

A Tour of the Cell (Slide 11)

§1. The Microscopic World of Cells

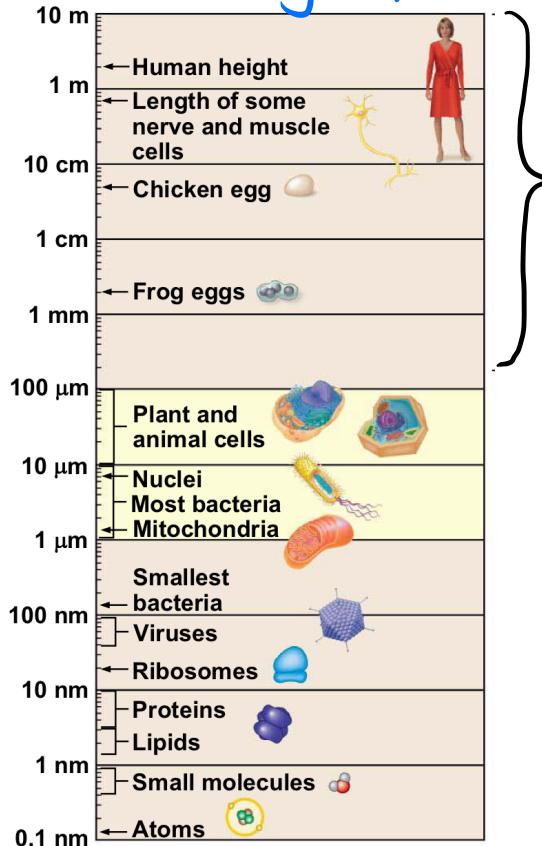
1. Organism

Organisms are either

1° **single-celled** : most prokaryotes (原核生物)
protists (原生生物)

2° **multicelled** : plants, animals, most fungi (真菌)

2. The size range of cells



Visible with the naked eye

* The longest nerve in human body: sciatic nerve

3. Cell theory

1° All living things are composed of cells

2° All cells come from earlier cells.

§2 The Two Major Categories of Cells

1. Two basic categories

1º Prokaryotic cells (原核细胞)

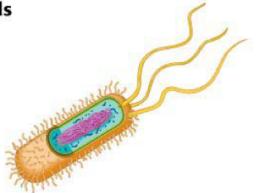
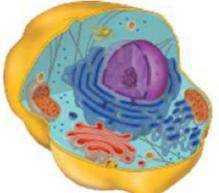
Bacteria and Archaea (古生菌)

2º Eukaryotic cells (真核细胞)

Protists, plants, fungi and animals.

2. Main differences

1º

Table 4.1 Comparing Prokaryotic and Eukaryotic Cells	
Prokaryotic cells	Eukaryotic cells
	
Plasma membrane of identical structure	
细胞质 Cytoplasm occupies entire interior of cell	Cytosol 胞质溶胶 Cytoplasm occupies the region between the nucleus and the plasma membrane
Nucleoid Single circular chromosome in nucleoid region	拟核 Chromosomes 染色体 One or more linear chromosomes in nucleus
carrying genes made of DNA	
	
Both have ribosomes, but structure differs slightly	
First evolved approximately 3.5 billion years ago	First evolved approximately 2.1 billion years ago
Smaller, simpler	Larger, more complex
No membrane-bound organelles 细胞器	Membrane-bound organelles (for example, nucleus, ER)
Most are surrounded by cell walls; some have capsules, pili, and/or flagella 荚膜 菌毛 鞭毛	Plant cells surrounded by cell walls; animal cells surrounded by extracellular matrix 胞外基质

2º Prokaryotic cells are older than eukaryotic cells.

3º Prokaryotic cells are usually smaller and simpler in structure.

4º Only eukaryotic cells have **membrane-bound organelles** (细胞器)

5º **Nucleus** (细胞核) houses most of a eukaryotic cell's DNA and is surrounded by a double membrane. A prokaryotic cell's DNA is coiled into a nucleus-

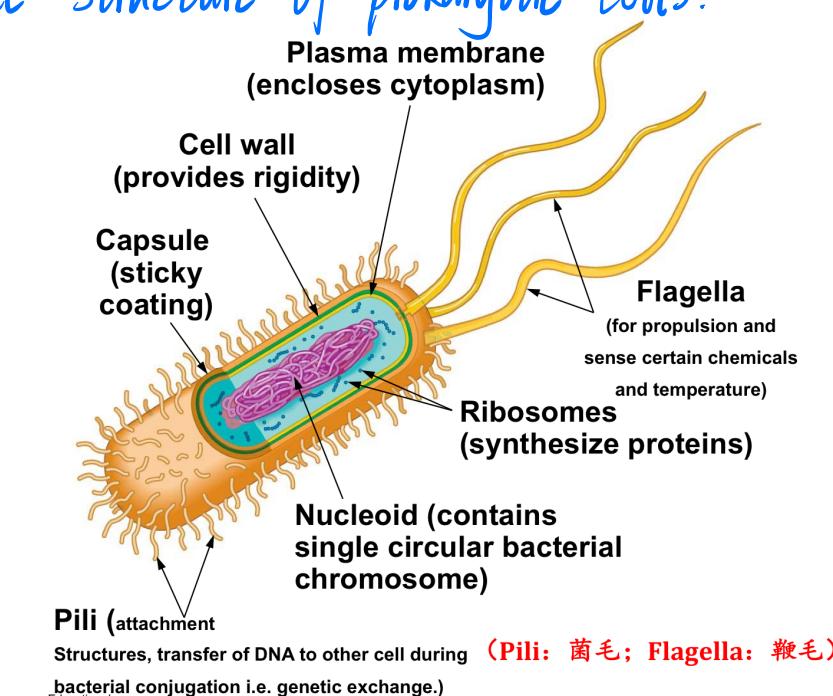
like region called the **nucleoid** (核)

3. Main similarities

- 1^o They are bounded by a thin **plasma membrane** (细胞质膜)
- 2^o Inside all cells is a thick, jelly-like fluid called the **cytosol** (胞质溶胶), in which cellular components are suspended.
- 3^o All cells have one or more **chromosomes** (染色体) carrying genes made of DNA.
- 4^o All cells have **ribosomes** (核糖体), tiny structures that build proteins according to the instructions from the genes.

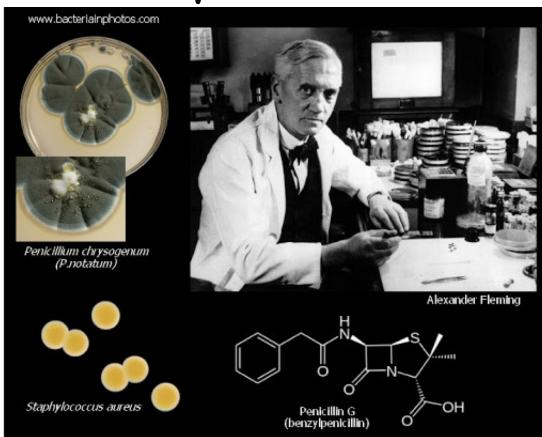
§3 A Prokaryotic Cell

1. The structure of prokaryotic cells.



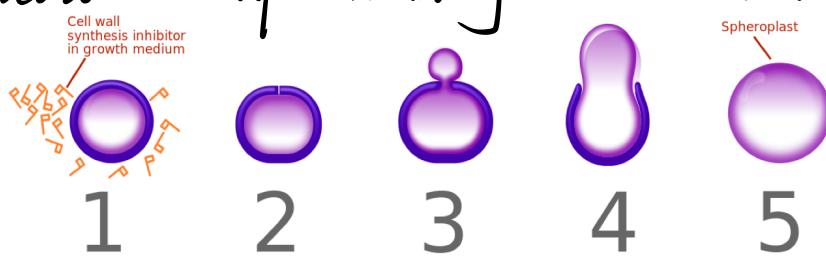
- 1^o Surrounding the plasma membrane of most prokaryotic cells is a rigid **cell wall**, which
 - ① protects the cell

