.

An individual Ig molecule is built up from two light (L) and two heavy (H) polypeptide chains linked together by disulfide bonds. Ig's are divided into five classes and into subclasses based on antigenic and structural differences in the H chains.

Inducer

A small molecule that triggers gene transcription by binding to a regulator protein (cf., Enzyme induction).

It acts by combining with the corresponding repressor protein to bring about an allosteric change so that the repressor is made incapable of combining with the operator of the system.

Induction

(1) An increase in the rate of synthesis of an (inducible) enzyme in response to the action of an inducer or environmental conditions.

An inducer is often the substrate of the inducible enzyme or a structurally similar substance (gratuitous inducer) that is not metabolized.

(2) The experimental elicitation of lytic growth by a prophage from lysogenic bacteria.

Inhibition (enzyme catalysis, see also Gold Book)

The decrease of the rate of an enzyme-catalyzed reaction by a chemical compound (inhibitor).

The inhibition mechanism may be "competitive" if the substrate has to compete with the structurally very similar inhibitor for the same active site; or "non-competitive": if the inhibitor binds to another site, thereby reducing the catalytic activity.

Inhibitor (see Effector)

Inoculation

The introduction of a small sample of organisms (microbial, plant or animal cells) into a culture medium to act as a seed for the production of large numbers of the same organism by growth and propagation.

Insert

A sequence of foreign DNA introduced into a restriction site (insertion site, cloning site) of a vector DNA.

Interferons

A class of glycoproteins (with sugar groups attached at specific locations) important in immune function.

They are able to inhibit the multiplication of viruses in cells.

Intron

An intervening section of DNA occurring almost exclusively within a eukaryotic gene but which is not translated to amino acid sequences in the gene product.

The introns are removed from the premature mRNA through a process called splicing to form an active mRNA.

Isoenzymes (see also Gold Book)

A group of related enzymes within an organism that catalyze the same reaction but possess different amino acid sequences or physical, biochemical, or immunological properties.

Isomerases (Enzyme Classification, Class No.5)

Enzymes that catalyze intramolecular rearrangements.

Isomerases are classified into racemases and epimerases, cis-trans isomerases, intramolecular oxidoreductases, intramolecular transferases, intramolecular lyases, and other isomerases.

Isomorph

Descriptive of an organism that is very similar in appearance to another, genetically unrelated, organism.

Lag phase

The growth interval (adaptation phase) between inoculation and start of the exponential phase during which there is little or no growth.

Leaching, microbial

A process for the solubilization of metals, mostly from poor ores, by lithotrophic bacteria.

Leader sequence

(1) A polynucleotide region between promoter and structural gene, necessary for the correct transcription of DNA into mRNA.

(2) An N-terminal extension of polypeptides (also known as the signal sequence) which is necessary for the transport of the protein into or through the membrane or for its secretion into the extracellular medium.

Lectins

Glycoproteins isolated from plants but recently found also in animals and microorganisms that react specifically with terminal glycosidic residues of other molecules (e.g., cell wall polysaccharides); some causing cells to agglutinate (cf., Agglutination)

Ligases (Synthetases) (Enzyme Classification, Class No. 6)

Enzymes that catalyze the ligation of two molecules with concomitant hydrolysis of the pyrophosphate bond in adenosine 5'-triphosphate (ATP) or a similar triphosphate, forming C-C, C-O, C-S, P-O, or C-N bonds.

In recombinant DNA technology, ligases covalently join together two sequences of DNA (e.g., host DNA and foreign DNA) by a phosphodiester bond.

Lyases (Enzyme Classification, Class No. 4)

Enzymes cleaving C-C, C-O, C-N and other bonds by other reactions than by hydrolysis or oxidation.

Lyases catalyze the addition of molecules to unsaturated compounds or the elimination of molecules creating an unsaturated residue.

Lysis

Cell rupture caused by physical or chemical means, or by phage infection and propagation leading to the release of the cell content; also the death of microorganisms after the stationary phase of a batch fermentation.

Lysogenic bacteria

Bacteria carrying a latent prophage.

The phage is either integrated into the bacterial chromosome or maintained as a low copy number plasmid thus allowing possible replication by the host.

Mapping

The determination of the relative positions of genes within the chromosomes or of restriction sites along a DNA molecule.

Marker (see also Gold Book)

(1) DNA: a fragment of known size used as reference for analytical purposes.

(2) Genetic: a gene with known phenotype and mapped position.

(3) Chromatography: a reference substance co-chromatographed with the sample to assist in identifying the components.

