Outline of Cell Biology
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BIOL>Cell

cell in biology

Biochemical structures {cell, biology} surrounded by membrane have 750 small molecules and 2000 macromolecules. Living cells have diameter 10^-5 meters and mass 10^-14 grams. Cells are sensitive to temperature change, chemicals, light, and touch. Chemical reactions take 0.001 seconds. Sunlight provides energy, directly for plants and indirectly for animals.

movement

Cells can move by amoeboid motion, cilia, cyclosis, flagella, or pinocytosis.

cell theory

Living things are cells or cell groups {cell theory}. Organism activities result only from cell actions. New cells form by cell division. All cells are similar.

extracellular matrix

Cell groups have extracellular fluids and matrices. Fluids outside cells supply nutrients. Connective tissue {extracellular matrix}| (ECM) supports body organs. Connective tissue has collagen, elastin, glycoproteins, and glycosaminoglycans. Glycoproteins include laminin, fibronectin, enactin, and nidogen. Glycosaminoglycans include ground substance, heparan sulfate, and proteoglycans.

Activated macrophages and trophoblast cells produce proteinases to break down ECM. Tumors produce gelatinase, glycosidase, hyaluronidase, and heparanase.

lysis

Cell membranes can rupture {lysis}|.

sensitivity of cell

All cells are sensitive to temperature change, chemicals, light, and touch {sensitivity, cell}. Specialized cells can respond to sounds, pressures, positions, molecules, temperatures, and light color, intensity, or direction.

ribozyme

RNA enzymes {ribozyme} can regulate biochemical reactions.

BIOL>Cell>Kinds

endothelia

blood-vessel-lining cells {endothelia}|.

fibroblast in skin

Skin cells {fibroblast, skin} can grow in culture for return under skin or in peritoneum.

hematopoietic cell

Bone-marrow cells {hematopoietic cell}| can make blood cells.

hepatocyte

Liver cells {hepatocyte}| can grow in culture for return to liver, spleen, or portal vein.

immortalized cell

Cell {immortalized cell} lines can keep dividing without limit.

multinucleate cell

Muscle fibers {multinucleate cell}| have multiple nuclei.

myoblast

Skeletal-muscle stem cells {myoblast}| fuse to make muscle fibers.

pluripotency

Cells can become any cell type {pluripotency}. Oct3/4, Sox2, c-Myc, and Klf4 proteins can restore pluripotency in adult cells {induced pluripotent stem cell} {IPS cell} {iPS cell}. Retroviruses, adenoviruses, or plasmids can take proteins into cells. However, c-Myc causes cancer, and retrovirus stays in cells.

satellite cell

Skeletal-muscle-tissue stem cells {satellite cell} remain beside muscle fibers and are for regeneration. They can grow in culture and return to muscle.

stem cell

Embryonic stem cells can become specific for organs and remain in protected regulatory niches. They can later divide to keep one cell {stem cell}| and make one cell for further division. Stem cells can become cancerous.

synctitium

Cell groups {synctitium}| can have links and function as wholes.

synctium

Cell groups can dissolve membranes and fuse to make multinucleated cytoplasm {synctium}| surrounded by membrane.

temperature-sensitive cells

Mutant organisms {temperature-sensitive cell} can have proteins sensitive to temperature and die or stop growing at higher temperatures.

BIOL>Cell>Kinds>Plasm

germ plasm

reproductive cells {germ plasm}|.

somatoplasm

body cells {somatoplasm}.

BIOL>Cell>Organelle

organelle

Cell parts {organelle}| {cell organelle} are plant cell wall, plasma membrane, nucleus, nucleolus, mitochondria, plastid, lysosome, Golgi complex, smooth endoplasmic reticulum, rough endoplasmic reticulum, centriole, and vacuole.

membrane of cell

Two-layer phospholipids {plasma membrane} {membrane, cell}| {cell membrane} surround cytoplasm and have integrated proteins. Phospholipid polar ends point toward outsides. Non-polar ends are between layers. Unsaturated fatty acids and other non-polar molecules can diffuse quickly through non-polar cell membrane.

proteins

Cell membrane has 25% of cell protein. Membrane proteins can help make phospholipids. Membrane proteins have patterns caused by external and internal electric forces.

proteins: channels

Membrane proteins {permion} can have channels that allow cations to pass from side with high concentration to side with low concentration. Cations control permion opening and closing. By active transport using energy from ATP and proteins, molecules can go across membrane from side with low concentration to side with high concentration.