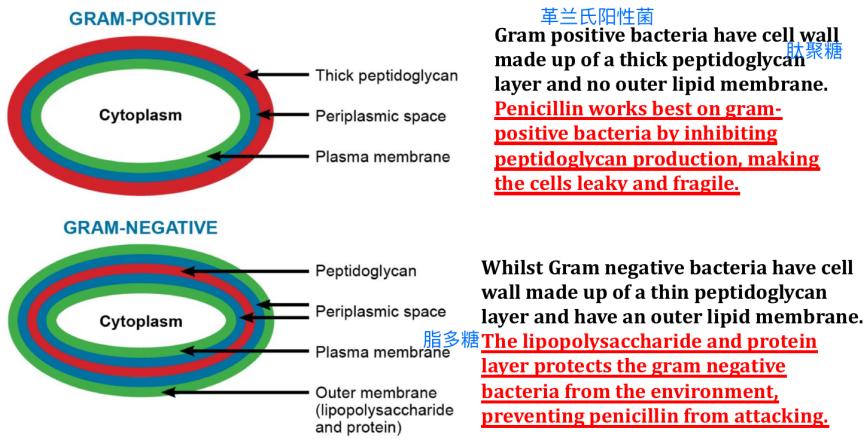
- ② helps maintain its shape
 - 2° Short projections called **pili** (菌毛), which can also attach to surfaces.
 - 3° **flagella** (鞭毛), long projections that propel them through
2. **Antibiotics:** drugs that target bacterial cells
- 1° The first **antibiotic** (抗生素) to be discovered was **penicillium** in 1920.



Scottish bacteriologist Alexander Fleming accidentally discovered the antibiotic in 1928, when he came back from a vacation and found that a green mold called *Penicillium notatum* had contaminated the dishes containing bacteria in his lab ... and were killing some of the bacteria he'd been growing.

- 2° Most antibiotics bind to **structures found only in bacterial cells**.
- Some antibiotics bind to the **bacterial ribosome**, leaving human ribosomes unaffected.
- Other antibiotics target **enzymes found only in the bacterial cells**.
- 3° Bacteria that attempt to grow and divide fail to do so, instead end up shedding their cell walls.





3. Mechanism of antibiotic resistance

- 1° Sometimes bacteria develop enzymes (**penicillinas**) which can degrade penicillin.
- 2° They can then transfer this ability to other bacteria through conjugation.
- 3° The gene for the penicillinase get integrated into a plasmid, and then the bacteria can transfer the plasmid through a sex pili.

4. Comparison of major structural features of archaea, bacteria and eukaryotes

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TABLE 3.1 Comparison of Major Structural Features of Archaea, Bacteria, and Eukaryotes

	Archaea	Bacteria	Eukaryotes
Cell wall	Usually present, no peptidoglycan	Usually present, with peptidoglycan	Sometimes present, no peptidoglycan
Plasma membrane	Yes	Yes	Yes
Nucleus	No	No	Yes
Membrane-bounded organelles	No	No	Yes
Ribosomes	Yes	Yes	Yes, larger than prokaryotic

§4 A Eukaryotic Cell

1. Basic information

- 1° Eukaryotic cells are fundamentally similar.
- 2° The region between the nucleus and plasma

membrane is the **cytoplasm** (细胞质)

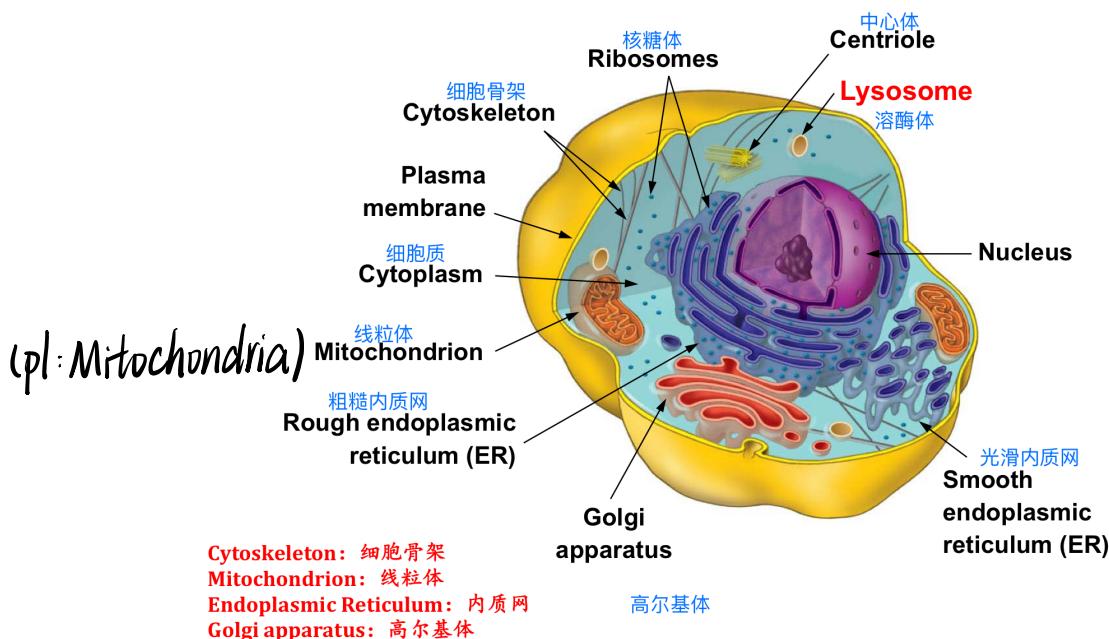
3° The cytoplasm of a eukaryotic cell consists of various organelles suspended in the liquid **cytosol** (胞质溶胶)

2. Different organelles in animal and plant cells

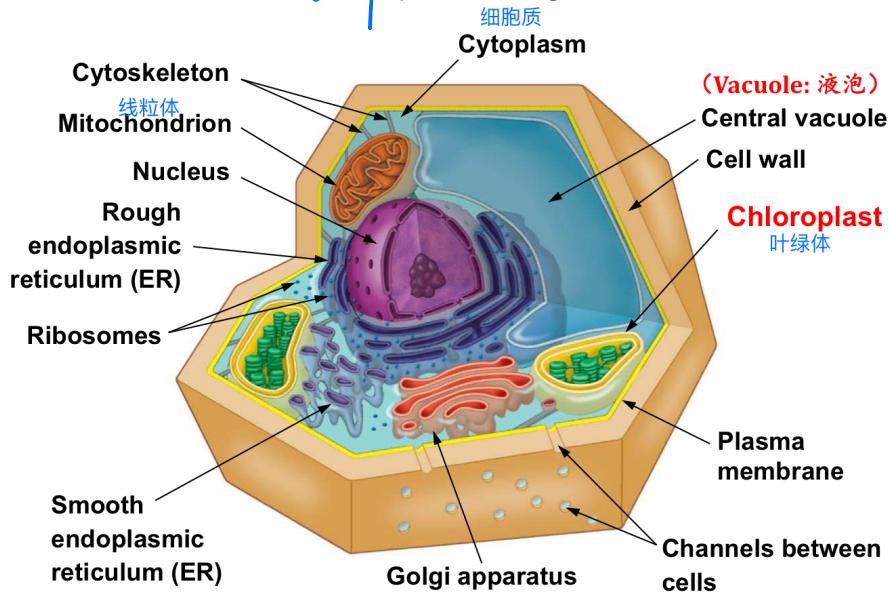
1° Only plant cells have **chloroplasts** (叶绿体)
(where **photosynthesis** (光合作用) occurs)

2° Only animal cells have **lysosomes** (溶酶体)
(bubbles of digestive enzymes surrounded by membranes)

