Glossary

Activator See Transcriptional activator.

Bioreactor A reaction chamber for biological processes, mostly in biotechnology.

Cladistics Method of classification employing genealogies alone in inferring phylogenetic relationships among organisms (see also Phylogeny).

Clade Phylogenetic lineage of related taxa from a common ancestral taxon.

Cloning vector Usually a plasmid or a viral genome adapted for the introduction (cloning) of foreign DNA and usually containing a selectable marker (e.g. antibiotic resistance gene). Foreign DNA is introduced at restriction enzyme cleavage sites.

cDNA Copy DNA made from an RNA molecule.

Diazotroph An organism that derives its nitrogen for growth by fixing atmospheric N2.

Domain A region of a protein, often forming a self-contained folded unit.

Electron paramagnetic resonance (EPR) spectroscopy The form of spectroscopy concerned with microwave-induced transitions between magnetic energy levels of unpaired electrons, i.e. those having a net spin. The spectrum is normally obtained by magnetic field scanning. Also known as electron spin resonance (ESR) spectroscopy or electron magnetic resonance (EMR) spectroscopy. The microwave frequency ν is measured in gigahertz (GHz) or megahertz (MHz). The following band designations are used: L(1.1 GHz), S(3.0 GHz), X(9.5 GHz), K(22.0 GHz) and Q(35.0 GHz). The static magnetic field at which the EPR spectrometer operates is measured by the magnetic flux density (B) and its recommended unit is the tesla (T). In the absence of nuclear hyperfine interactions, B and ν are related by: $h\nu = g\mu_B B$ where h is the Planck constant, μ_B is the Bohr magneton, and the g factor, g, is a parameter which is characteristic of the spin system.

Electron-nuclear double resonance (ENDOR) spectroscopy A magnetic resonance spectroscopic technique for the determination of *hyperfine* interactions between electrons and nuclear spins. There are two principal techniques. In continuous-wave ENDOR the intensity of an *electron paramagnetic resonance* signal, partially saturated with microwave power, is measured as radio frequency is applied. In pulsed ENDOR the radio frequency is applied as pulses and the EPR signal is detected as a spin-echo. In each case an enhancement of the EPR signal is observed when the radiofrequency is in resonance with the coupled nuclei.

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Exon (see also Intron) That part of a eukaryotic gene which is both transcribed and expressed in the gene product.

Extended X-ray absorption fine structure (EXAFS) A technique for observing the local structure around a metal centre, using X-rays from a synchrotron source. The atom of interest absorbs photons at a characteristic wavelength and the emitted electrons, undergoing constructive or destructive interference as they are scattered by the surrounding atoms, modulate the absorption spectrum. The modulation frequency corresponds directly to the distance of the surrounding atoms while the amplitude is related to the type and number of atoms. In particular, bond lengths and coordination numbers may be derived.

Fourier-transform infrared (FTIR) spectroscopy Spectroscopy based on excitation of vibrational modes of chemical bonds in a molecule. The energy of the infrared radiation absorbed is expressed in inverse centimeters (cm^{-1}), which represents a frequency unit. For transition-metal complexes, the ligands $-C{\equiv}N$ and $-C{=}O$ have characteristic absorption bands at unusually high frequencies, so that they are easily distinguished from other bonds. The position of these bonds depends on the distribution of electron density between the metal and the ligand; an increase of charge density at the metal results in a shift of the bands to lower frequencies.

Gene Bank/Library Collection of DNA fragments representing part or all of the genome of an organism held in a cloning vector in a suitable host. Used to isolate and replicate genes of interest independently of their original host. *A cDNA library* is constructed from RNA using reverse transcriptase and represents those genes which are expressed in that cell at a particular time but which may be only a small proportion of all the genes in the cells. A cDNA library reflects the abundance of mRNA molecules in the cell.

Genome The total genetic information present in an organism. Viral genomes are unusual in that they can be diverse. Examples of viral genomes include single-stranded DNA, single- and double-stranded RNA molecules.

Hydron The hydrogen ion, $^{1}H^{+}$, is generally referred to as the proton, which is the nucleus of hydrogen, ^{1}H. But since hydrogenase can also use deuterium ions (deuterons, $^{2}H^{+}$) and tritium ions (tritons, $^{3}H^{+}$) as substrates, the correct term is 'hydrons', which does not discriminate between the isotopes.