proteins: receptors

Protein receptors {cell surface receptor} bind circulating proteins and can facilitate transport across cell membranes.

cell wall

Plant cells have cellulose layers {cell wall}| around plasma membranes, for cell support.

mitochondrion

In cytoplasm, animal cells have oblong bodies {mitochondrion}| with double membranes. Inner membrane has many folds {cristae}, holding oxidative-phosphorylation and TCA-cycle enzymes. Mitochondria have small DNA circles.

vacuole

Cells can have cell membrane {vacuole}| surrounding liquid, oil, food, starch, or protein. Protozoa vacuoles can fill with water and then pump water out.

centromere

Animal and lower plant cells have chromosomes, which have centers {centromere}| where microtubules attach. After chromosome duplication, microtubules pull one chromosome to one side and the other chromosome to other side, preparing cell nucleus and cell to split into two cells.

BIOL>Cell>Organelle>Nucleus

nucleus

Animal and plant cells have DNA-containing oval bodies {nucleus, cell}|, surrounded by double membrane. Nuclear membranes extend into cytoplasm as endoplasmic reticulum tubes and end at Golgi complex.

nucleolus

Cell nuclei can have spherical bodies {nucleolus}| that synthesize rRNA.

BIOL>Cell>Organelle>Protein

microtubule

Cell cytoplasm contains protein tubules {microtubule}| to transport molecules.

structure

13 columns of parallel tubulin filaments {protofilament} can combine in linear sequences. Tubulins are globular proteins and are 900-amino-acid biglobular alpha-tubulin and beta-tubulin dimers. Microtubules have 25-nm outside diameter and 14-nm inside diameter. Microtubules contain only water molecules.

forms

Two conformations have different bending around subunit junction: symmetrical form and unstable form. Brain microtubules are stable, but muscle and mitotic microtubules are unstable.

connection

Microtubules connect sideways by proteins {microtubule associated proteins} (MAP).

functions

Vesicles, granules, mitochondria, and chromosomes move along microtubule outsides, using ATPase molecules like kinesins and dyneins. Microtubules are cytoskeleton components, which also have actin and other proteins. Groups of microtubules and other proteins make cilia, flagella, and centrioles. Microtubules make pairs or triples. Cilia have nine triples in circle with middle pair.

anesthetics

Some anesthetics bind to microtubules.

neurofilament

Neuron cytoplasm contains protein filaments {neurofilament}|.

BIOL>Cell>Organelle>Centrosome

centrosome

Animal and lower plant cells have microtubule-organizing centers {centrosome}| {spindle pole body}. Spindle pole bodies have RNA and separate to cell sides during mitosis. Centrosomes have centrioles and other proteins.

In cell division, centrioles duplicate, microtubules align between centrioles and connect to duplicated-chromosome centromeres, and centrioles separate, pulling half the chromosomes one way and half the other. Centrioles organize spindle between them during cell division and can duplicate themselves. Bodies have nine microtubule triplets in one circle, with no central microtubules.

centriole

Animal and lower plant cells have two separate cylindrical bodies {centriole}|, perpendicular to each other, near cell nucleus, which are centrosome parts. Centrioles organize spindle between them during cell division and can duplicate themselves. Centrioles have nine microtubule triplets in one circle, with no central microtubules.

BIOL>Cell>Organelle>Microsome

microsome

Ribosomes, Golgi complexes, lysosomes, and endoplasmic reticulum are similar organelles {microsome}|.

endoplasmic reticulum

Nucleated cells have cytoplasm membrane-tube networks {endoplasmic reticulum}| (ER), extending from cell nucleus. Endoplasmic reticulum can have attached ribosomes {rough endoplasmic reticulum} or no attached ribosomes {smooth endoplasmic reticulum}. Neurons, unlike other cells, have much rough endoplasmic reticulum. ER adds sugars to proteins.

Golgi complex

All cells, except mature sperm cells and red blood cells, have tubular-membrane networks {Golgi complex}| that store cell products, such as plant-cell cellulose, before secretion. Golgi complexes are near cell nucleus. Golgi complex adds sugars to proteins.

ribosome

Free-floating or rough-endoplasmic-reticulum RNA-protein complexes {ribosome}| synthesize cellular proteins.