3. An idealized animal cell



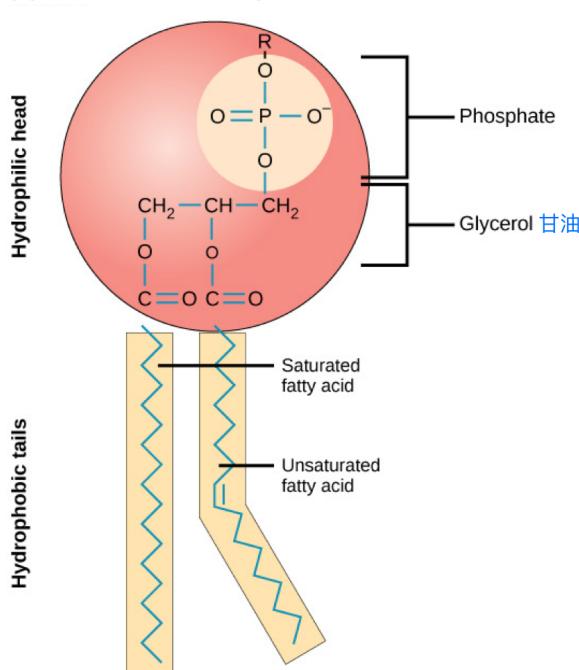
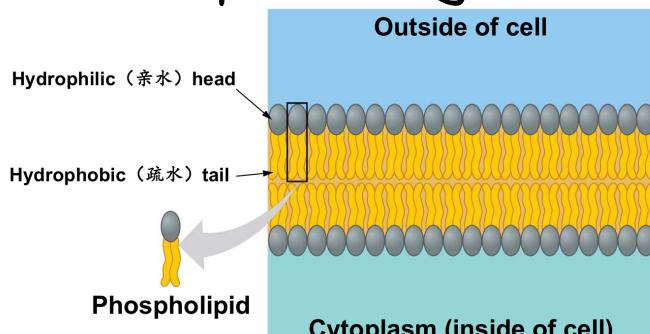
4. An idealized plant cell



85 The Plasma Membrane

1. Phospholipid bilayer (磷脂双分子层)

- 1^o The plasma membrane and other membranes of the cell are composed mostly of **phospholipids** (磷脂), which group together to form a two-layer sheet called a **phospholipid bilayer**.
- 2^o Phospholipids are **amphipathic** (两性亲水的) lipids.
- 3^o Each phospholipid is composed of two distinct regions:
 - ① a "head" with negatively charged phosphate group
 - ② two nonpolar fatty acid "tails".



- 4^o **Hydrophobic molecules diffuse across freely**

- 5° Channels / pores allow polar molecules through.
2. Cholesterol (胆固醇) is a component of animal cell membranes
- 1° Most of the cholesterol molecule is hydrophobic and therefore embeds (嵌入) within the tails of the bilayer. A small portion (hydroxyl -OH group) is hydrophilic and is attached to the phospholipid head. These cholesterol molecules are positioned between the phospholipids in the membrane.
- 2° Application: Cholesterol in mammalian (哺乳动物的) membranes tend to reduce membrane fluidity (流动性) and permeability (渗透率) to some solutes.

3. Proteins

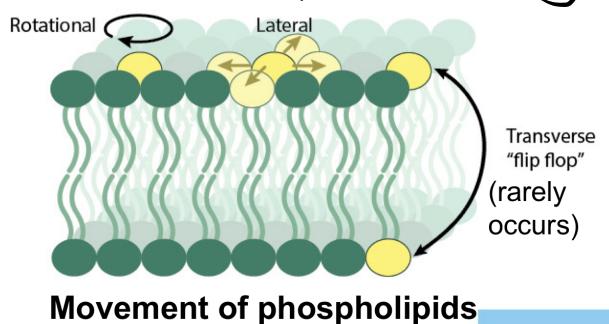
Suspended in the phospholipid bilayer of most membranes are proteins that

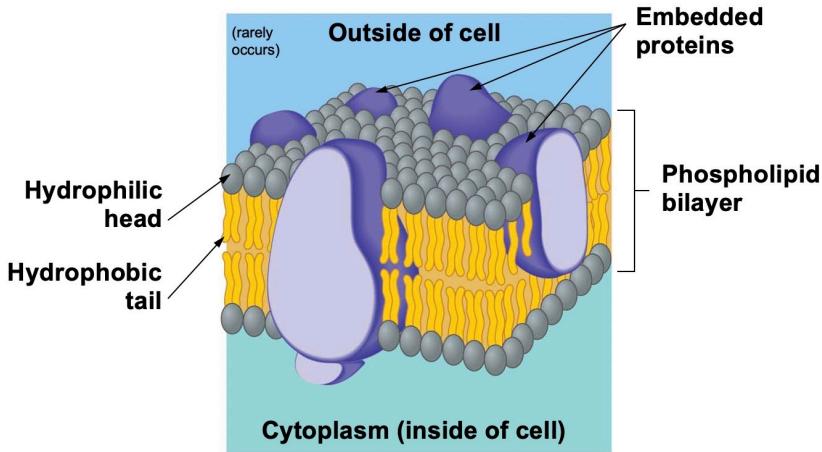
- 1° help regulate traffic across the membrane
2° perform other functions.

4. Fluid mosaic

The plasma membrane is a fluid mosaic (流动镶嵌)

- 1° fluid because molecules can move freely past one another
2° mosaic because of the diversity of proteins in the membrane.





(b) Fluid mosaic model of membrane

§6 Cell Surfaces

1. Plant cells

1° Plant cells have a **cell wall** made from **cellulose fibers** (纤维素纤维)

2° Plant cell walls

① protect the cells

② maintain cell shape

③ keep cells from absorbing too much water.

2. Animal cells

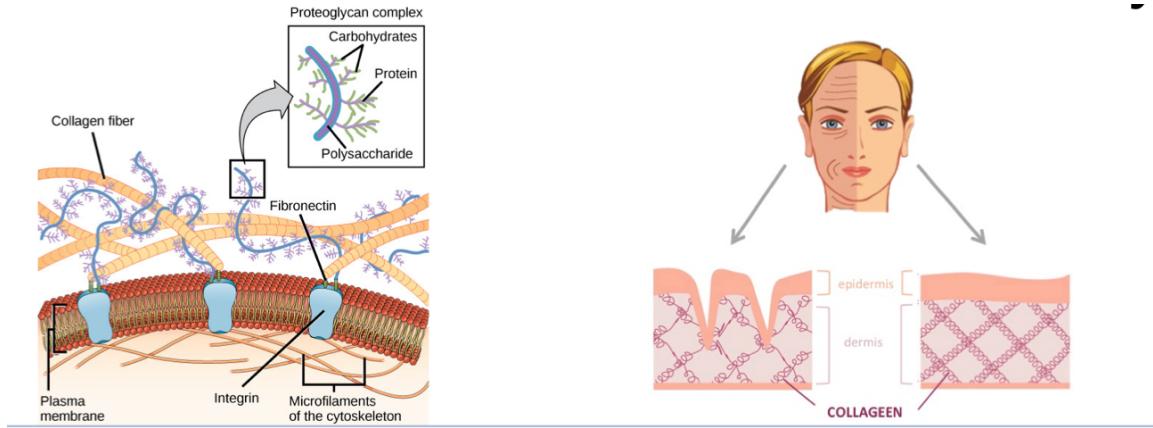
1° Animal cells lack cell walls

2° Fibers made of the **protein collagen** (胶原蛋白)

① hold cells together in tissues

② can have protective and supportive functions.