Mass transfer (see also Gold Book)

Spontaneous (irreversible) process of transfer of mass across non-homogeneous fields.

The driving force can be the difference in concentration (in liquids) or partial pressure (in gases) of the component. In fluids, mass transfer may be enhanced by turbulent flow. In biological systems, mass transfer through membranes may result from normal diffusion, facilitated diffusion or (cf.) active transport.

Meiosis

The reductive cell division which results in daughter cells containing one copy of each of the chromosomes of the parent.

The entire meiotic process involves two separate divisions (meiosis I and meiosis II). The first division is a true reductive division with the chromosome number being halved, whereas the second division resembles mitosis in many ways. Thus, a diploid parental cell will give rise to haploid daughter cells (cf., Ploidy).

Meristem

A plant tissue consisting of cells which are capable of undergoing mitotic division.

Meristems are relatively undifferentiated and have a high degree of totipotency. Meristem tissues can be cultured under sterile conditions for the vegetative propagation of valuable plants.

Mesophiles

Microorganisms which grow at moderate temperatures in the range 20 - 45°C, and which have an optimum growth temperature in the range 30 - 39°C.

Messenger RNA (mRNA)

An RNA molecule that transfers the coding information for protein synthesis from the chromosomes to the ribosomes. mRNA is formed from a DNA template by transcription. It may be a copy of a single gene or of several adjacent genes (polycistronic mRNA). On the ribosome, the sequence is converted into the programmed amino acid sequence through translation.

Metabolism

The entire physical and chemical processes involved in the maintenance and reproduction of life in which nutrients are broken down to generate energy and to give simpler molecules (catabolism) which by themselves may be used to form more complex molecules (anabolism).

In case of heterotrophic organisms, the energy evolving from catabolic processes is made available for use by the organism.

Metabolite

Any intermediate or product resulting from metabolism.

Methanogens

Strictly anaerobic archaeobacteria, able to use only a very limited substrate spectrum (e.g., molecular hydrogen, formate, methanol, methylamine, carbon monoxide or acetate) as electron donors for the reduction of carbon dioxide to methane.

Methylotrophic microorganisms

Organism that use, as substrates for growth, C1 compounds containing carbon in a lower oxidation state than in carbon dioxide.

Microcarrier

A small, beaded material, derived from silica, glass, dextran or similar materials, used for the immobilization of biocatalysts, or as a support for the culture of anchorage-dependent animal cell lines.

Microorganisms

Microscopic living entities: prokaryotes (e.g., Bacteria) or eukaryotes (e.g., Fungi).

Mitochondria

Organelles appearing in all eukaryotic cells which produce ATP as useful energy for the cell by oxidative phosphorylation.

The proteins for the adenosine 5'-triphosphate (ATP)-generating electron transport of the respiration chain are located in the inner mitochondrial membrane. Mitochondria contain many enzymes of the citric acid cycle and for fatty acid β -oxidation. Many of them are coded for by nuclear DNA.

Mitosis

The process whereby a cell nucleus divides into two daughter nuclei, each having the same genetic complement as the parent cell.

Monoclonal antibodies (MAbs)

A single species of immunoglobulin molecules produced by culturing a single clone of a hybridoma cell.

MAbs recognize only one chemical structure, i.e., they are directed against a single epitope of the antigenic substance used to raise the antibody.

mRNA (see Messenger RNA)

Mutagenesis

The introduction of permanent heritable changes i.e. mutations into the DNA of an organism.

Mutation

A heritable change in the nucleotide sequence of genomic DNA (or RNA in RNA viruses), or in the number of genes or chromosomes in a cell, which may occur spontaneously or be brought about by chemical mutagens or by radiation (induced mutation).

Mutation rate (h^{-1})

The frequency with which a mutation occurs within a organism or gene.

In general, rates of spontaneous mutation vary between one in 10^4 and one in 10^8 per gene per generation, and can be considerably increased by mutagens.

Myeloma cell

A malignant plasma cell which can synthesize excessive amounts of whole antibody or single immunoglobulin chains.

Neutrophilic organisms

Organisms preferring a neutral medium for growth.

Nitrogen fixation

The assimilation of atmospheric nitrogen by microbial reduction to ammonia and conversion into organonitrogen compounds such as amino acids. Only a limited number of microorganisms are able to fix nitrogen.

Nucleic acids

Macromolecules composed of sequences of nucleotides that perform several functions in living cells, e.g., the storage of genetic information and its transfer from one generation to the next (DNA), and the expression of this information in protein synthesis (mRNA, tRNA), and may act as functional components of subcellular units such as ribosomes (rRNA).