Hyperfine interaction, or hyperfine coupling (hfc) The interaction between an electron in a paramagnetic center and nuclear spin. It can be observed as a splitting of lines in an EPR spectrum, or a pair of lines in an ENDOR spectrum. There are two components to the hyperfine interaction: through bonds (contact hyperfine interaction) and through space (dipolar interaction). The magnitude of the coupling can provide information about relative location of the nucleus relative to the paramagnetic centre.

In-frame mutation A mutation, usually a deletion, which does not shift the reading frame downstream of the mutation.

Intron (see Exon) That part of a eukaryotic gene which is transcribed but, as a result of editing through the spliceosome assembly, is not expressed in the final gene product.

Kilobase (Kb) A thousand base pairs of DNA or a thousand bases of RNA. This is a significant number because the average gene is 1,000 base pairs long.

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Knallgas A mixture of hydrogen and oxygen that is too low in hydrogen to initiate an explosion. Hence knallgas reaction – the biological oxidation of low concentrations of hydrogen with oxygen.

Ligation The joining of two DNA strands to each other to form a 5′ to 3′ phosphodiester linkage. The reaction is catalysed by the enzyme DNA-ligase which is important in DNA replication and repair and when purified it is used for joining DNA *in vitro*.

Lithotroph An organism that derives its energy for growth from the conversion of inorganic substances.

Minimal hydrogenase The part of a hydrogenase structure that is found in all hydrogenases of a particular type, and which is therefore proposed to be the essential part for its function. For example in the NiFe hydrogenases, this comprises the NiFe catalytic centre in the large subunit, and the proximal [4Fe-4S] cluster in the small subunit.

Mössbauer spectroscopy The Mössbauer effect is resonance absorption of γ radiation of a precisely defined energy, by specific nuclei. It is the basis of a form of spectroscopy used for studying coordinated metal ions. The principal application in bioinorganic chemistry is ^{57}Fe. The source for the γ rays is ^{57}Co, and the frequency is shifted by the Doppler effect, moving it at defined velocities (in mm/s) relative to the sample. The parameters derived from the Mössbauer spectrum (isomer shift, quadrupole splitting, and the hyperfine coupling) provide information about the oxidation, spin and coordination state of the iron.

Motif A sequence of amino acids in a protein, which is found in many different species, and which has a particular function such as binding a metal center.

Operon A group of two or more adjacent genes which are transcribed from a single promoter on a single messenger RNA. Operons often contain functionally related genes. Messenger RNA which carries the information for two genes is known as polycistronic.

Open reading frame (ORF) See Translation.

Overexpression The production of abnormally high levels of foreign (usually) proteins or RNA molecules in a host cell usually by cloning the gene of interest into an overexpression vector.

Phototroph An organism that derives its energy for growth from photosynthesis.

Phylogeny Evolutionary history. The genealogical history of a group of organisms represented by its hypothesized ancestor–descendent relationships.

Plasmid A relatively (cf. the chromosome) small (>20 Kb), usually circular, double-stranded DNA molecule found in prokaryotes capable of replicating independently of the chromosome. Plasmids carry genes which are usually not essential for the growth of the organism except under special conditions. Some plasmids carry genes for antibiotic resistance. See also Ti-plasmid. Some plasmids however can be very large, e.g. the plasmids in Rhizobium species.

Polarity The phenomenon where a mutation in one gene exerts cis effects on downstream genes. Usually polar mutations lower expression of the downstream genes.

Polymerase chain reaction (PCR) The process by which a specific sequence of DNA can be amplified (copied many times) *in vitro*. It requires a pair of primers and template DNA, thermostable DNA polymerase (e.g. *Taq* polymerase), deoxynucleotide triphosphates and a thermocycler. The process can amplify large

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amounts of a specific DNA sequence (an amplicon) given just a few molecules of template. A revolutionary technique in biology.

Primer A short length of single-stranded DNA or sometimes RNA (usually ~20 bases which can be synthesized) which is complementary to a known DNA sequence so that it can bind there and serve for the initiation of DNA replication.

Promoter Usually a specific region of DNA at which RNA-polymerase binds and initiates transcription.

Ribosome binding site (RBS) See Translation.

