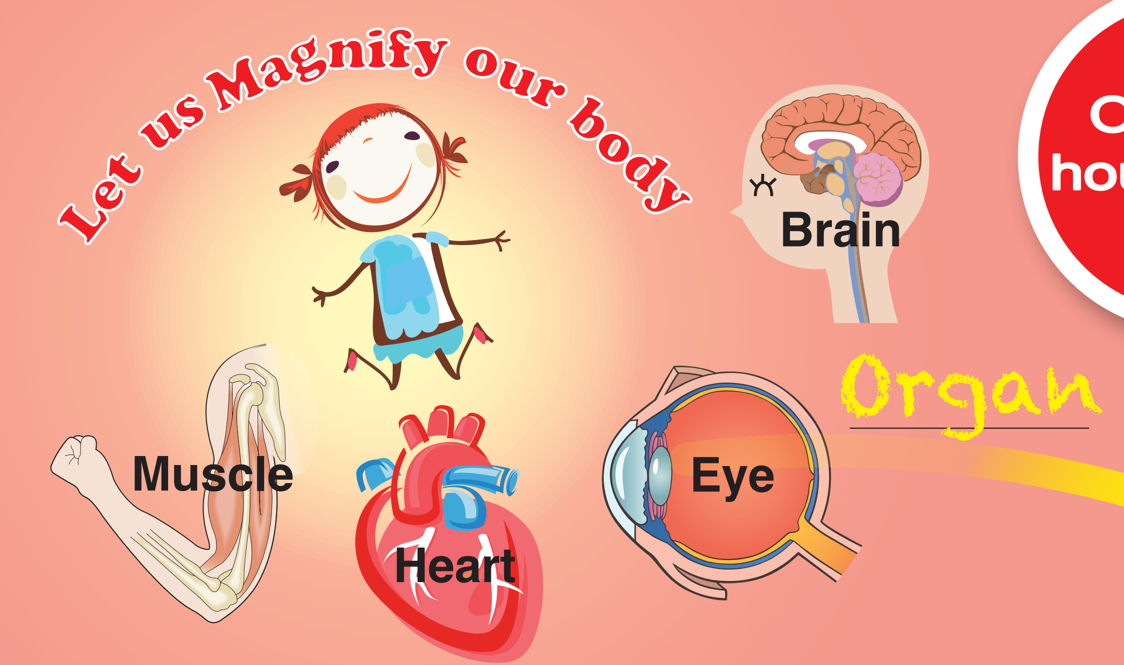
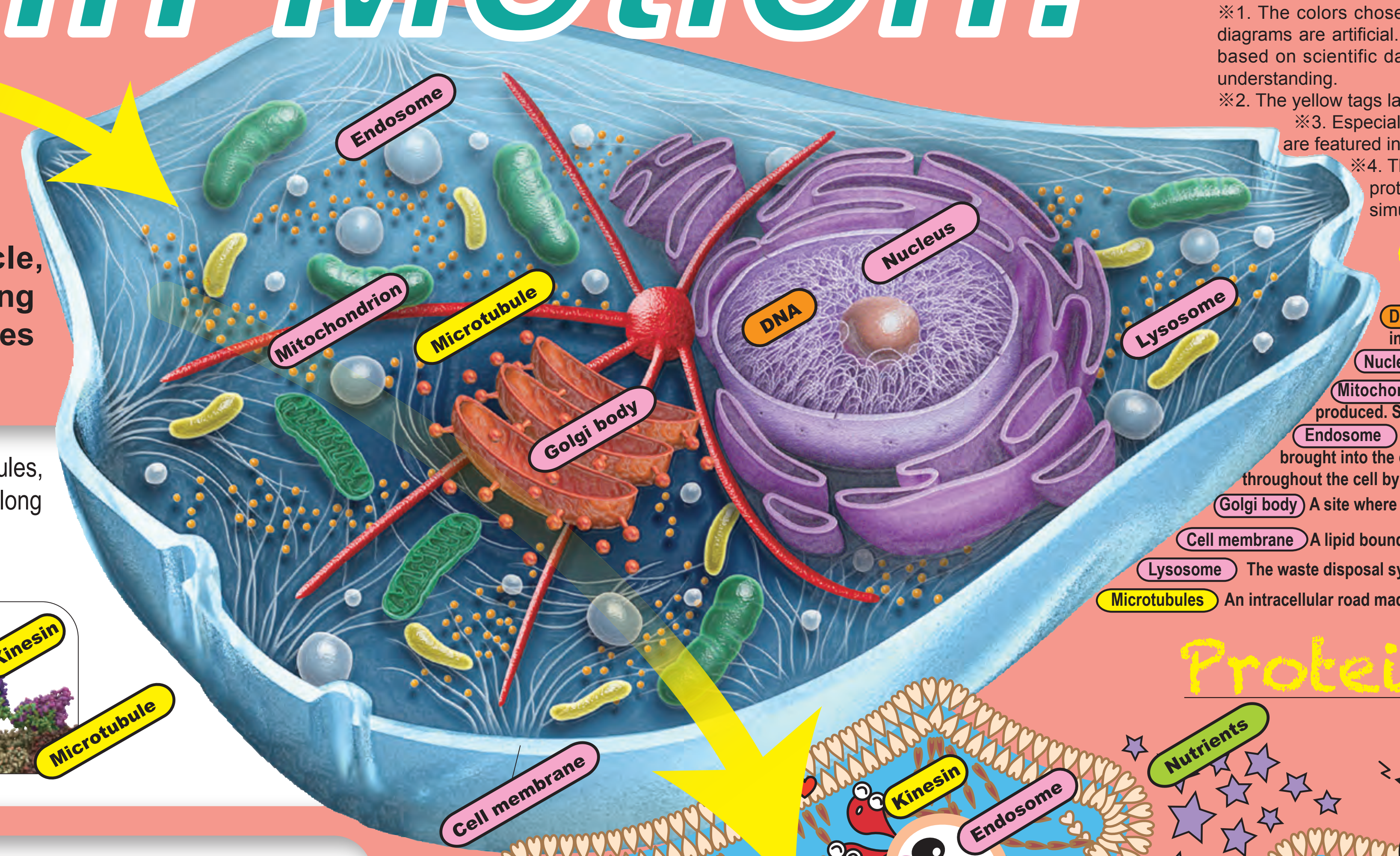