RNA contains D-ribose, DNA contains 2-deoxy-D-ribose as the sugar component.

Nucleosides

Compounds in which a purine or pyrimidine base is β -N-glycosidically bound to C-1 of either 2-deoxy-D-ribose or of D-ribose, but without any phosphate groups.

The common nucleosides in biological systems are adenosine, guanosine, cytidine, and uridine (which contain ribose) and deoxyadenosine, deoxyguanosine, deoxycytidine and thymidine (which contain deoxyribose).

Nucleotides

Nucleosides with one or more phosphate groups esterified mainly to the 3' -or the 5' -position of the sugar moiety.

Nucleotides found in cells are adenylic acid, guanylic acid, uridylic acid, cytidylic acid, deoxyadenylic acid, deoxyguanylic acid, deoxycytidylic acid and thymidylic acid.

Nutrient medium

A composite formulation of organic substrates, minerals, growth factors and vitamins, either liquid or solidified with polymers such as agar or gelatin, used for the cultivation of microorganisms, animal cells or plant tissue cultures.

Operator gene (see Operon)

Operon

A functional unit consisting of a promoter, an operator and a number of structural genes, found mainly in prokaryotes.

The structural genes commonly code for several functionally related enzymes, and although they are transcribed as one (polycistronic) mRNA each is independently translated. In the typical operon, the operator region acts as a controlling element in switching on or off the synthesis of mRNA.

Organelles

Separated compartments within a cell with specialized functions, e.g. nuclei (containing most of the genetic material), mitochondria (respiratory energy supply for the cell), chloroplasts (location of photosynthesis) etc.

Origin of replication (ori)

A sequence of DNA at which replication is initiated on a chromosome, plasmid or virus.

Oxidoreductases (Enzyme Classification, Class No. 1)

Enzymes that catalyze electron transfer in oxidation-reduction reactions.

Oxidoreductases are classified into several groups according to their respective donors or acceptors.

Phages (see Bacteriophages)

Phenotype

The observable structural and functional characteristics of an organism determined by its genotype and modulated by its environment.

Photophosphorylation

The transformation of light (solar) energy for the reduction of CO₂ and the generation of adenosine 5'-triphosphate, ATP.

Photosynthesis

A metabolic process using light energy absorbed by chlorophyll and other photosynthetic pigments for the reduction of CO₂, followed by the formation of organic compounds.

Plasmid

An extrachromosomal genetic element consisting generally of a circular duplex of DNA which can replicate independently of chromosomal DNA.

R-plasmids are responsible for the mutual transfer of antibiotic resistance among microbes. Plasmids are used as vectors for cloning DNA in bacteria or yeast host cells.

Pleiotropic gene

A gene affecting more than one (apparently unrelated) characteristic of the phenotype.

Ploidy

A term indicating the number of sets of chromosomes present in an organism, e.g. haploid (one) or diploid (two).

Plug flow

Flow of fluids in which there is no mixing in the direction of flow.

Probe

A specific DNA or RNA sequence which has been labelled by radioactivity, fluorescence labels or chemiluminescence labels and which is used to detect complementary sequences by hybridization techniques such as blotting or colony hybridization.

Productivity r ($\text{kg}\cdot\text{m}^{-3}\cdot\text{h}^{-1}$)

An economical figure denoting the mass of a product formed per unit reactor volume and unit time.

Productivity is often referred to per unit of enzyme or biomass.

Prokaryote

A unicellular organism characterized by the absence of a membrane-bound nucleus.

Prokaryotes include bacteria, blue-green algae (Cyanobacteria, formerly Cyanophyta) and mycoplasmas.

Promoter (gene technology, see also Gold Book)

The DNA region, usually upstream to the coding sequence of a gene or operon, which binds and directs RNA polymerase to the correct transcriptional start site and thus permits the initiation of transcription.

Prophage

The latent state of a phage genome in a lysogenic bacterium.

Prosthetic group

The non-amino acid portion of a conjugated protein.

Examples include cofactors such as flavines or cytochromes, as well as lipids and polysaccharides which are the prosthetic groups of lipoproteins and glycoproteins, respectively.

Proteases

Enzymes that catalyze the hydrolysis of proteins.

Usually several proteolytic enzymes are necessary for the complete breakdown of polypeptides to their amino acids.

Protein engineering

A technique used to produce proteins with altered or novel amino acid sequences.

The methods used are (1) transcription and translation systems from synthesized lengths of DNA or RNA with novel sequences, (2) chemical modification of "normal proteins; or (3) solid-state polypeptide synthesis to form proteins.