BIOL>Cell>Organelle>Microsome>Lysosome

lysosome

Cells have membrane-surrounded regions {lysosome}| containing enzymes {lysozyme} that can catabolize {autophagy, lysosome} large molecules, such as membranes and poorly folded, denatured, foreign, damaged, or used proteins, and remove sugars from proteins. Ubiquitin recognizes and binds to such proteins, marking them for later break down. Autophagosomes fuse with lysosomes.

autophagosome

Double-layer membranes {phagophore} can form in cytoplasm. Phagophores increase if nutrients, growth factors, and/or oxygen have low concentration.

process

Phagophore membranes close around damaged cell molecules and make spheres {autophagosome}. Autophagosome formation needs apg8 protein, similar to ubiquitin, which undergoes phosphoglycerolipidation with phosphatidylethanolamine to integrate into membrane. Ubiquitin recognizes and binds damaged proteins, marking them for later break down.

lysosomes

After autophagosome formation, membrane proteins leave, and autophagosomes fuse with cell lysosomes. Lysosomes contain lysozyme, which removes sugars from proteins and catabolizes {autophagy, autophagosome} large molecules, such as membranes and poorly folded, denatured, foreign, damaged, or used proteins.

proteosome

Structures {proteosome}| break peptide bonds using ubiquitin.

processing body

Cell organelles {processing body} {P-body} can store used mRNAs and break them down using RNAses, such as Dhh1p. They affect RNA interference using Argonaute protein.

BIOL>Cell>Organelle>Plastid

plastid

Plant-cell bodies {plastid}| can synthesize or store food. Plastids include chloroplasts, leucoplasts, and chromoplasts.

chloroplast

Plastids {chloroplast}| can contain chlorophyll for photosynthesis.

chromoplast

Plastids {chromoplast}| can contain color pigments.

leucoplast

Plastids {leucoplast}| can store starch.

BIOL>Cell>Organelle>Plasm

cytoplasm

Nucleated cells have regions {cytoplasm}| inside cell membrane but outside cell nucleus.

protoplasm

Cells have gel {protoplasm}| that contains cell organelles.

BIOL>Cell>Cell Cycle

cell cycle

All eukaryotic cells have the same cell-division sequence {cell cycle}| and cell-cycle controls.

cytokinesis

After mitosis, cells pinch membrane in at middle until both sides meet, and then cell splits to form two cells {cytokinesis}. Mitosis and cytokinesis are independent processes.

BIOL>Cell>Cell Cycle>Meiosis

meiosis in biology

Diploid eukaryotic germ cells produce haploid sex-cell gametes {meiosis, biology}|, such as sperm and eggs. One germ cell makes four haploid cells. First stage is prophase. Next stage is segregation. Then cell divides, making two diploid cells {doublet, cell}, with doubled, paired chromosomes. In both cells, chromosomes separate to cell sides on spindles. Then nucleus splits. Cytokinesis makes each diploid cell into two cells.

prophase of meiosis

First meiosis phase {prophase, meiosis} has synapsis, replication, and tetrad formation. First, homologous chromosomes have synapsis. Then all chromosomes replicate, by semiconservative replication, except at chromosome centromere, where chromosome pairs remain attached. Then homologous, doubled chromosomes synapse to make tetrads.

synapsis

In meiosis prophase, diploid germ cell pairs homologous chromosomes {synapsis}.

semiconservative replication

After synapsis, paired nucleic acids replicate to make two new nucleic acids {semiconservative replication, meiosis}.

tetrad

Homologous, doubled chromosomes synapse to make four-chromosome groups {tetrad}, attached at centromeres.

segregation of chromosomes

One chromosome pair from each tetrad goes to one centriole pole, and the other chromosome pair goes to other centriole pole {segregation, chromosome}| {chromosome segregation}. Because any two chromosomes can segregate, meiosis increases variation.

BIOL>Cell>Cell Cycle>Meiosis>Recombination

recombination of chromosome

At meiosis prophase first synapsis makes chromosome pairs. Pairs can interchange chromosome segments {recombination, DNA}| {homologous recombination} {crossing-over}.

process

Both double helices unwind. Enzyme splits homologous strands at same positions. Ends can reattach to other homologous strand or repair themselves. Both double helices rewind.

crossing over: one cut

Enzymes can split homologous nucleic acids at the same position. Ends can reattach so halves exchange. Left end is from one nucleic acid, and right end is from other nucleic acid. Left end is from other nucleic acid, and right end is from one nucleic acid.

crossing over: two cuts

Enzymes can split homologous nucleic acids at same two positions. Ends can reattach so middle section exchanges. Left end is from one nucleic acid, middle is from other nucleic acid, and right end is from one nucleic acid. Left end is from other nucleic acid, middle is from one nucleic acid, and right end is from other nucleic acid.

recombination

Recombination makes strands with different allele sequences. Because recombination mixes alleles, meiosis increases variation. Only homologous chromosomes have recombination, because only homologous chromosomes pair and because enzymes can split them at same place. Yeast has high recombination.

gene knockout

Gene-middle recombination inactivates genes. Gene-end recombination allows recombined genes to replace original genes {transplacement}. Transplacement can replace normal genes with inactive genes, so cell loses gene function or product {gene knockout}. For experiments, knockout mice can have gene deactivation.