One per household
Proteins in Motion!

Proteins within our body are dynamic and constantly moving as they carry out specific functions. For example, some proteins rotate to create energy, others walk along filaments to deliver cargo, or dock to transfer materials from the extracellular world. Motion of the proteins is essential to carry out cellular processes needed for life!

※1. The colors chosen to represent cells and proteins in the schematic diagrams are artificial. Although the 3D structures of proteins depicted are based on scientific data, they were modified in this diagram for ease of understanding.
※2. The yellow tags label proteins, while pink tags label organelles.
※3. Especially, proteins that exhibit dynamic motion within the cell are featured in this poster. These proteins are not drawn to scale.
※4. The 3D structure of the protein shown in the "Dynamic protein folding" section was generated using a computer simulation.

Our body consists of many different organs, such as the muscle, heart, eye, and brain. Each organ is made up of many cells. Looking inside a magnified cell, you can see it is full of tiny proteins with sizes of only one hundred-thousandth of a millimeter.

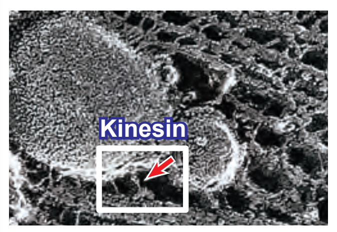


Cell

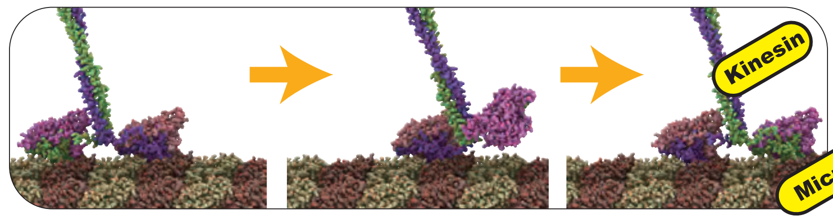
- **DNA** Deoxyribonucleic acid. A molecule that stores genetic information.
- **Nucleus** A space for DNA storage.
- **Mitochondrion** A place where adenosine triphosphates (ATPs) are produced. See the "Rotating!" section.
- **Endosome** A storage vesicle containing nutrients and other components brought into the cell from the extracellular world. Endosomes are delivered throughout the cell by kinesin and dynein. See the "Walking!" section.
- **Golgi body** A site where proteins are packaged for export.
- **Cell membrane** A lipid boundary between the cell and the extracellular world.
- **Lysosome** The waste disposal system of a cell where biomolecules are degraded.
- **Microtubules** An intracellular road made of proteins.

