1. Bacterial Cells

A kitchen contains many parts. The stove is used for cooking, the refrigerator keeps food cold, and a sink is used for cleaning up. Each part has a function, and each part contributes to the function of the kitchen as a whole. Each part also has a particular structure that helps it perform its function. For example, a refrigerator wouldn't be able to do its job unless it had a cold, hollow place to store the food.

Like a kitchen, cells are filled with cell parts. Each part has a distinct shape and function that allows it to do its job. Cells with different functions have different cell parts, but all cells, even a simple bacterial cell, have four parts in common: a cell membrane, cytoplasm, DNA, and ribosomes. Figure 1A illustrates the parts that all cells have in common. Why do all cells need these particular parts?

The Cell Membrane Surrounds a Cell All cells are surrounded by a flexible cell membrane. The cell membrane is a protective structure that encloses a cell and functions to control what enters and leaves the cell. In order to fulfill its function, the membrane is made of a material that allows some kinds of particles pass through, while other kinds of particles are held back. This property is called selective permeability. For example, a window screen is selectively permeable because it lets air pass through while holding back insects. Similarly, a cell membrane lets water or oxygen pass through freely while holding back bigger substances, like cell debris.

DNA Carries Instructions Before a house can be built, an architect must create blueprints that contain instructions for how to build the house. The blueprints instruct the workers on what size to make the kitchen and where to place the sink. Like the house, a cell also needs instructions for building its parts. DNA is a substance that makes up the instructions for building the cell's components and for carrying out its life processes. The thousands of substances and structures made within a cell are built according to specific instructions in the DNA. For example, a cell needs instructions for building each part of its cell membrane. These instructions allow it to make a specific type of membrane. Other instructions in DNA are for making the structures and substances that release energy from food and for those that allow a cell to divide into two new cells.

If construction workers were building the bedroom in a house, they would have the blueprint of the entire house, but they don't have to read the part about where to put the sink in the kitchen. Similarly, not all instructions in the DNA are needed at the same time or place. Because of this, cells have mechanisms for "reading" and interpreting parts of the instructions at different times. For example, once the cell membrane is made, the cell might not need to access that part of the instructions again, unless the cell membrane is damaged.

Ribosomes Make Proteins Another cell part found in all cells are ribosomes. Ribosomes are small cell structures that make proteins by following the instructions in DNA. A protein is a substance that makes up much of an organism's structure. Proteins also participate in most chemical reactions that occur in cells.

Cytoplasm Fills a Cell All cells also contain cytoplasm, a gel-like substance that fills the inside of a cell. If you imagine a cell as a balloon full of gel, the balloon would be the cell membrane and the gel would be the cytoplasm. Most of the cell's processes take place in the cytoplasm. For example, the ribosomes make proteins in the cytoplasm. In a bacterial cell, the DNA is found in the cytoplasm.

A basic bacterial cell has these four main parts, whereas all the cells of multicellular organisms have a number of additional parts. A cell membrane, cytoplasm, DNA, and ribosomes are essential for all living things, and so they are found in every living cell.

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2. Animal Cells

There are many different kinds of animals, from sponges to worms to humans, and they are all multicellular. Not all animal cells are identical, but they have a surprising amount in common with one another. How are your cells like the cells of a worm?

In addition to the basic parts, many types of cells—including animal cells—have additional parts. Organelles, are membrane-enclosed structures in a cell that perform a certain function for the cell. Like walls separating different rooms in a house, an organelle's membrane separates it from the other parts of the cell. This allows the cell to carry out specific functions in separate areas at the same time.

The Nucleus Stores DNA The cells of multicellular organisms have a nucleus, a large organelle that contains the cell's DNA. If you think of a cell as being similar to a factory, the nucleus is like the main office where all the instructions for running the factory are stored. The nucleus has its own membrane that regulates what enters and exits the nucleus, and it helps protect the DNA. This is like the factory's main office has a locked door and only lets in people with a key. All of a multicellular organism's cells have the exact same copy of DNA in their nucleus. The difference between a skin cell and a neuron is which instructions on the DNA it "reads" and when.