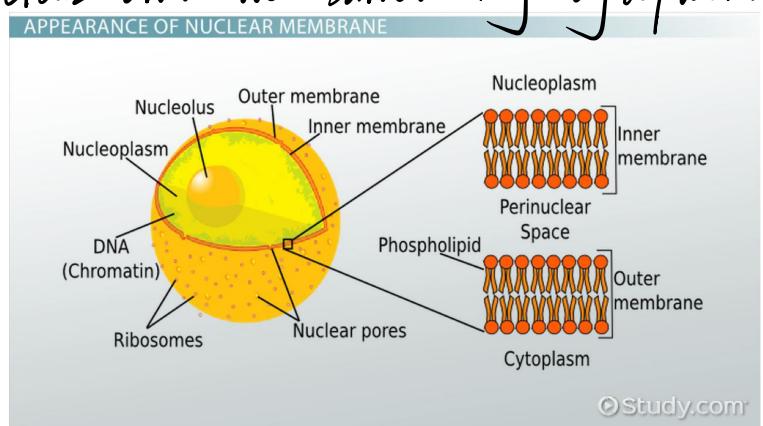
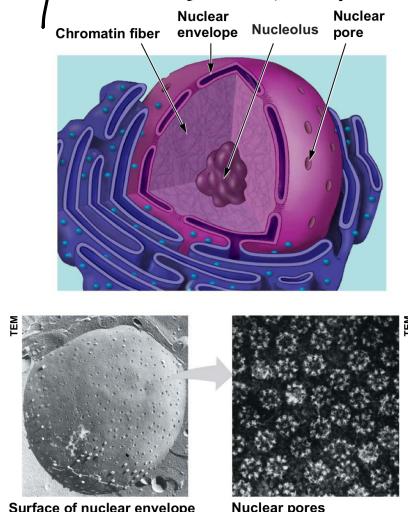
3° In addition, the surfaces of most animal cells contain cell junction (连接), structures that connect cells together into tissues, allowing the cells to function in a coordinated way.



37. The Nucleus and Ribosomes: Genetic Control of the Cell

1. Nucleus

- 1° The nucleus is the control center of the cell.
- ① Each gene is a stretch of DNA that stores the information necessary to produce a particular protein.
- ② Proteins do most of the actual work of the cell.
- 2° The nucleus is separated from the cytoplasm by a **double** membrane called the **nuclear envelope** (核膜)
- 3° **Nuclear pores** (核孔) in the envelope allow certain materials to pass between the nucleus and the surrounding cytoplasm.

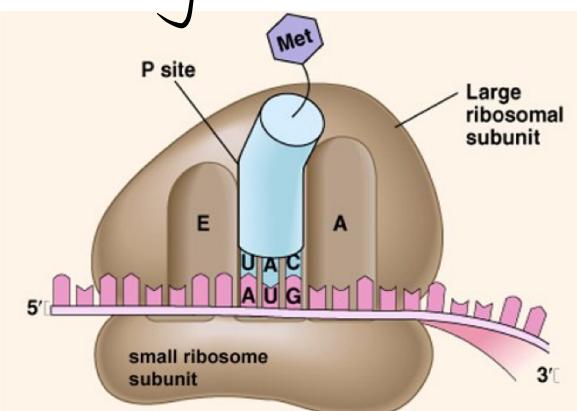


- 4° With the nucleus, long DNA molecules and associated proteins form fibers called **chromatin** (染色质). Each long chromatin fiber constitutes one chromosome.

- 5^o The **nucleolus** (核仁) is
- ① a prominent structure within the nucleus
 - ② the site where the synthesis ribosome RNA takes place.
 - ③ the site which assembles the small and large subunits of the ribosome
- 6^o histones → histone acetylation → modification of lysine / Arginine → neutralization → loose up nucleosomes → transcription.

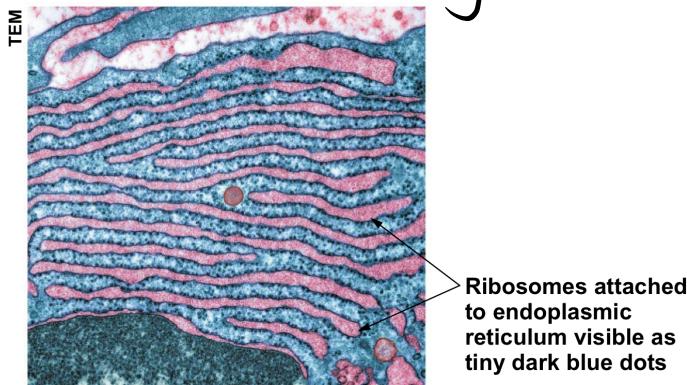
2. Ribosomes

- 1^o Ribosomes are **responsible for protein synthesis**.
- 2^o In eukaryotic cells, the components of ribosomes are made in the nucleus and then transported through the pores of the nuclear envelope into the cytoplasm, where ribosomes begin their work.



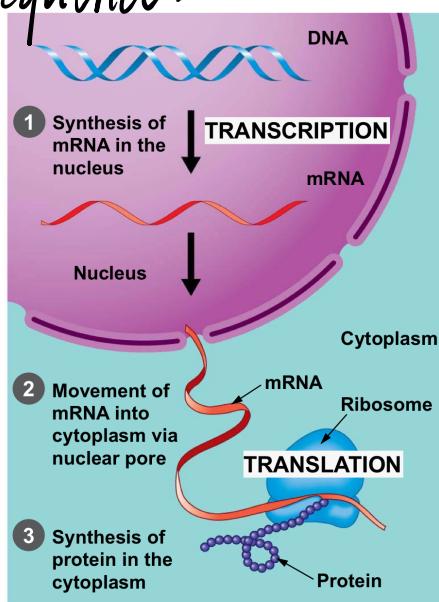
- 3^o Although structurally identical, some ribosomes are suspended in the cytosol, making proteins that remain within the fluid of the cell. Others are attached to the outside of the nucleus or an organelle called the endoplasmic reticulum,

making proteins that are incorporated into membranes or secreted (3rd) by the cell.



3. How DNA directs protein production

- 1^o DNA transfers its coded information to a molecule called messenger RNA (mRNA)
- 2^o mRNA
 - ① exits the nucleus through pores in the nuclear envelop and
 - ② travels to the cytoplasm, where it binds to a ribosome.
- 3^o A ribosome moves along the mRNA, translating the genetic message into a protein with a specific amino acid sequence.



§8 The Endomembrane System: Manufacturing and Distributing Cellular Products

1. The **endomembrane system** (内膜系统) in a cell consists of:

- 1° the nuclear envelope
- 2° the endoplasmic reticulum
- 3° the Golgi apparatus
- 4° lysosomes and
- 5° vacuoles

2. These membranous organelles are either

- 1° physically connected or
- 2° linked by **vesicles** (囊泡), sacs made of membrane.

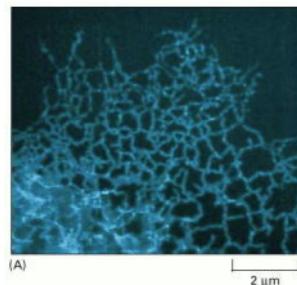
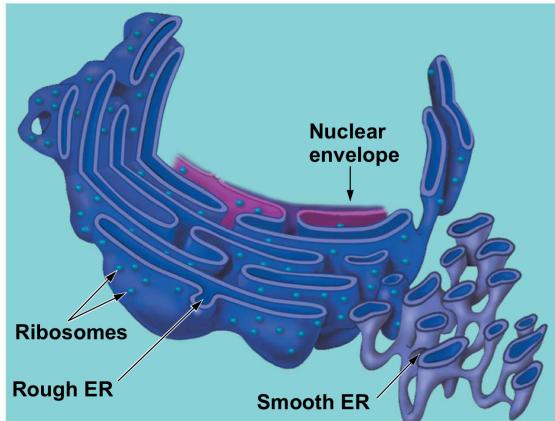
§9 The Endomembrane System: The Endoplasmic Reticulum

1. **Endoplasmic reticulum**

1° The **endoplasmic reticulum (ER)** (内质网) is one of the main manufacturing facilities in a cell.

