

Exhibit 2

**MOLECULAR BIOLOGY OF
THE CELL
THIRD EDITION**

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Front cover: The photograph shows a rat nerve cell in culture. It is labeled (*yellow*) with a fluorescent antibody that stains its cell body and dendritic processes. Nerve terminals (*green*) from other neurons (not visible), which have made synapses with the cell, are labeled with a different antibody. (Courtesy of Olaf Mundigl and Pietro de Camilli.)

Dedication page: Gavin Borden, late president of Garland Publishing, weathered in during his mid-1980s climb near Mount McKinley with MBoC author Bruce Alberts and famous mountaineer guide Mugs Stump (1940–1992).

Back cover: The authors, in alphabetical order, crossing Abbey Road in London on their way to lunch. Much of this third edition was written in a house around the corner. (Photograph by Richard Olivieri.)

carrier protein

Membrane transport protein that binds to a solute and transports it across the membrane by undergoing a series of conformational changes.

cartilage

Form of connective tissue composed of cells (chondrocytes) embedded in a matrix rich in type II collagen and chondroitin sulfate.

catabolism

General term for the enzyme-catalyzed reactions in a cell by which complex molecules are degraded to simpler ones with release of energy. Intermediates in these reactions are sometimes called catabolites.

catalyst

Substance that accelerates a chemical reaction without itself undergoing a change. Enzymes are protein catalysts.

***cdc* gene (cell-division-cycle gene)**

Gene that controls a specific step or set of steps in the cell cycle. Originally identified in yeasts.

Cdk protein—see cyclin-dependent protein kinase**cDNA—see complementary DNA****cell-adhesion molecule (CAM)**

Protein on the surface of an animal cell that mediates cell-cell binding.

cell body

Main part of a nerve cell that contains the nucleus. The other parts are axons and dendrites.

cell cortex

Specialized layer of cytoplasm on the inner face of the plasma membrane. In animal cells it is an actin-rich layer responsible for cell-surface movements.

cell cycle

Reproductive cycle of the cell: the orderly sequence of events by which the cell duplicates its contents and divides into two.

cell division

Separation of a cell into two daughter cells. In eucaryotic cells it entails division of the nucleus (mitosis) closely followed by division of the cytoplasm (cytokinesis).

cell fusion

Process in which the plasma membranes of two cells break down at the point of contact between them, allowing the two cytoplasm to mingle.

cell junction

Specialized region of connection between two cells or between a cell and the extracellular matrix.

cell line

Population of cells of plant or animal origin capable of dividing indefinitely in culture.

cell locomotion (cell migration)

Active movement of a cell from one location to another, particularly the migration of a cell over a surface.

cell-mediated immunity

Immune responses mediated by T lymphocytes.

cell plate

Flattened membrane-bounded structure that forms from fusing vesicles in the cytoplasm of a dividing plant cell and is the precursor of the new cell wall.

cell wall

Mechanically strong extracellular matrix deposited by a cell outside its plasma membrane. It is prominent in most plants, bacteria, algae, and fungi. Not present in most animal cells.

cellulose

Structural polysaccharide consisting of long chains of covalently linked glucose units. It provides tensile strength in plant cell walls.

central nervous system (CNS)

Main information-processing organ of the nervous system. In vertebrates it consists of the brain and spinal cord.

centriole

Short cylindrical array of microtubules, closely similar in structure to a basal body. A pair of centrioles is usually found at the center of a centrosome in animal cells.

centromere

Constricted region of a mitotic chromosome that holds sister chromatids together; also the site on the DNA where the kinetochore forms and then captures microtubules from the mitotic spindle.

centrosome (cell center)

Centrally located organelle of animal cells that is the primary microtubule organizing center and acts as the spindle pole during mitosis. In most animal cells it contains a pair of centrioles.

chaperone (molecular chaperone)

Protein that helps other proteins avoid misfolding pathways that produce inactive or aggregated states.

checkpoint

Point in the eucaryotic cell-division cycle where progress through the cycle can be halted until conditions are suitable for the cell to proceed to the next stage.

chelate

Combine reversibly, usually with high affinity, with a metal ion such as iron, calcium, or magnesium.

chemiosmotic coupling

Mechanism in which a gradient of hydrogen ions (a pH gradient) across a membrane is used to drive an energy-requiring process, such as ATP production or the rotation of bacterial flagella.

chemotaxis

Motile response of a cell or an organism that carries it toward or away from a diffusible chemical.