Mitochondria Release Energy All cells and the organelles in them need energy to perform their functions. Mitochondria are organelles that convert energy in nutrients into usable energy. Whether an organism eats food or makes its own, its cells must get energy from the nutrients. Cells that need a lot of energy, such as muscle cells, have many mitochondria. Like a factory's power plant, mitochondria provide energy to run a cell.

Organelles Transport Materials One of the functions of a cell is to make new parts and transport them where they are needed. Like a factory, a cell takes in materials from the environment and produces products. In the same way that a factory might spin cotton yarn to make T-shirts, a cell makes proteins and other substances that will be assembled into structures. After the products are made, some of the cell's organelles work together like a factory's shipping room to sort, package, and transport materials.

The endoplasmic reticulum, also called ER, is an organelle where some cell parts are made; it is important for transporting materials from one part of the cell to another. As you can see in Figure 2B, the ER looks like a system of flattened tubes that is often found surrounding the nucleus. Some of the ER is covered with ribosomes. Ribosomes on the ER assemble a protein and then the protein enters the tube of the ER. Small pieces of ER break off and wrap the protein to form a package, which is sent through the ER to another organelle, called the Golgi apparatus.

The Golgi apparatus looks like a stack of pancakes. It receives the small proteins from the ER and assembles them into larger, more complex proteins. Then, it either stores the large proteins or packages them for shipping to a specific part of a cell, to the cell membrane, or out of the cell.

Organelles Store Materials and Remove Waste Like many factories, cells take in large amounts of materials and store them to be used gradually. What is used for making products eventually becomes waste and needs to be removed. How are raw materials stored? What do cells do with wastes? Organelles that store materials are called vacuoles, and organelles that break down waste are called lysosomes. Vacuoles are like the storage room of a factory, while lysosomes are like the trash and recycling collection area. Lysosomes contain chemicals that break down large particles of waste into smaller particles to be recycled. Both organelles have a membrane that keeps the components inside the organelle away from the rest of the cell. These are usually considered to be different organelles, but there is some data that they might be the same in certain animal cells.

3. Plant Cells

You have seen what animal cells look like. But if you were to look through a microscope at plant and animal cells, how could you know which is which?

Plant cells have most of the same organelles that animal cells have. However, plant cells have three structures that animal cells do not have: chloroplasts, a cell wall, and a central vacuole.

Chloroplasts Make Food Animals need to eat food, but plants do not. Plants can make their own food because many of their cells contain an organelle that allows them to do so. A chloroplast is an organelle that uses the sun's energy to make sugar through the process of photosynthesis. A green pigment in the chloroplast, called chlorophyll, absorbs energy from sunlight. This energy is used in a chemical reaction to convert carbon dioxide and water into sugar. The sugar is the cell's food. It is stored as sugar until it is needed for energy and is broken down.

Not all plant cells have chloroplasts. For example, cells in roots have no chloroplasts. Since there is no sunlight underground, these root cells cannot perform photosynthesis. However, cells in a plant's leaves have many chloroplasts for performing photosynthesis.

The Central Vacuole Stores Liquids Plant cells have one large, central vacuole, which is much bigger than the vacuoles found in animal cells. As you can see in Figure 3A, the central vacuole is often the largest organelle in a plant cell. The central vacuole stores and gets rid of waste. It is so large because it also stores water and other liquid materials that will be needed by the cell, and it helps to maintain the cell's shape by filling with fluid.

Cell Walls Support a Plant A plant cell is surrounded by a cell wall, a protective outer covering that lies just outside the cell membrane. A cell wall helps the cell keep a rigid shape. Suppose you filled a balloon with water. The water balloon is squishy and can easily burst. But if you placed the water balloon inside a cardboard box, it would be much less likely to break because the box would protect it. A box would also make the combined parts more rigid and give it a definite shape. The cell wall accomplishes the same functions for a plant cell.

The cell wall is not an organelle because it is not surrounded by a membrane, but it is a very important plant cell structure. It regulates the amount of water in the cell, allowing water to pass through but preventing the cell from bursting. The cell wall works with the central vacuole to keep a plant upright. When the cells have water, the fluid filled vacuole pushes the cytoplasm and cell membrane against the cell wall. This pressure helps to make the cell rigid so that it can keep its shape and support the parts of the plant. In the same way, the filled water balloon presses on the sides of its box and helps prevent the box from collapsing inward. If you forget to water a plant for a short time, it soon begins to droop. When the central vacuole is not filled, the cytoplasm and cell membrane shrink away from the cell wall, as seen in the photo, and the plant wilts. The cell walls still maintain the shapes of the cells so that the plant is able to pop right up again when it is watered, as long as the cells have not died.