2° The ER

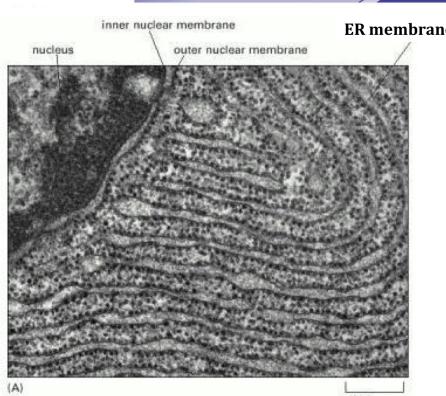
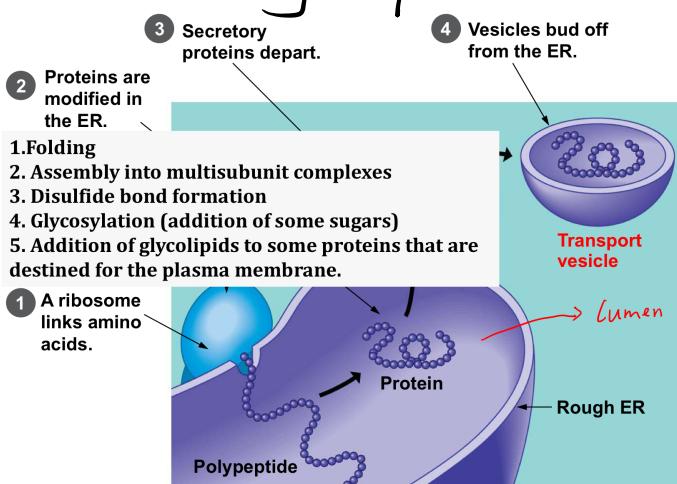
- ① produces an enormous variety of molecules,
- ② is connected to the nuclear envelope.
- ③ is composed of interconnected rough and smooth ER that have different structures and functions.



Part of the ER network in a cultured mammalian cell, stained with an antibody that binds to a protein retained in the ER. The ER extends as a network throughout the entire cytosol, so that all regions of the cytosol are close to some portion of the ER membrane.

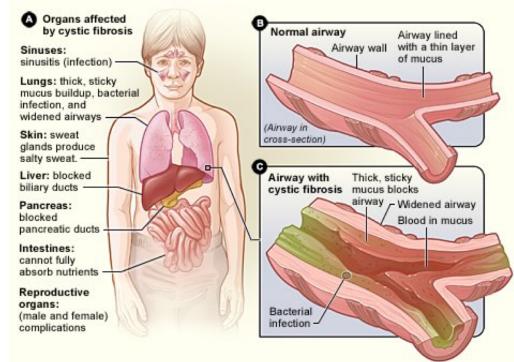
2. Rough ER

- 1° The “rough” in **rough ER** (粗面内质网) refers to ribosomes that stud the outside of its membrane.
- 2° Ribosomes attached to the rough ER produce proteins that will be
 - ① inserted into the growing ER membrane,
 - ② transported to other organelles
 - ③ eventually exported.



An electron micrograph of the rough ER in a pancreatic exocrine cell that makes and secretes large amounts of digestive enzymes every day. The cytosol is filled with closely packed sheets of ER membrane studded with ribosomes.

In **cystic fibrosis** (囊性纤维症) a mutated plasma membrane channel protein is retained in the rough endoplasmic reticulum because it is folded incorrectly. Without this protein in its correct location, the cell is unable to regulate the transport of the chloride ion, resulting in the inability to regulate water levels in lung and other kinds of cells.



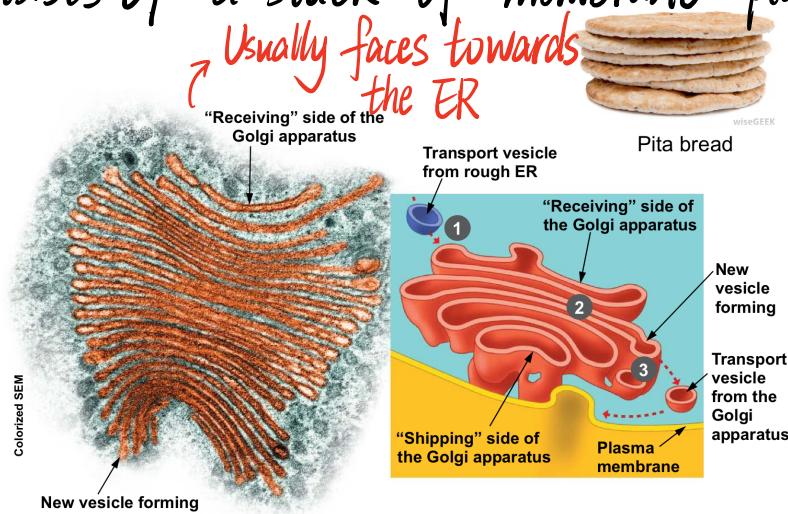
3. Smooth ER (光滑内质网)

- 1° lacks surface ribosomes
- 2° produces **lipids**, including **steroid** (类固醇) (the cells in ovaries (卵巢) or testes (睾丸) that produce the steroid sex hormones (激素) are enriched with smooth ER)
- 3° produces the **phospholipids** and **cholesterol** used in membrane formation, and along with the membrane proteins produced by the rough ER.
it can synthesize more membrane for itself, for the Golgi complex, the cell membrane, lysosome, and others.
- 4° helps liver cells detoxify circulating drugs.
It has an association with drug tolerance.
- 5° produces triglycerides
- 6° produces glycogen (糖原) in skeletal muscles and livers

8.10 The Endomembrane System: The Golgi Apparatus

1. The Golgi apparatus (高尔基体)

- 1° works in partnership with the ER
- 2° receives, refines, stores and distributes chemical products of the cell.
- 3° consists of a stack of membrane plates



2. How Golgi apparatus works

- 1° Products made in the ER reach the Golgi apparatus in **transport vesicles**.
- 2° Proteins within a vesicle are usually modified by **enzymes** during their transit from the receiving to the shipping side of the Golgi apparatus.
- 3° The shipping side of a Golgi stack is a depot from which finished products can be carried in transport vesicles to other organelles or to the plasma membrane.
- 4° Proteins made at the rough ER have specific molecular tags that serve as "Zip codes" to tell the Golgi apparatus whether they belong inside the cell in some membrane-bound organelle or in a secretory vesicle.

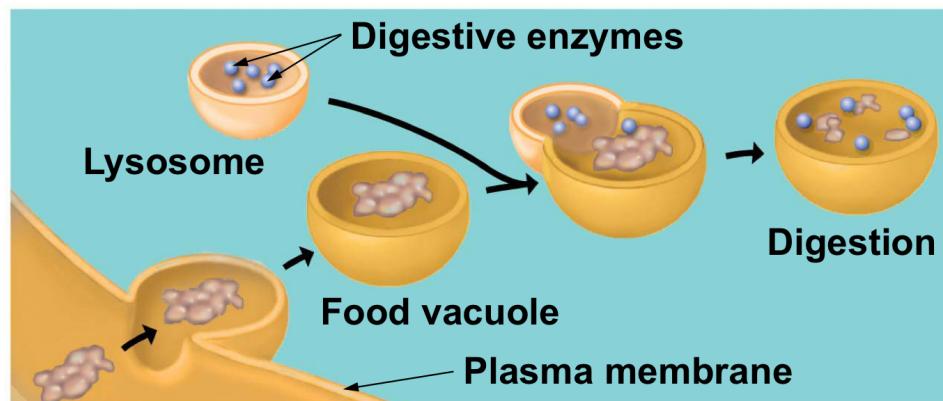
8.11 The Endomembrane System: Lysosome

1. Lysosome

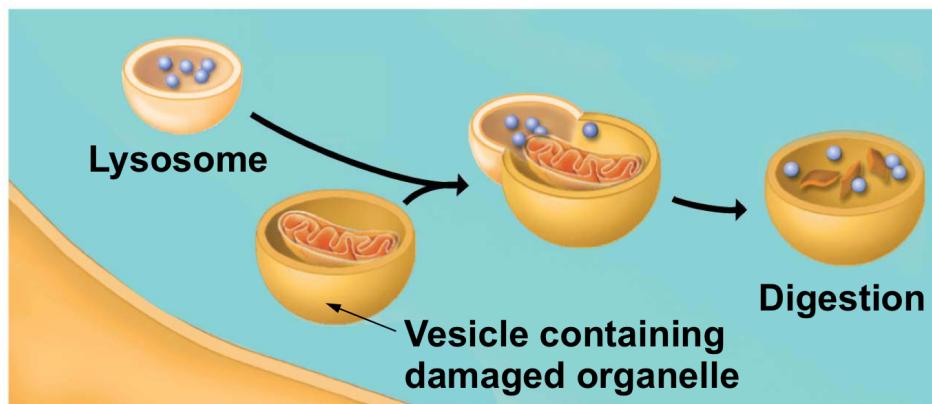
- 1° A **lysosome** (溶酶体) is a membrane - enclosed sac of digestive enzymes found in **animal cells**.
- 2° Most plant cells do not contain lysosomes.
- 3° Enzymes in a lysosome can break down large molecules such as proteins, polysaccharides, fats and nucleic acids.