BIOL>Cell>Cell Cycle>Mitosis

mitosis

Cell-nucleus DNA can replicate to make two DNA sets {mitosis}|. Growing cells spend 5% of time in mitosis.

cell cycle

All eukaryotic cells have the same cell-division sequence and cell-cycle controls. First, cell differentiates and grows but does not divide, in gap 1 stage. Then cell begins cell division. DNA synthesizes, and chromosomes replicate, in S stage. Then cell grows with no DNA replication, in gap 2 stage. In M stage, mitosis has chromosome doubling prophase, chromosome pairing metaphase, chromosome separation on spindles anaphase, and cell-nucleus splitting telophase. The long interphase between mitoses includes gap-1, S, and gap-2 stages.

mitosis start

Nuclear-to-cytoplasmic volume ratio controls mitosis. Cell division starts after cell grows enough. Perhaps, hormones control mitosis.

proteins

More than 60 cell-division-cycle (CDC) proteins control cell cycle. They regulate metabolism in non-growing cells, trigger mitosis, and coordinate growth and division in growing cells.

cytokinesis

After mitosis, cell splits, as membrane pinches in, to make two cells. Mitosis and cytokinesis are independent processes.

yeast

In Saccharomyces cerevisiae budding yeast, bud is start of DNA synthesis. Bud grows throughout other stages. Cell nucleus differs in gap 2 and mitosis. In Schizosaccharomyces pombe fission yeast, cell length shows cell-cycle stage. Cell nucleus differs in gap 2 and mitosis. Budding yeast CDC28 and fission yeast cdc2 make serine, threonine kinase, which binds to different cyclins to make proteins {maturation promoting factor} (MPF) that start cell division and act from gap 2 to mitosis. Factor complex breakup ends mitosis.

temperature

Mutant organisms {temperature-sensitive organism} can have temperature-sensitive proteins and die or stop growing at higher temperature.

metaphase stoppage

Colcemid, trypsin, and Giemsa stain stop cells at metaphase. Typically, bromodeoxyuridine precedes chemical stoppage.

BIOL>Cell>Cell Cycle>Mitosis>Phases

prophase of mitosis

First mitosis phase {prophase, mitosis} doubles chromosomes. Chromosomes condense, and human chromosomes have 350 to 550 bands. RNA-containing spindle-pole body centrosomes separate to cell sides. Microtubules form between centrosomes. Chromosome kinetochores attach to microtubules.

metaphase

Second mitosis phase {metaphase} pairs chromosomes. Chromosomes align halfway between centrosomes.

anaphase

Third mitosis phase {anaphase} separates chromosomes on spindles. Chromosomes move toward spindle poles.

telophase

Last mitosis phase {telophase} splits cell nucleus. Poles move apart.

interphase

Between mitoses, long phase {interphase} includes gap-1, S, and gap-2 stages.

BIOL>Cell>Metabolism

metabolism

Living things have linked biochemical reactions {metabolism}| for anabolism and catabolism. Cells produce and break down, and store energy in and release energy from, complex organic molecules.

anabolism
Biochemical reactions can create complex organic molecules {anabolism}|.

catabolism
Biochemical reactions can break down complex organic molecules {catabolism}|.

homeostasis in metabolism
Metabolism tends to maintain intracellular environments in constant equilibrium {homeostasis, metabolism}|. In biochemical reactions, reaction products decrease molecule production rate by changing regulatory-enzyme amounts. Cells also release hormones that regulate and coordinate cellular activities.

BIOL>Cell>Movement

amoeboid motion
Cells can move by pushing cytoplasm forward {amoeboid motion}|.

cilia
Vertebrate cells can have membrane protuberances {cilia}| {cilium} one-hundredth to one-thousandth cell diameter. At cilia bases, bodies {basal body} have nine tubules and duplicate at cell division.

Primary cilia have nine outer filaments and no central filaments. Most vertebrate cells have one primary cilium, and it does not move. Primary cilia receive signals, relay signals to cell body along tubules {intraflagellar transport}, and affect development and wound-healing. Sonic hedgehog protein binds to primary cilia and releases signal proteins that travel to nucleus. Leptin binds to hypothalamus-neuron primary cilia. Wnt binds to primary cilia to orient developing-tissue cells.

