Cells

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Nearly all cells are too small to be seen with the naked eye. Scientific observation of cells requires microscopy, which magnifies images of samples. Two major methods for microscopy are light microscopy and electron microscopy. Light microscopy uses humanly visible light passed through a sample and then through one or more lenses to form a magnified image. Regardless of magnification, the resolution of a light microscope is limited by the smallest wavelength of visible light. Viewing objects (like organelles) that are much smaller than cells requires electron microscopy, which allows for much higher resolution by using streams of electrons to produce an image of a sample.

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A typical prokaryotic cell (like a bacterium) is much smaller than a typical eukaryotic cell. A typical prokaryotic cell includes not only a plasma membrane (like all cells) but also a cell wall that lies exterior to the plasma membrane. One or more whip-like flagella might be present to aid in locomotion. Since prokaryotes do not have membrane-bounded organelles, the DNA (usually a single, circular chromosome) is found in the cytoplasm. The region of the cytoplasm in which the chromosome is found is called the nucleoid.

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Any plasma membrane is made up chiefly of phospholipids arranged in a bilayer. Embedded in that phospholipid bilayer are different kinds of particles, including proteins having various functions. Proteins (or any other particles) that are connected to the plasma membrane are examples of membrane-bound particles.

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Despite the huge variety of cells found in nature, nearly all cells occur in a fairly small range of sizes. Therefore, all unicellular organisms are roughly the same size, and multicellular organisms reach large size not by being made of large cells, but rather by being made of many small cells. This is because there is an upper limit to the volume of a single cell beyond which the cell cannot survive. The size of a cell is constrained by the surface area-to-volume ratio. As a cell increases in size (in all three dimensions), its surface area increases, but its volume increases even more. Therefore, the surface area-to-volume ratio will decrease as a cell grows. If a cell becomes too big, there will not be enough surface (its membrane) to allow for enough exchange of materials with the surroundings to keep the cell alive.

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A typical animal cell is pictured. Animal cells contain many different kinds of organelles:

- The nucleus includes a region, called the nucleolus, where ribosomal RNA is produced. The nucleus also contains the chromosomes. Eukaryotic chromosomes are linear, and each chromosome is made of a mixture of molecules (called chromatin) that includes a DNA molecule and many protein molecules.
- Outfoldings from the nuclear envelope give rise to a different organelle, the endoplasmic reticulum, which includes two major parts:
  - The rough endoplasmic reticulum (RER) appears as a collection of flattened sacs. The surface of the RER appears rough, because tiny organelles called ribosomes are associated with the surface of the RER. The main function of the RER is to receive newly made proteins from ribosomes, modify those proteins in some way, and send them to another organelle, the Golgi complex.
  - The smooth endoplasmic reticulum (SER) is continuous with the RER, but its form is more tube-like than sac-like. It appears smooth, because it lacks the associated ribosomes. The main functions of the SER are lipid synthesis and storage of various particles, including calcium ions that act as signals.
- Though it is an organelle, a ribosome is not membrane-bounded. A single ribosome is made up of two subunits. Each subunit is a mixture of proteins and ribosomal RNA. Proteins (polypeptides) are built at ribosomes, using amino acids as building blocks. This process is called translation, and it requires a molecule, called messenger RNA, that serves as a set of instructions for how to assemble the protein.
- The Golgi complex (also called Golgi apparatus or simply Golgi) is a collection of flattened sacs appearing similar to the RER. It operates as a receiving and shipping center with the cell. As such, it has two functionally different sides. The *cis* face (lying next to the RER) receives vesicles containing proteins from the RER. The incoming vesicles fuse with the Golgi's own membrane, spilling the proteins into the lumen of the Golgi complex. The Golgi complex then packages the proteins in new vesicles (made of Golgi membrane from the *trans* face), which are sent to the appropriate places for those proteins to function. This can be somewhere inside the cell, or the proteins can be exported out of the cell or embedded within the plasma membrane.
- Microvilli are tiny, finger-like projections of the plasma membrane. They drastically increase the surface area for cells that have microvilli.
- Lysosomes are vesicular organelles that contain digestive (or lytic) enzymes that break down particles safely within the lysosomes.
- Peroxisomes are vesicular organelles that break down peroxides.
- The cytoskeleton is an infrastructure made up of three kinds of protein fibers (microfilaments, intermediate filaments, and microtubules). The cytoskeleton provides structure to the cell, maintains order, and serves as a system of miniature roads along which particles can be transported.
- A centrosome is a microtubule organizing center that becomes important when a eukaryotic cell is close to undergoing cell division (mitosis or meiosis).
- A flagellum (if present) is able to propel the cell through its medium.

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A typical plant cell is pictured. Most of the organelles are also found in animal cells. Unlike an animal cell, a plant cell features a relatively rigid cell wall on the exterior surface of the plasma membrane.

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A vacuole is a membrane-bounded organelle similar to but larger than a vesicle. A central vacuole is an organelle found in plant cells but not in animal cells. It contains mostly water, but the plant cell can also dump various materials into the central vacuole, thereby removing them from the cytoplasm. Because a central vacuole occupies a large fraction of a plant's volume (and because they contain mostly water), plants are able to grow more rapidly than animals.

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Membrane is continuously being moved, via vesicles, from one organelle to another, including the plasma membrane.

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The mitochondrion is one of three doubly membrane-bounded organelles. Mitochondria occur not only in plants and animal, but in other eukaryotes as well. The inner membrane is highly folded to increase the surface area. Each fold is called a crista. A mitochondrion contains its own ribosomes and its own DNA. The function of mitochondria is cellular respiration, which is a series of chemical reactions that extract energy from sugar and store that energy in molecules of ATP.

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The chloroplast is one of three doubly membrane-bounded organelles. Chloroplasts occur in photosynthetic eukaryotes, including plants. The inner membrane is elaborated into a system of interconnected sacs, called thylakoids, that are arranged in stacks called grana. The function of a chloroplast is photosynthesis, which is a series of chemical reactions driven by the energy of light to produce organic molecules (sugars) out of inorganic molecules (carbon dioxide). In photosynthetic eukaryotes, the sugars produced in chloroplasts are then broken down in mitochondria to release energy that is stored in ATP molecules.

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Flagella and cilia are two kinds of motive structures (i.e., they cause motion).
A flagellum is much longer than a cilium, and a flagellated cell usually has a flagellum (or several flagella) at just one end of the cell. Movement of a flagellum propels the cell through the medium.
A cilium is hairlike in appearance, and it is much shorter than a flagellum. A ciliated cell typically features cilia over a large fraction of the cell surface. Movement of cilia can either propel a cell through its medium, or cause the medium to move past the surface of a cell if the cell is anchored in place.