Walking!

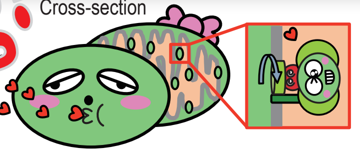
Intracellular "roads," made of proteins called microtubules, extend throughout a cell. Kinesins and dyneins walk along these intracellular roads to transport cargo, such as mitochondria and endosomes.



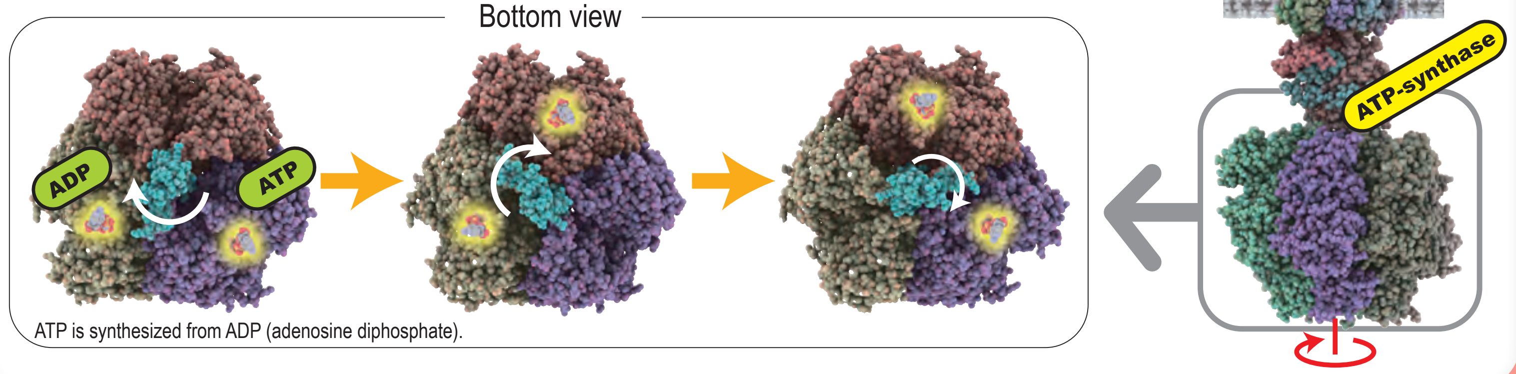
An electron micrograph of a kinesin protein carrying cargo (red arrow).



Rotating!

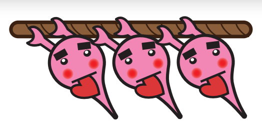


Proteins called ATP-synthases rotate within mitochondrial membranes to produce ATP molecules (adenosine triphosphates), which provide energy for proteins to do work.

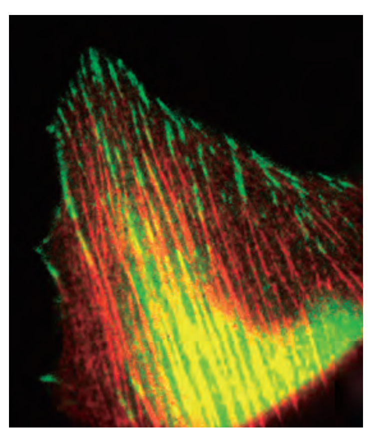


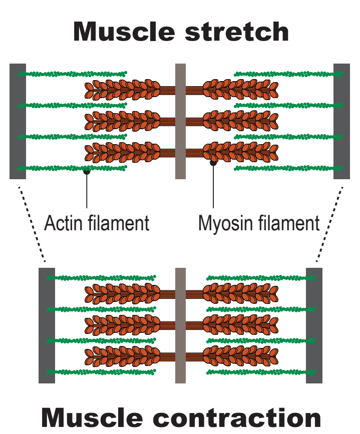
ATP is synthesized from ADP (adenosine diphosphate).