Protoplast

A spherical, osmotically-sensitive cell without its cell wall but retaining an intact cell membrane.
 Protoplasts are used to create hybrid cells via protoplast fusion.

Prototrophs

Microorganisms capable of growing on a defined minimal medium from which it can synthesize all required compounds.

Psychrophiles

Microorganisms growing at or below a temperature optimum of 15°C.

Recalcitrance (Persistence)

Ability of a substance to remain in a particular environment in an unchanged form.

Receptor

A molecule or a polymeric structure in or on a cell which specifically recognizes and binds to a compound acting as a molecular messenger (neurotransmitter, hormone, lymphokine, lectin, drug, etc.).

Recognition site

- (1) A nucleotide sequence to which a protein binds specifically.
- (2) An amino acid sequence in an antibody molecule to which the specific antigen binds specifically.

Recombinant DNA technology (see Gene manipulation)**Regulator gene**

A gene which codes for a protein (an activator or repressor) having the ability to induce or repress the transcription of other genes.

Replication

The duplication of DNA as part of the reproductive cycle of a cell or virus.

During replication the two DNA strands in the double helix separate, and each strand then acts as a template specifying the base sequence of newly synthesized complementary strands.

Repression

Binding of a protein (repressor) to the operator sequence in an operon thus preventing the transcription of the following structural gene(s) into mRNA and consequently synthesis of protein. (cf., Enzyme repression).

Residence time (Hydraulic retention time) t_r

The average time a particle or volume element of the culture resides in a bioreactor (or other device) through which a liquid medium continuously flows.

Residence time of the liquid is the reciprocal of dilution rate.

Restriction enzymes

Endonucleases which recognize specific base sequences within a DNA helix, creating a double-strand break of the DNA.

Type I restriction enzymes bind to these recognition sites but subsequently cut the DNA at different sites. Type II restriction enzymes both bind and cut within their recognition or target sites.

Reverse transcriptases

Enzymes found in retroviruses that can synthesize complementary single-strands of DNA from an mRNA sequence as template. They are used in genetic engineering to produce specific cDNA molecules from purified preparations of mRNA.

Ribonucleic acids (RNA)

Linear polymer molecules composed of a chain of ribose units linked between positions 3 and 5 by phosphodiester groups to which the bases adenine or guanine (via N-atom 9) or uracil or cytosine (via N-atom 1), respectively, are attached by β -N-glycosidic bonds (cf., Nucleotides). The three most important types of RNAs in the cell are, cf., Messenger RNA, Transfer RNA, Ribosomal RNA.

Ribosomal RNA (rRNA)

RNA molecules which are essential structural and functional components of ribosomes, the subcellular units responsible for protein synthesis.

Ribosomes

Subcellular units composed of specific RNA molecules and a large number of proteins that are responsible for protein synthesis.

RNA (see Ribonucleic acids)

rRNA (see Ribosomal RNA)

Saprophyte

An microorganism that feeds on dead and decaying organic matter. Saprophytes excrete enzymes that digest organic residues externally, the low molecular weight compounds formed then being absorbed.

Secondary metabolites

Metabolites which are produced by routes other than the normal metabolic pathways, mostly after the phase of active growth and under conditions of deficiency. The biological significance of many secondary metabolites is not exactly known.

Selection

A laboratory method applying a mixture of microorganisms to particular growth conditions under which only the cells with particular characteristics can survive and may be isolated.

Sequencing (protein, nucleic acids)

Analytical procedures for the determination of the order of amino acids in a polypeptide chain or of nucleotides in a DNA or RNA molecule.

Shear rate (see also Gold Book)

The velocity gradient in a flowing fluid.

Shuttle vector

A DNA molecule (e.g., Plasmid) that is able to replicate in two different host organisms and can therefore be used to "shuttle" or convey genes from one to the other.

Signal sequence (see Leader sequence, definition (2))

Single cell protein (SCP)

Microbial biomass or proteins extracted therefrom obtained from processes in which bacteria, yeasts, other fungi, or algae are cultivated in large quantities as human or animal protein supplement in animal feed or in human nutrition.

Species

A taxonomic subdivision of a genus; a group of closely related, morphologically and physiologically similar individuals.

Splicing

(1) of RNA: the procedure by which introns are removed from eukaryotic precursor mRNA molecules and adjacent exon sequences are joined together (spliced).

(2) of DNA: manipulation for joining together double-stranded DNA fragments with protruding single-stranded "sticky ends" by means of ligases.

Spore

A dormant cellular form that has very low metabolic activity and that can give rise to a vegetative cell upon germination.