Motile cilia have nine outer filaments and two central filaments. Cells can have many or no motile cilia. Central filaments allow wave-like motion. Coordinated waves can establish clockwise or counterclockwise motion and so designate right from left, as needed to place and structure body tissues and organs.

Eye and nose receptors have modified cilia that contain receptive chemicals.

flagellum
Cilia and flagella have same organization.

cyclosis
Cells can move by spinning themselves {cyclosis}.

flagellum
Cells can move by twisting one long hair-like membrane protuberance {flagella} {flagellum}. Cilia and flagella have same organization.

pinocytosis
Plant and lower-animal cells can extend cell membrane around food material and then re-close membrane to make food vacuoles {pinocytosis}|.

taxis
Cells can move toward or away from stimuli {taxis}|. Single-cell organisms can move toward or away from oxygen (aerotaxis, in bacteria), molecules (chemotaxis, in bacteria and protozoa), gravity (geotaxis, in protozoa), light (phototaxis, in phytoflagellates and protozoa), and contact (thigmotaxis).

Organisms can change activity (kinesis) in response to stimulus. Organisms can grow (tropism) toward or away from stimuli.

kinesis
Organisms can change activity {kinesis} in response to stimulus. For example, organisms can grow (tropism) toward or away from stimuli.

BIOL>Cell>Protein

monophore

Biological molecules can have binding elements {monophore}, identifiable by mass spectrometry.

motility factor

Growth-factor-related proteins {motility factor} can aid cell migration by increasing membrane ruffling, lamellae, and pseudopodia. Autocrine motility factor (AMF), autotaxin, scatter factor or hepatocyte growth factor, TGF-a or EGF, and insulin-like growth factor (IGF) have membrane receptors and stimulate chemokinesis and chemotaxis.

sepsis

Cells can make cytokines and oxidizers that cause septic shock {sepsis, cell}|. Kif1C and other proteins can sequester toxins, such as anthrax toxin, in macrophages, to prevent sepsis.

BIOL>Cell>Protein>Adhesion

adhesion of cells

Cell-cell binding {adhesion, cell}| involves cell-membrane proteins, such as integrins, cadherins, Deleted in Colon Cancer (DCC), and CEA.

integrin

B-integrin and twenty similar proteins {integrin} are transmembrane receptors for weak-binding glycoprotein adhesion molecules, such as extracellular-matrix fibronectin, collagen, vitronectin, and laminin. Inside cells, integrins link to cytoskeleton talin, vinculin, and actin microfilaments. Alpha-integrin maintains long-term potentiation (LTP) and aids memory.

cadherin

E-cadherin, P-cadherin, and N-cadherin proteins {cadherin} are calcium adhesion molecules (CAM). E-cadherin is 120 kDa, spans cell membrane, and connects with catenins that link to cytoskeleton actin. Cancer cells have low cadherin and low intercellular adhesion. Protocadherin affects brain development.

BIOL>Cell>Protein>Membrane Transport

transportan

Peptides {transportan} can go through membranes, using transactivation response elements in 5' long terminal repeats.

transactivation response

Transportan peptides can go through membranes, using conserved regions {transactivation response element} {TAR element} in 5' long terminal repeats (LTR).

BIOL>Cell>Protein>Motor

motor protein

Proteins {motor protein} can use ATP to bind to, and then slide on, microtubules. All eukaryotes have motor proteins. ATPases, kinesins, and dyneins are motor proteins.

kinesin

Kinesin-related proteins have similar 340-amino-acid motor domains, with one ATP-binding site and one tubulin microtubule-binding site. Microtubule-binding sites hold onto one protein strand, while ATP-binding site transfers other protein strand forward. Most kinesins move toward fast-growing microtubule end {microtubule plus}. Some kinesins move toward other microtubule end {microtubule minus}. C-terminal motor kinesin-related proteins move toward microtubule minus. Kinesin-related KHC, Unc-104, and KRP85/95 assist membrane-bound organelle transport, as well as mitosis and meiosis spindle and chromosome movements.

dynein

Cytoplasmic dyneins move microtubules that move cilia and flagella. Motor domains have elastic parts that strain and then release.

catenin

Proteins {catenin} link to cytoskeleton actin proteins.

processive motility

Proteins move microtubule one step per ATP and can perform 100 steps {processive motility}.