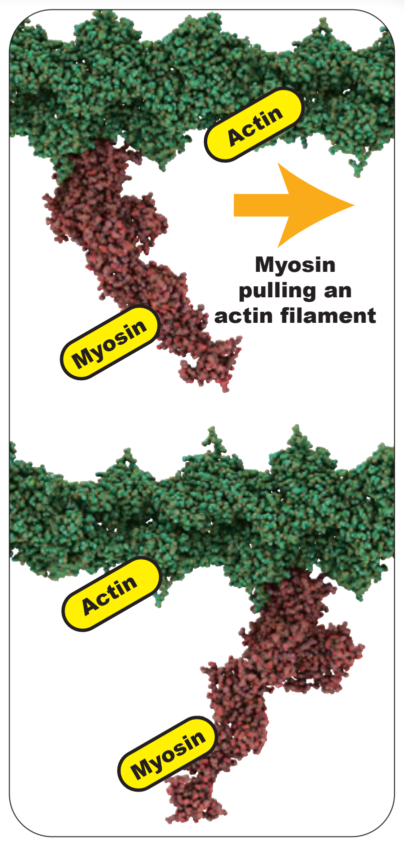
Pulling!



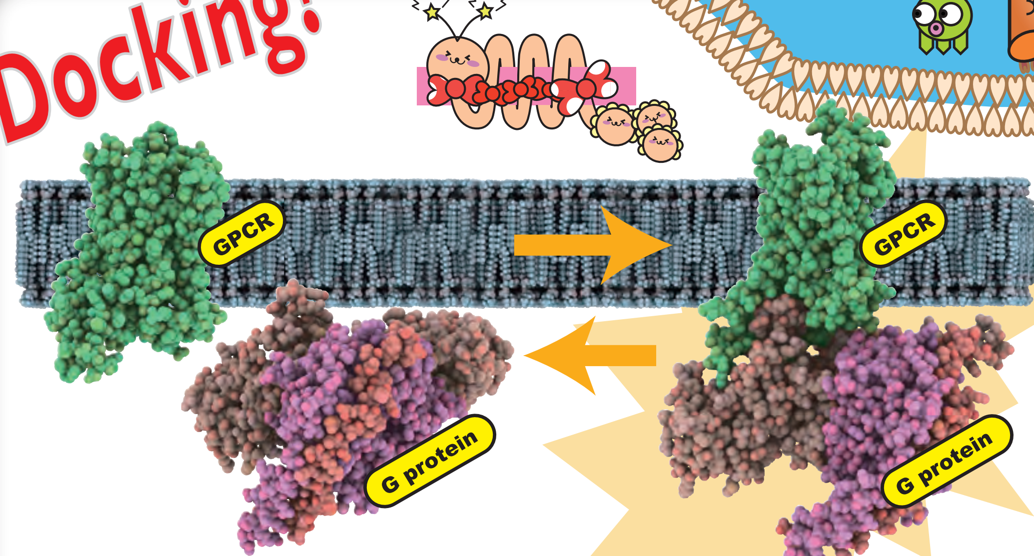
The pulling action of myosins on actin filaments causes muscle contraction. Myosins (red) also pull on the cell's cytoskeleton (green) to maintain cell shape (photograph). Although the strength of a single myosin is small, large forces are generated when many myosins work together.