2. Digestive functions

- 1° Engulf (吞噬) nutrients
 - ① Many single-celled protists (原生生物) engulf nutrients in tiny cytoplasmic sacs called **food vacuoles** (食物泡)
 - ② Lysosomes fuse with the food vacuoles, exposing the food to digestive enzymes.
 - ③ Small molecules that result from this digestion, such as amino acids, leave the lysosome and nourish the cell.
- 2° Destroy harmful bacteria
- 3° Engulf and digest parts of another organelle
- 4° Sculpt tissues during embryonic development, helping to form structures such as fingers

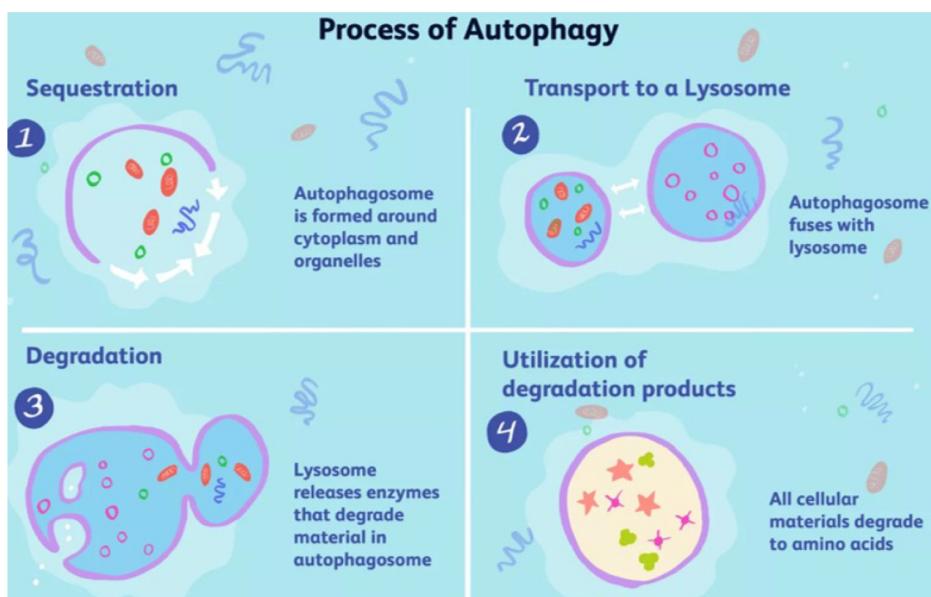


(a) A lysosome digesting food



(b) A lysosome breaking down the molecules of damaged organelles

It helps to remove unnecessary or dysfunctional components of the cell.



3. Tay-Sachs disease (戴薛克斯症)

Occasionally, a child inherits the inability to make a lysosomal enzyme, and therefore has a lysosomal storage disease. In **Tay-Sachs disease**, the cells surround nerve cells cannot break down the lipid ganglioside GM2, which then accumulates inside lysosomes and affects the nervous system. At about six months, the infant can no longer see and then gradually loses hearing and even the ability to move. Death follows at about three years of age.



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1. Vacuoles

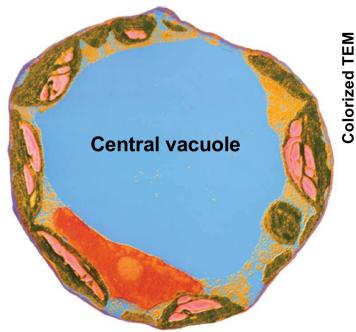
Vacuoles (液泡) are large sacs made of membrane that bud off from the ER or Golgi apparatus.

2. Functions

- 1° Food vacuoles bud from the plasma membrane
- 2° Certain freshwater protists have contractile vacuoles (伸缩泡) that pump out excess water that flows into the cell from the outside environment

3. Central vacuole

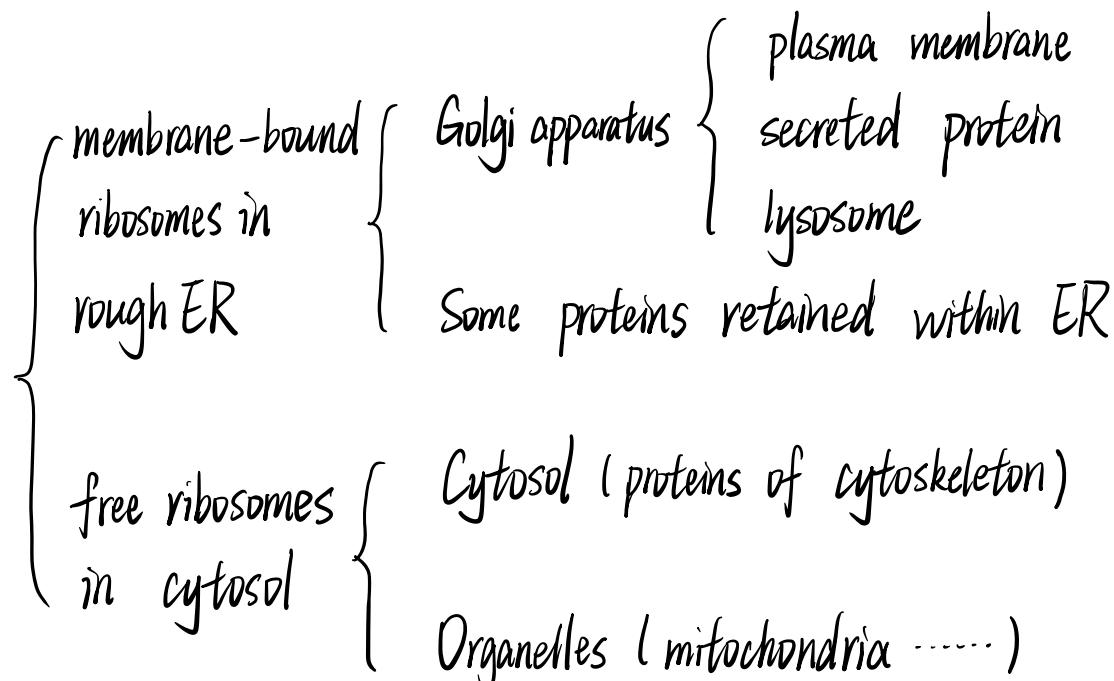
- 1° A central vacuole can account for more than half the volume of a mature plant cell.
- 2° The central vacuole of a plant cell is a versatile compartment that may
 - ① store organic nutrients.
 - ② absorb water
 - ③ contain pigment (色素) that attract pollinating insects (传粉昆虫) or poisons that protect against plant-eating animals.
 - ④ contain digest enzymes.