Chlamydomonas

Unicellular green alga with two flagella.

chlorophyll

Light-absorbing pigment that plays a central part in photosynthesis.

chloroplast

Specialized organelle in green algae and plants that contains chlorophyll and performs photosynthesis. It is a specialized form of plastid.

cholesterol

Lipid molecule with a characteristic four-ringed steroid structure that is an important component of the plasma membranes of animal cells. (See Figure 10-8.)

chromaffin cell

Cell that stores adrenaline in secretory vesicles and secretes it in times of stress when stimulated by the nervous system.

chromatid

One copy of a chromosome formed by DNA replication that is still joined at the centromere to the other copy.

chromatin

Complex of DNA, histones, and nonhistone proteins found in the nucleus of a eucaryotic cell. The material of which chromosomes are made.

chromatography

Biochemical technique in which a mixture of substances is separated by charge, size, or some other property by allowing it to partition between a moving phase and a stationary phase.

chromosome

Structure composed of a very long DNA molecule and associated proteins that carries part (or all) of the hereditary information of an organism. Especially evident in plant and animal cells undergoing mitosis or meiosis, where each chromosome becomes condensed into a compact, readily visible thread.

cilium (plural cilia)

Hairlike extension of a cell containing a core bundle of microtubules and capable of performing repeated beating movements. Cilia are found in large numbers on the surface of many eucaryotic cells, and they are responsible for the swimming of many single-celled organisms.

cisterna (plural cisternae)

Flattened membrane-bounded compartment, as found in the endoplasmic reticulum or Golgi apparatus.

citric acid cycle (TCA, or tricarboxylic acid cycle; Krebs cycle)

Central metabolic pathway found in all aerobic organisms. Oxidizes acetyl groups derived from food molecules to CO₂ and H₂O. Occurs in mitochondria in eucaryotic cells.

clathrin

Protein that assembles into a polyhedral cage on the cytoplasmic side of a membrane so as to form a clathrin-coated pit, which buds off to form a clathrin-coated vesicle.

cleavage

(1) Physical splitting of a cell into two. (2) Specialized type of cell division seen in many early embryos whereby a large cell becomes subdivided into many smaller cells without growth.

clone

Population of cells or organisms formed by repeated (asexual) division from a common cell or organism. Also used as a verb: "to clone a gene" means to produce many copies of a gene by repeated cycles of replication.

cloning vector

Genetic element, usually a bacteriophage or plasmid, that is used to carry a fragment of DNA into a recipient cell for the purpose of gene cloning.

coated pit

Invagination of the plasma membrane associated with a bristlelike layer of protein on its cytoplasmic surface. Pinches off to form a coated vesicle in the process of endocytosis.

coated vesicle

Small membrane-bounded organelle formed by the pinching off of a coated region of membrane. Some coats are made of clathrin, whereas others are made from other proteins.

codon

Sequence of three nucleotides in a DNA or messenger RNA molecule that represents the instruction for incorporation of a specific amino acid into a growing polypeptide chain.

coenzyme

Small molecule tightly associated with an enzyme that participates in the reaction that the enzyme catalyzes, often by forming a transient covalent bond to the substrate. Examples include biotin, NAD⁺, and coenzyme A.

coenzyme A

Small molecule used in the enzymatic transfer of acyl groups in the cell. (See also **acetyl CoA** and Figure 2-20.)

cofactor

Inorganic ion or coenzyme that is required for an enzyme's activity.

coiled-coil

Especially stable rodlike protein structure formed by two α helices coiled around each other.

collagen

Fibrous protein rich in glycine and proline that is a major component of the extracellular matrix and connective tissues. Exists in many forms: type I, the most common, is found in skin, tendon, and bone; type II is found in cartilage; type IV is present in basal laminae.

combinatorial

Describes any process that is governed by a specific combination of factors (rather than by any single factor), with different combinations having different effects.

complement

System of serum proteins activated by antibody-antigen complexes or by microorganisms. Helps eliminate pathogenic microorganisms by directly causing their lysis or by promoting their phagocytosis.

complementary DNA (cDNA)

DNA molecule made as a copy of mRNA and therefore lacking the introns that are present in genomic DNA. Used to determine the amino acid sequence of a protein by DNA sequencing or to make the protein in large quantities by cloning followed by expression.

complementary nucleotide sequence

Two nucleic acid sequences are said to be complementary if they can form a perfect base-paired double helix with each other.

complex

Assembly of molecules that are held together by noncovalent bonds. Protein complexes perform most cell functions.

conformation

Spatial location of the atoms of a molecule—for example, the precise shape of a protein or other macromolecule in three dimensions.

connective tissue

Any supporting tissue that lies between other tissues and consists of cells embedded in a relatively large amount of extracellular matrix. Includes bone, cartilage, and loose connective tissue.

connexon

Water-filled pore in the plasma membrane formed by a ring of six protein subunits. Part of a gap junction: connexons from two adjoining cells join to form a continuous channel between the two cells.

free-energy change (ΔG)

Change in the free energy during a reaction: the free energy of the product molecules minus the free energy of the starting molecules. A large negative value of ΔG indicates that the reaction has a strong tendency to occur. (See Panel 14-1, pp. 668-669.)