4. Transport through the Cell Membrane

Imagine a chain link fence around a factory. Vehicles can enter only if a gate is moved, but there is a path for people to pass. Tiny creatures, like mice, don't even need the path and can run through the gaps in the fence. How is a cell's membrane like the factory's fence?

Some particles are able to pass through a cell membrane easily, like the mouse or person. The cell does not need to use energy to get them from one side to the other. However, other particles need help, like opening the gate for the car. For these, often larger particles, the cell has to use energy to get them across the membrane.

Transport Without Energy Like the mouse, small particles such as oxygen easily pass through the cell membrane. They do this by a process known as diffusion. Diffusion does not need energy. It occurs because particles move randomly in all directions. Since they are small, these particles will fit through the gaps of the membrane. Sometimes, there are more particles on one side of the membrane than the other. In this case, the concentration of particles is higher on that side. When the concentration is higher on one side, more particles will randomly move towards the lower concentration side.

Another form of diffusion is facilitated diffusion. Remember that the cell membrane is selectively permeable, so some particles, like sugar or salts, are too large or cannot pass directly through the membrane. They need a channel. Like the path that let people through the gate, protein structures in the membrane function to allow the movement of these particles. These substances travel through the protein channels often from the side of the membrane with a higher concentration to the side with a lower concentration of particles. It is called facilitated diffusion because the protein helps, or facilitates, particles to pass through the membrane. Facilitated diffusion, like diffusion, does not require energy from the cell. You can compare diffusion and facilitated diffusion in Figure 4A.

Transport Using Energy Unlike the different types of diffusion, it takes energy for a cell to move a substance to the side of the membrane where it is already in high concentration. It also takes energy to move particles that are very large or a lot of particles at once across the membrane, like opening the gate for the car to pass through the fence.

In one type of transport requiring energy, particles are moved from an area of lower concentration to one of higher concentration. This requires a process known as active transport. In active transport, proteins in the membrane act as gates that let things pass in a certain direction, but the gate closes behind them.

In two other kinds of transport requiring energy, cells have to take-in or transport-out large particles or many particles at once. This helps for particles that are too large to pass directly through the cell membrane by diffusion, facilitated diffusion, or active transport. These processes are called endocytosis or exocytosis, depending on whether the particles are moving into or out of the cell. The word endocytosis comes from the Greek words, endo meaning inside or into, cyto meaning container, and sis meaning a process. Similarly, exocytosis would mean out of a container, or cell. The word exit will help you remember the meaning of this word.

Both endocytosis and exocytosis involve the cell membrane folding around the particle to be transported. Figure 4B shows an example of endocytosis and exocytosis. In endocytosis, part of the cell membrane folds inward to make a pouch. The large particle outside the cell is then surrounded by the membrane pouch, which pinches off to carry the particle into the cell. Exocytosis is the reverse direction. In this process a large particle or many particles are carried to the cell membrane wrapped in a sphere of membrane. The sphere fuses with the cell membrane in order to open up and releases the particles out of the cell.

5. Cells Must Be Small

Nearly all cells are so small that they cannot be seen without using a microscope. Cells can grow larger, but why aren't there giant cells? What stops a cell from growing really large?

Everything a cell needs or must get rid of must pass through its cell membrane, which makes up the cell's surface and separates the inside of the cell from the environment. As a cell grows, it needs more substances and produces more wastes. The amounts of cytoplasm that make up its volume increase faster than its surface area does. If it continued to grow, the cell might get so large that its cell membrane could not take in enough needed materials to supply it. And, the materials that needed to enter or exit the cell might not be able to get where they need to go fast enough because of the longer distance. Before a cell reaches this point, it will stop growing and instead divide to form two smaller cells. Smaller cells have a larger surface area in relation to their volume than larger cells do, making membrane transport more efficient. Thus cells must remain somewhat small in order to survive.