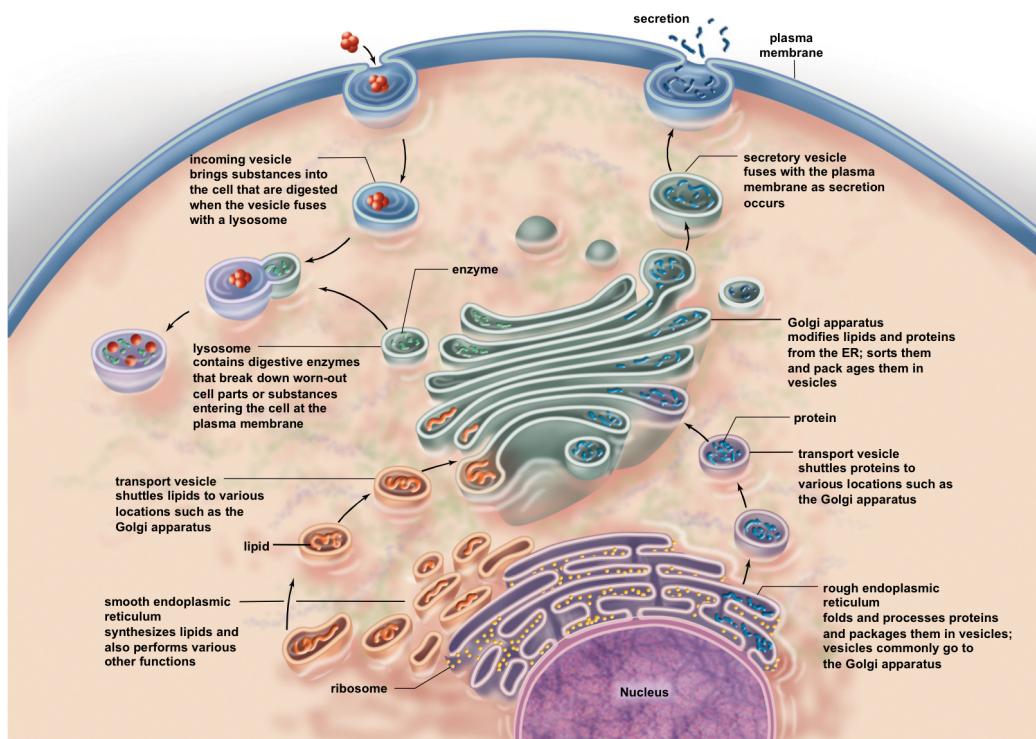
(b) Central vacuole in a plant cell

§13 The Endomembrane System: Protein Translation and Conclusion

1. Protein translation



2. Conclusion



§14 Energy Transformations: Chloroplasts

1. Photosynthesis

1° Most of the living world runs on the energy provided by photosynthesis. (光合作用)

2º Photosynthesis is the conversion of light energy from the sun to

- ① the chemical energy of sugar
- ② other organic molecules.

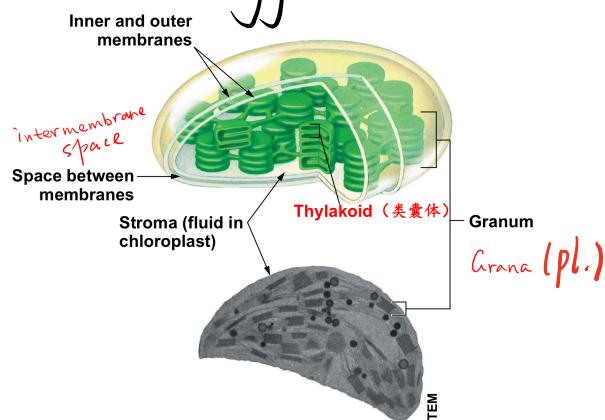
2. Chloroplasts

Chloroplasts (叶绿体) are

- 1º unique to the photosynthetic cells of plants and algae (藻类)
- 2º the organelles that perform photosynthesis.

3. The structure of chloroplasts

- 1º Chloroplasts are divided into compartments by two membranes, one inside the other.
- 2º The **stroma** (基质) is a thick fluid found inside the innermost membrane.
- 3º Suspended in stroma is a network of membrane-enclosed disks and tubes, which form another compartment.
 - ① The disks occur in interconnected stacks called **grana** (基粒)
 - ② The grana are a chloroplast's solar power packs, the structures that trap light energy and convert it to chemical energy.



§15 Energy Transformations: Mitochondria

1. Mitochondria

Mitochondria (线粒体)

1° are found in almost all eukaryotic cells.

2° are the organelles in which cellular respiration (呼吸作用) takes place

3° produce ATP from the energy of food molecules.

2. The structure of mitochondria

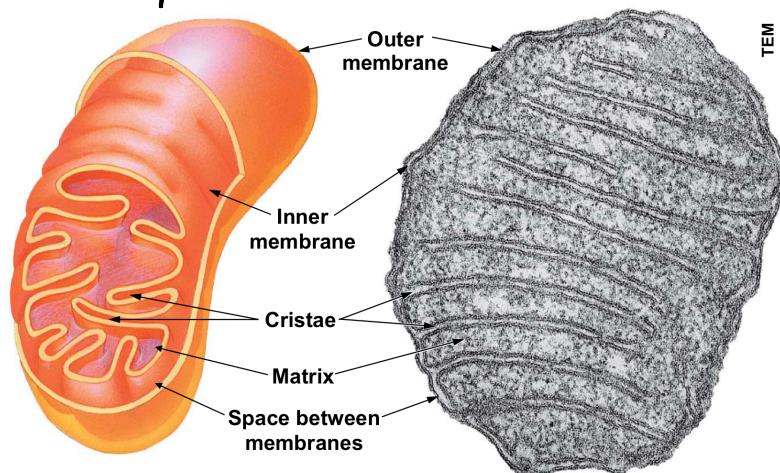
1° An envelope of two membranes encloses the mitochondrion, and the inner membrane encloses a thick fluid called the mitochondrial matrix (基质)

2° The inner membrane of the envelope has numerous infoldings called cristae (脊)

3° The folded surface

① includes many of the enzymes and other molecules that function in cellular respiration

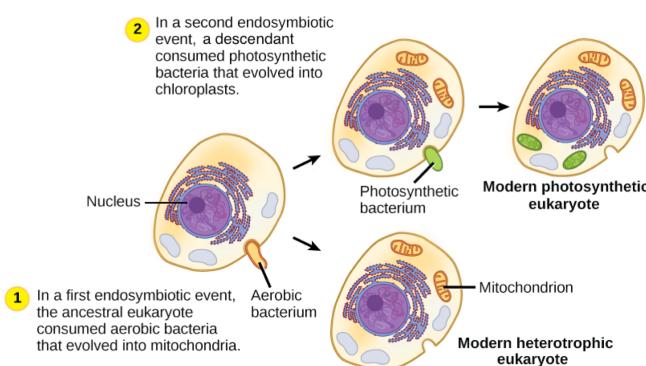
② creates a greater area for the chemical reactions of cellular respiration.



3. Some facts about mitochondria and chloroplasts

- 1^o Mitochondria and chloroplasts contain their own DNA that encodes some of their own proteins made by their own ribosomes.
- 2^o Each chloroplast and mitochondrion contains a single circular DNA chromosome that resembles a prokaryotic chromosome
 - The mitochondrial genome contains 37 genes that encode 13 proteins, 22 tRNAs, and 2 rRNAs.
 - The 13 mitochondrial gene-encoded proteins all instruct cells to produce protein subunits of the enzyme complexes of the oxidative phosphorylation system, which enables mitochondria to act as the powerhouses of our cells.
- 3^o Each chloroplast and mitochondrion can grow and pinch in two, reproducing themselves.
- 4^o Mitochondria are very dynamic and can change shapes, locations and number to suit a cell's need.
- 5^o Mitochondria fuse by fusion to form a tubular network.
 - 6^o This is evidence that mitochondria and chloroplasts evolved from ancient free-living prokaryotes that established residence within other, larger host prokaryotes.
 - This phenomenon, where one species lives inside a host species, is a special type of symbiosis (共生关系).
 - Over time, mitochondria and chloroplasts likely became increasingly interdependent with the host prokaryote, eventually evolving into a single organism with inseparable parts.