Sporulation

The generation of a spore by a bacterium (by morphological conversion) or by a yeast (as a product of meiosis).

Stationary phase (fermentation, see also Gold Book)

The phase of a culture of microorganisms or animal and plant cells cultured in vitro that follows the exponential growth phase and in which there is little or no growth.

In some cases it is a phase of product formation, e.g., formation of secondary metabolites.

Sticky ends

The staggered ends of complementary sequences of DNA which result from cleavage by restriction enzymes.

Strain

A genetically homogeneous population of organisms of common origin at a subspecies level that can be differentiated from other populations by morphological, physiological, biochemical or other taxonomic features.

Substrate (biocatalysis, see also Gold Book)

(1) The chemical entity whose conversion to a product or products is catalyzed by one or several enzymes.

(2) A solution or dry mixture containing all ingredients which are necessary for the growth of a microbial culture or for product formation.

(3) Component in the nutrient medium, supplying the organisms with carbon (C-substrate), nitrogen (N-substrate) etc.

Template

The nucleic acid single strand that is copied during replication or transcription.

Terminator

A sequence of DNA lying beyond the 3' end of the coding segment of a gene which is recognized by RNA polymerase as a signal to stop synthesizing mRNA.

Thermophile

An organism that can tolerate high temperatures and that grows optimally at temperatures above 45°C.

Tissue culture (see Cell culture)

Transcription

The process by which the genetic information encoded in a linear sequence of nucleotides in one strand of DNA is copied into an exactly complementary sequence of RNA.

Transduction

The transfer of genetic information from one bacterium to another by means of a transducing bacteriophage.

When the phage is grown on the first host, a fragment of the host DNA can be incorporated into the phage particles. This foreign DNA can be transferred to the second host upon infection with progeny phage from the first experiment.

Transferases (Enzyme Classification, Class No.2)

Enzymes that catalyze reactions in which a group is transferred from one compound to another.

Groups that are transferred are Cl, aldehydic or ketonic residues, acyl, glycosyl, alkyl, nitrogenous, phosphorus and sulfur-containing groups.

Transfer RNA (tRNA)

A single-stranded RNA molecule containing about 70 - 90 nucleotides, folded by intrastrand base pairing into a characteristic secondary ("cloverleaf") structure that carries a specific amino acid and matches it to its corresponding codon on an mRNA during protein synthesis.

Transformation (gene technology, see also Gold Book)

A process for genetic alteration of a cell following incorporation of foreign DNA.

Translation

The unidirectional process that takes place on the ribosomes whereby the genetic information present in an mRNA is converted into a corresponding sequence of amino acids in a protein.

Transposon

A movable DNA element that can be inserted at new sites into plasmids or chromosomes independently of the host cell recombination system.

Prokaryotic transposons can carry genes that confer new phenotypic properties, such as resistance to antibiotics on the host.

tRNA (see Transfer RNA)

Ultrafiltration (see also Gold Book)

A separation process whereby a solution containing a solute of molecular size significantly greater than that of the solvent molecule is removed from the solvent by the application of a hydraulic pressure which forces only the solvent to flow through a suitable membrane, usually having a pore size in the range 0.001 - 0.1 μm .

Vaccine

An agent containing antigens produced from killed, attenuated or live pathogenic microorganisms, synthetic peptides or by recombinant organisms, used for stimulating the immune system of the recipient to produce specific antibodies providing active immunity and/or passive immunity in the progeny.

Vector

(1) A DNA molecule (plasmid, virus, bacteriophage, artificial or cut DNA molecule) capable of being replicated and bearing cloning sites for the introduction of foreign DNA, used to introduce this DNA into host cells.

(2) Any organism that transmits a disease between two hosts.

Virus

An infectious agent composed of nucleic acids (DNA or RNA) surrounded by a protein, or protein and lipid coat.

Viruses are able to replicate only within a suitable host cell.

Wild type

The most frequently encountered genotype in natural breeding populations.

Xenobiotics

Man-made compounds with chemical structures foreign to a given organism.

Yeasts

Unicellular, non-photosynthetic, commonly saprophytic, spore-forming organisms which usually multiply asexually by budding or fission.

Yield Y

Ratio expressing the efficiency of a mass conversion process.

The yield coefficient is defined as the amount of cell mass (kg) or product formed (kg, mol) related to the consumed substrate (carbon or nitrogen source or oxygen in kg or moles) or to the intracellular ATP production (moles).

Zygote

The cell obtained as a result of complete or partial fusion of meiotically (cf., Meiosis) produced cells.

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