Redox potential The driving force for an oxidation–reduction reaction. Reduction can be considered either as the addition of hydrogen or electrons to a molecule (since $H^+ + e^- \rightleftharpoons H^{\bullet}$); oxidation is the opposite process. Any redox (reduction–oxidation) reaction can be divided into two half-reactions: one in which a chemical species, A, undergoes oxidation, and one in which another chemical species, B, undergoes reduction:

$$A_{ox} + B_{red} = A_{red} + B_{ox}.$$

The reducing equivalents transferred can be considered either as hydrogen atoms or electrons. The driving force for the reaction, E, is the reduction/oxidation (redox) potential, and can be measured by electrochemistry; it is often expressed in millivolts. The number of reducing equivalents transferred is n. The redox potential of a compound A depends on the concentrations of the oxidized and reduced species $[A_{ox}]$ and $[A_{red}]$ according to the Nernst equation:

$$E = E_m + RT/nF \ln([A_{ox}]/[A_{red}]).$$

The midpoint potential of a half-reaction E_m, is the value when the concentrations of oxidized and reduced species are equal, $[A_{ox}] = [A_{red}]$. In biological systems the standard redox potential of a compound is the reduction/oxidation potential measured under standard conditions, defined at pH = 7.0 versus the hydrogen electrode. On this scale, the potential of O_2/water is +815 mV, and the potential of water/H_2 is −414 mV. A characteristic of redox reactions involving hydrogen transfer is that the redox potential changes with pH. The oxidation of hydrogen $H_2 = 2H^+ + 2e^-$ is an $n = 2$ reaction, for which the potential is −414 mV at pH 7, changing by −59.2 mV per pH unit at 30°C.

Repressor See Transcriptional repressor.

Transformation Processes by which DNA is introduced into a host organism. Some organisms (cells) are naturally competent for DNA uptake. In most others the DNA has to be introduced into the cell by various artificial means including soaking cells in high levels of divalent cations (usually Ca^{2+}), treating with electric shock (electroporation) or by shooting DNA coated 'bullets' into cells (ballistic techniques or 'gene guns').

Transcription The process of copying a DNA sequence into an RNA molecule catalysed by the enzyme RNA polymerase.

Transcriptional activator A protein which activates (up regulates) transcription of a specific gene or group of genes. Transcriptional activators are DNA binding proteins which usually bind to specific sequences close to the promoter and enhance the binding of RNA polymerase and/or stimulate the rate of transcription

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initiation. Some activators bind at a distance from the promoter yet can interact with RNA polymerase to enhance transcription via a loop in the DNA.

Transcriptional repressor A protein (usually) which binds at a specific sequence in DNA at, or close to, the promoter and blocks the binding of RNA polymerase and hence blocks transcription of the genes controlled by that promoter.

Translation The complex process of interpreting the message in messenger RNA in the form of a polypeptide chain. The components of the system include: transfer RNAs, aminoacyl tRNA synthetases and the ribosome assembly. Messenger RNAs carry specific signals which allow ribosomes to recognize and bind to the message. These signals differ in eukaryotes and prokaryotes. In prokaryotes, the signal is usually a short purine-rich region (see ribosome binding site) approximately 10 bases upstream of the translation start site (usually, but not always, AUG). In eukaryotes the mRNA requires to be processed before it can be recognized by the ribosome. Translation terminates at a stop codon (UAA, UGA, UAG). The region between the initiation and termination of translation is usually known as an open reading frame (ORF).

Translational coupling Two or more adjacent genes in an operon which overlap or are separated by a few base pairs so that, at the level of messenger RNA, ribosomes terminating translation of first gene reinitiate translation of the second, or subsequent gene. Translational coupling may allow stoichiometric amounts of gene products to be produced.

Transposon A small mobile DNA element of no more than a few kbp which is capable of copying and inserting itself into a new location in a genome. When transposons insert into genes, they cause mutations (insertional inactivation). Tranposons may carry markers such as antibiotic resistance. Some have been engineered to carry reporter genes, e.g. the gene for β-galactosidase (*lacZ*) so that they can act as reporters of gene activity when inserted in the correct orientation.

X-ray absorption near edge structure (XANES) The X-ray absorption spectrum, as for EXAFS, may also show detailed structure below the absorption edge. This arises from excitation of core electrons to high level vacant orbitals, and can be used to estimate the oxidation state of the metal ion.

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