Mitochondria and chloroplasts



31b The Cytoskeleton: Cell Shape and Movement

1 Cytoskeleton

The cytoskeleton (细胞骨架)

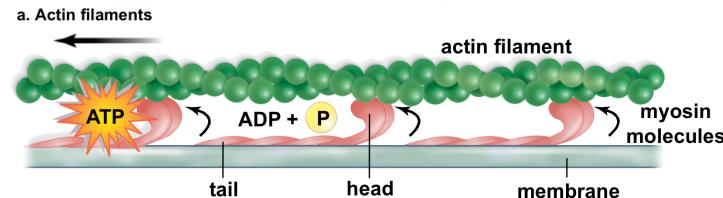
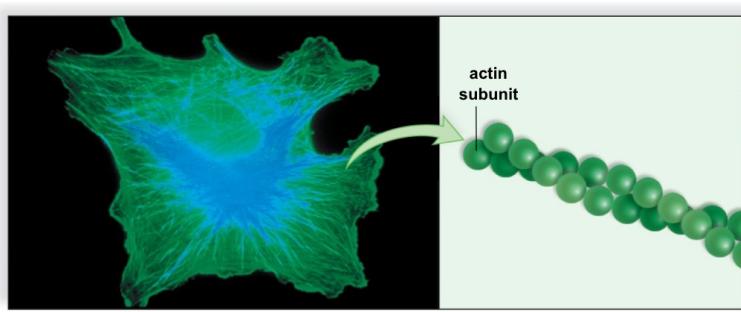
- 1° is a network of fibers extending throughout the cytoplasm
- 2° serves as both skeleton and "muscles" for the cell, functioning in support and movement.
- 3° provides anchorage and reinforcement for many organelles in a cell.

2 Types

- 1° Microtubules (微管) are hollow tubes of protein.
- 2° Intermediate filaments (中间微丝) and microfilaments (actin filaments) (微丝/肌动蛋白丝) are thinner and solid.

3. Actin Filament

- 1° Two actin (肌动蛋白) chains twisted in helix, thinnest
- 2° Roles
 - ① Structural - dense web under plasma membrane
 - ② Found in intestinal microvilli (小肠指状突起)
- 3° Actin interacts with motor molecules (myosin (肌凝蛋白))



4° Help the cytokinesis (胞质分裂) of mitosis (有丝分裂)

A. Intermediate Filaments

1° Intermediate in size

2° Functions:

① Support nuclear envelope

② Support junctions between

{ cell-cell
cell-extracellular matrix
cell-organelles

B. Microtubules

1° Hollow tubes composed of α, β -tubulins (微管蛋白)

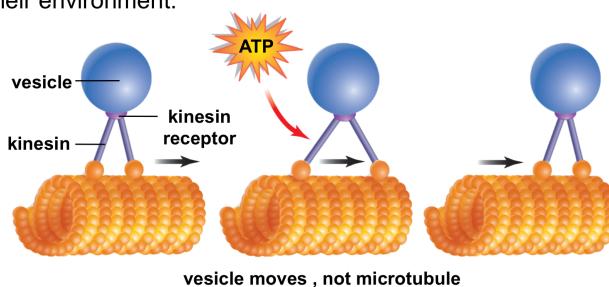
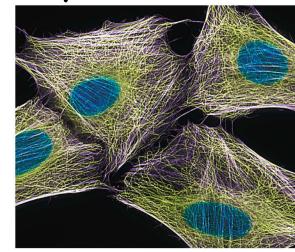
2° Guide the transport of cargos to the proper locations.

3° Assemble and disassemble according to the movement of the cells

4° Assemble under the control of Microtubule Organizing Center (MTOC). Most important MTOC is centrosome



The skin cells of a chameleon rely on microtubules to move pigment granules around so that they can take on the color of their environment.



- Microtubules guide the transport of organelles, vesicles, and macromolecules, or other cargoes to their proper locations.
- Interacts with motor molecules kinesin and dynein to cause movement of organelles.

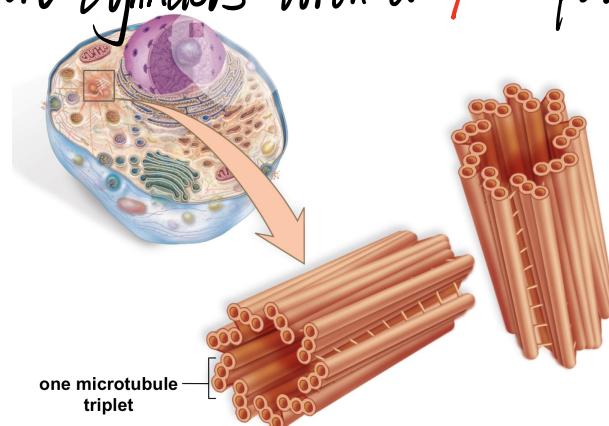


The crawling movement of an amoeba is due to the rapid degradation and rebuilding of microtubules.

1. Centrioles (中心粒)

1° Found in centrosome (中心体)

2° Short cylinders with a 9+0 pattern of microtubule triplets.



2. Centrosomes

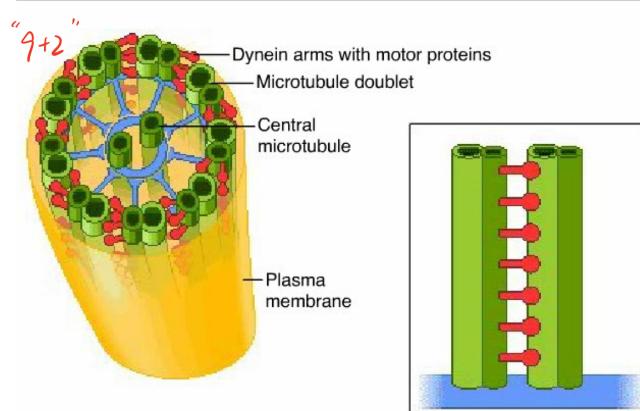
Form the spindle apparatus (纺锤体) during cell division.

§18 Cilia (纤毛) and Flagella (鞭毛)

1. Flagella

1° move sperm cells in liquid

2° 9+2 structure

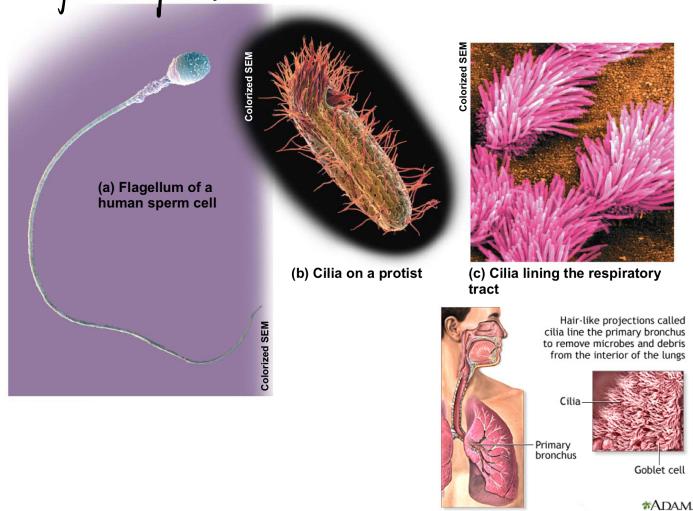


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2. Cilia

1° Cilia in lungs sweep out the dirts and mucus.

Smoking paralyzes and even destroys cilia, adding the risk for infection.



Why do some men with a type of hereditary sterility (遗传性不育) also suffer from respiratory problems?

- Because human sperm rely on flagella for movement, it is easy to understand why problems with flagella can lead to male infertility (不育症).
- Some men with a type of hereditary sterility (遗传性不育) also suffer from respiratory problems because of a defect in the structure of their flagella and cilia.