G₀ phase

(G-"zero" phase) State of withdrawal from the eucaryotic cell-division cycle by entry into a quiescent G₁ phase; often seen in differentiated cells.

G₁ phase

Gap 1 phase of the eucaryotic cell-division cycle, between the end of cytokinesis and the start of DNA synthesis.

G₂ phase

Gap 2 phase of the eucaryotic cell-division cycle, between the end of DNA synthesis and the beginning of mitosis.

G protein

One of a large family of heterotrimeric GTP-binding proteins that are important intermediaries in cell-signaling pathways. Usually activated by the binding of a hormone or other signaling ligand to a seven-pass transmembrane receptor protein.

GAG (glycosaminoglycan)

Long, linear, highly charged polysaccharide composed of a repeating pair of sugars, one of which is always an amino sugar. Mainly found covalently linked to a protein core in extracellular matrix proteoglycans. Examples include chondroitin sulfate, hyaluronic acid, and heparin.

gamete

Specialized haploid cell, either a sperm or an egg, serving for sexual reproduction.

ganglion (plural ganglia)

Cluster of nerve cells and associated glial cells located outside the central nervous system.

ganglioside

Any glycolipid having one or more sialic acid residues in its structure. Found in the plasma membrane of eucaryotic cells and especially abundant in nerve cells.

gap junction

Communicating cell-cell junction that allows ions and small molecules to pass from the cytoplasm of one cell to the cytoplasm of the next.

gastrula

Animal embryo at an early stage of development where cells are invaginating to form the rudiment of a gut cavity. (From Greek *gaster*, belly.)

gene

Region of DNA that controls a discrete hereditary characteristic, usually corresponding to a single protein or RNA. This definition includes the entire functional unit, encompassing coding DNA sequences, noncoding regulatory DNA sequences, and introns.

gene regulatory protein

General name for any protein that binds to a specific DNA sequence to alter the expression of a gene.

general transcription factor

Any of the proteins whose assembly around the TATA box is required for the initiation of transcription of most eucaryotic genes.

genetic code

Set of rules specifying the correspondence between nucleotide triplets (codons) in DNA or RNA and amino acids in proteins.

genome

Total genetic information carried by a cell or an organism.

genomic DNA

DNA constituting the genome of a cell or an organism. Often used in contrast with cDNA (DNA prepared by reverse transcription from messenger RNA).

genotype

Genetic constitution of an individual cell or organism.

germ cells

Precursor cells that give rise to gametes.

germ line

The lineage of germ cells (which contribute to the formation of a new generation of organisms), as distinct from somatic cells (which form the body and leave no descendants).

giga-

Prefix denoting 10⁹. (From Greek *gigas*, giant.)

glial cells

Supporting cells of the nervous system, including oligodendrocytes and astrocytes in the vertebrate central nervous system and Schwann cells in the peripheral nervous system.

globular protein

Any protein with an approximately rounded shape; contrasts with highly elongated, fibrous proteins such as collagen.

glucose

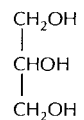
Six-carbon sugar that plays a major role in the metabolism of living cells. Stored in polymeric form as glycogen in animal cells and as starch in plant cells. (See Panel 2-3, pp. 52-53.)

glutaraldehyde

Small reactive molecule with two aldehyde groups that is often used as a cross-linking fixative.

glycerol

Small organic molecule that is the parent compound of many small molecules in the cell, including phospholipids.

**glycocalyx (cell coat)**

Carbohydrate-rich layer that forms the outer coat of a eucaryotic cell. Composed of the oligosaccharides linked to intrinsic plasma membrane glycoproteins and glycolipids, as well as glycoproteins and proteoglycans that have been secreted and reabsorbed onto the cell surface.

glycogen

Polysaccharide composed exclusively of glucose units used to store energy in animal cells. Large granules of glycogen are especially abundant in liver and muscle cells.

glycolipid

Membrane lipid molecule with a short carbohydrate chain attached to a hydrophobic tail.

glycolysis

Ubiquitous metabolic pathway in the cytosol in which sugars are incompletely degraded with production of ATP. (Literally, "sugar splitting.")