Fluorescence micrograph



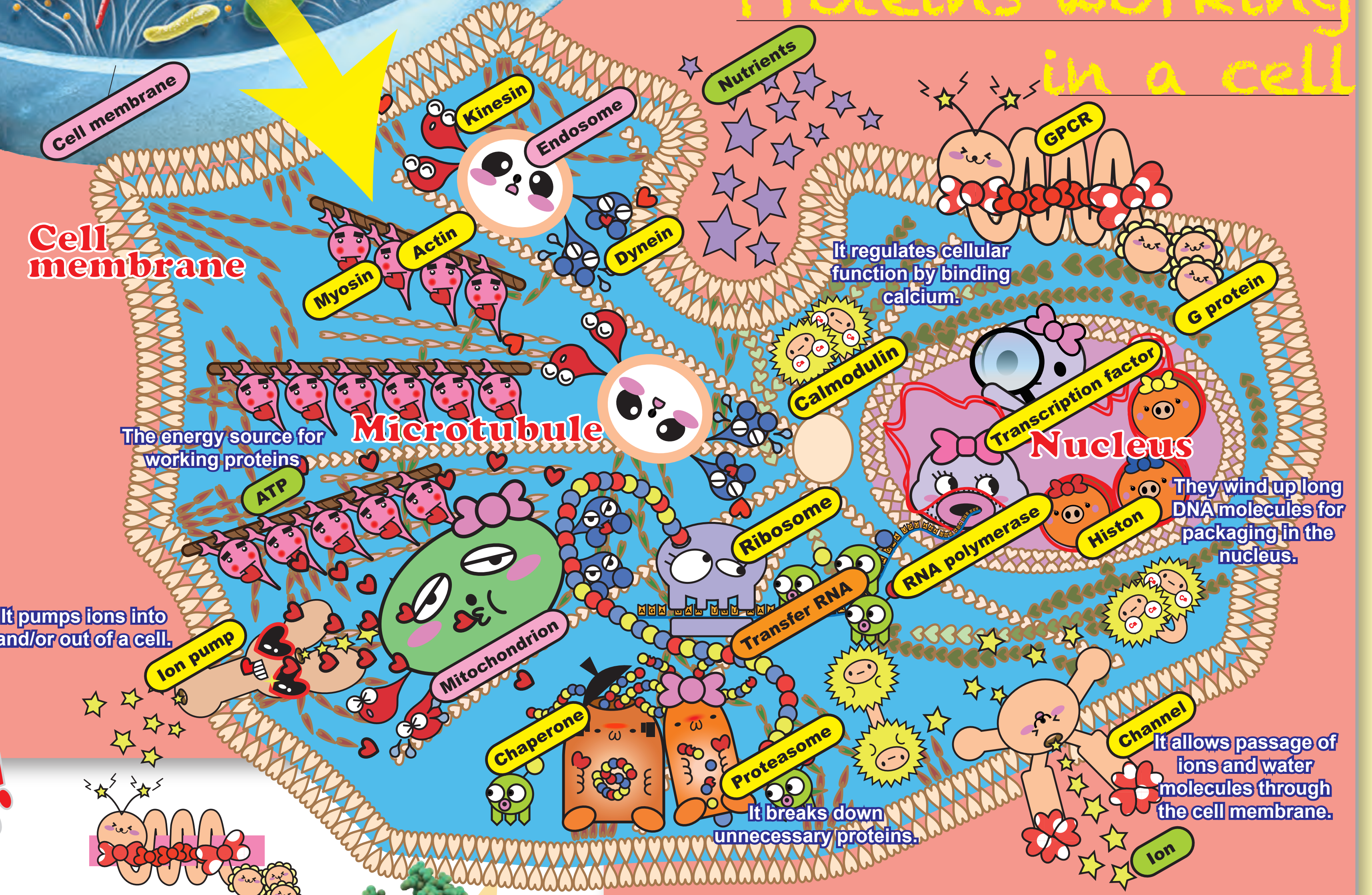


Docking!



Sensory proteins that detect light, compounds in food (taste), scents, and hormones are embedded in cell membranes. External signals are transferred to the inside of a cell by docking an intracellular signaling protein to a transmembrane sensory protein.

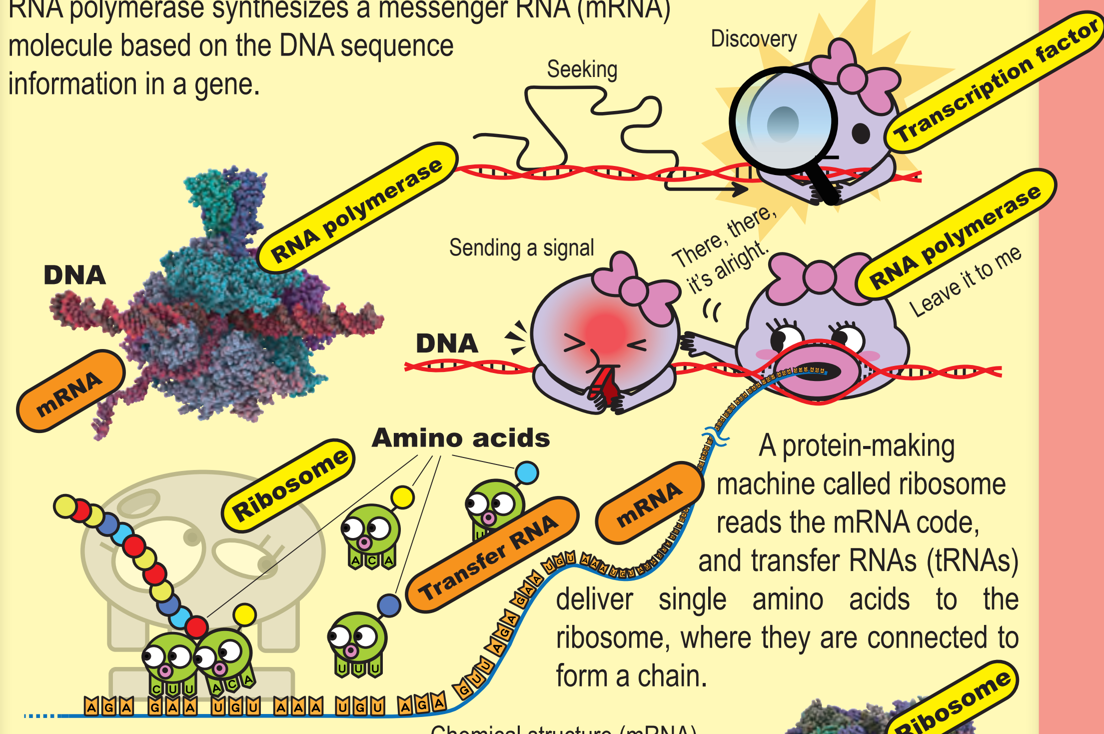
Proteins working in a cell



Protein Synthesis

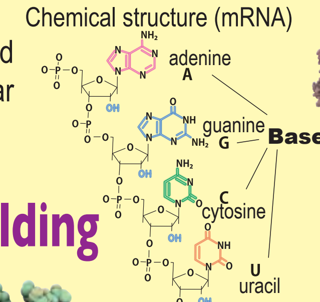
A protein is an amino acid chain that is folded into a specific shape. Different proteins have different amino acid sequences and unique shapes. Amino acid sequences are encoded in our DNA (deoxyribonucleic acid). A protein called a transcription factor binds DNA at specific locations where proteins are encoded in our genes.

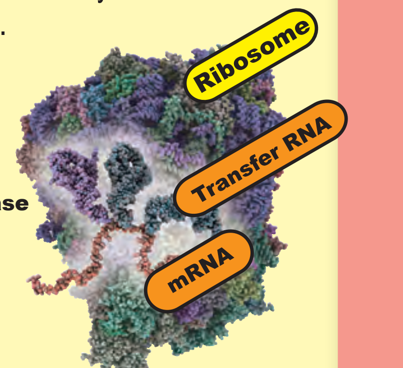
When it binds DNA at these sites, it sends a signal to recruit RNA polymerase. Then, RNA polymerase synthesizes a messenger RNA (mRNA) molecule based on the DNA sequence information in a gene.



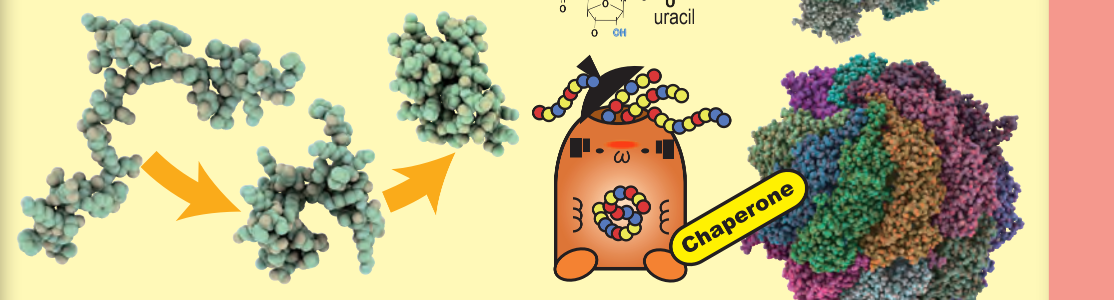
A protein-making machine called ribosome reads the mRNA code, and transfer RNAs (tRNAs) deliver single amino acids to the ribosome, where they are connected to form a chain.

Lastly, the synthesized amino-acid chain is folded into a particular shape by a chaperone protein.





Dynamic protein folding

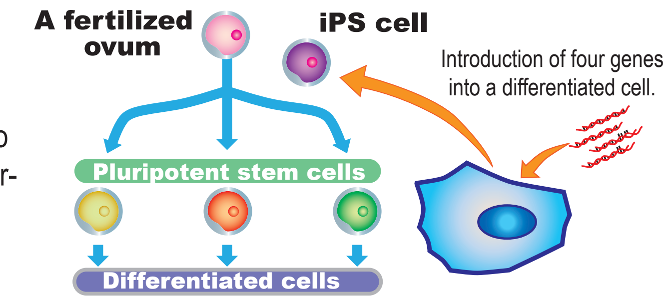


Protein folding is sometimes helped by chaperones.

Proteins are folded inside chaperones.

iPS cells (induced Pluripotent Stem Cells)

Artificially introducing genes that encode proteins, such as transcription factors, into a cell can alter its properties. iPS cells are an example of this.

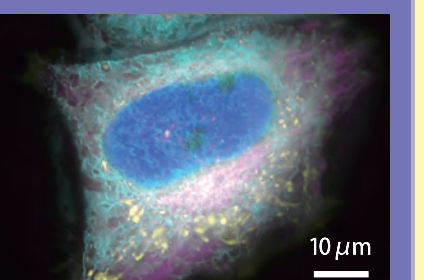


Stem cells are remarkable for the ability to give rise to various types of specialized cells, such as neurons, blood cells, and photoreceptor (or visual) cells. The process of cell specialization is known as cell differentiation. Differentiated cells were once thought to have irreversibly lost their ability to differentiate into different cell types. However, Dr. Shinya Yamanaka (2012 Nobel Prize laureate) found that the introduction of four key genes into differentiated cells caused these cells to transform into pluripotent stem cells and to once again able to differentiate into various cell types. Therefore, it is now possible to "induce" differentiated cells to become stem cells that can differentiate to cells of any tissue or organ.

Observing live cells using luminescent proteins

There exists luminescent proteins although we do not have them in our body. In 1961, green fluorescence protein (GFP) was isolated from a jellyfish by Dr. Osamu Shimomura (2008 Nobel Prize laureate).

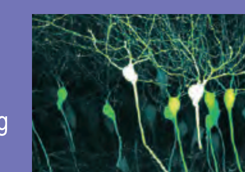
Since then, multicolored luminescent proteins have been developed. Within a cell, different organelle components can be labeled with luminescent proteins and then visualized by fluorescence microscopy.



A cell in which organelles are labeled using multicolored fluorescent proteins and visualized under a fluorescence microscope (fluorescence micrograph). Nucleus (blue); mitochondria (yellow); endoplasmic reticulum (cyan); microtubules (violet).

Examples of differentiated cells

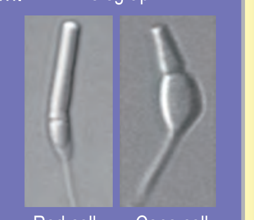
Neurons: In neurons, kinesin and dynein carry cargo such as mitochondria and endosomes along the microtubules (See the "Waking!" section).


Laser-scanning confocal micrograph

Red blood cells: Oxygen is stored in hemoglobins within red blood cells, and it is transported throughout the body by the blood stream.


Scanning electron micrograph

Photoreceptor cell: Within the retina of the eye, there are two types of photoreceptor (visual) cells, rod cells that work in the dark and cone cells that work in the light. Only one kind of protein, called rhodopsin, senses light within the rod cells, while three different proteins sense red-, green-, or blue-colored light within cone cells.



Differential interference micrograph

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Protein structures All structural data of proteins are provided from Protein Data Bank Japan (PDBj, http://pdbj.org/). PDB codes: kinesin (3KION, 2XRP), ATP-syntase (3XRY, 1E1R), action and myosin (4A7F, 1MMD, 1VOM 1S5G), GPCR and trimeric G-protein (3NY8, 3SN6), ribosome (3U5B, 3U5C, 3U5D, 3U5E, 2Y0U), chaperon (4D8Q), GFP (1EMA). 3D images were constructed by QuteMol (http://qutemol.sourceforge.net/).

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