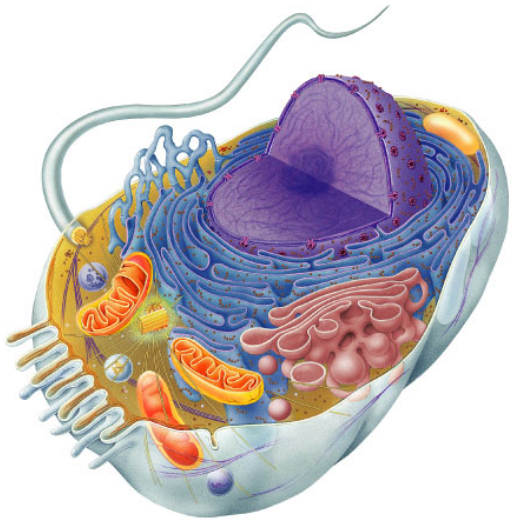
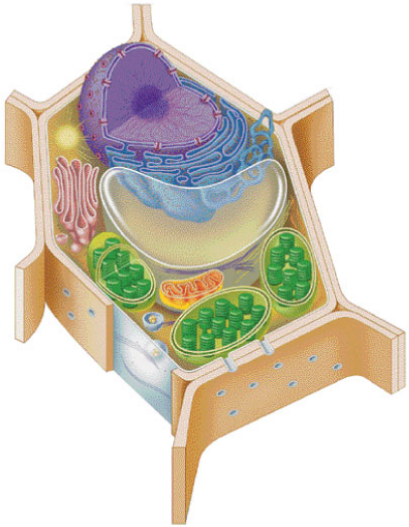
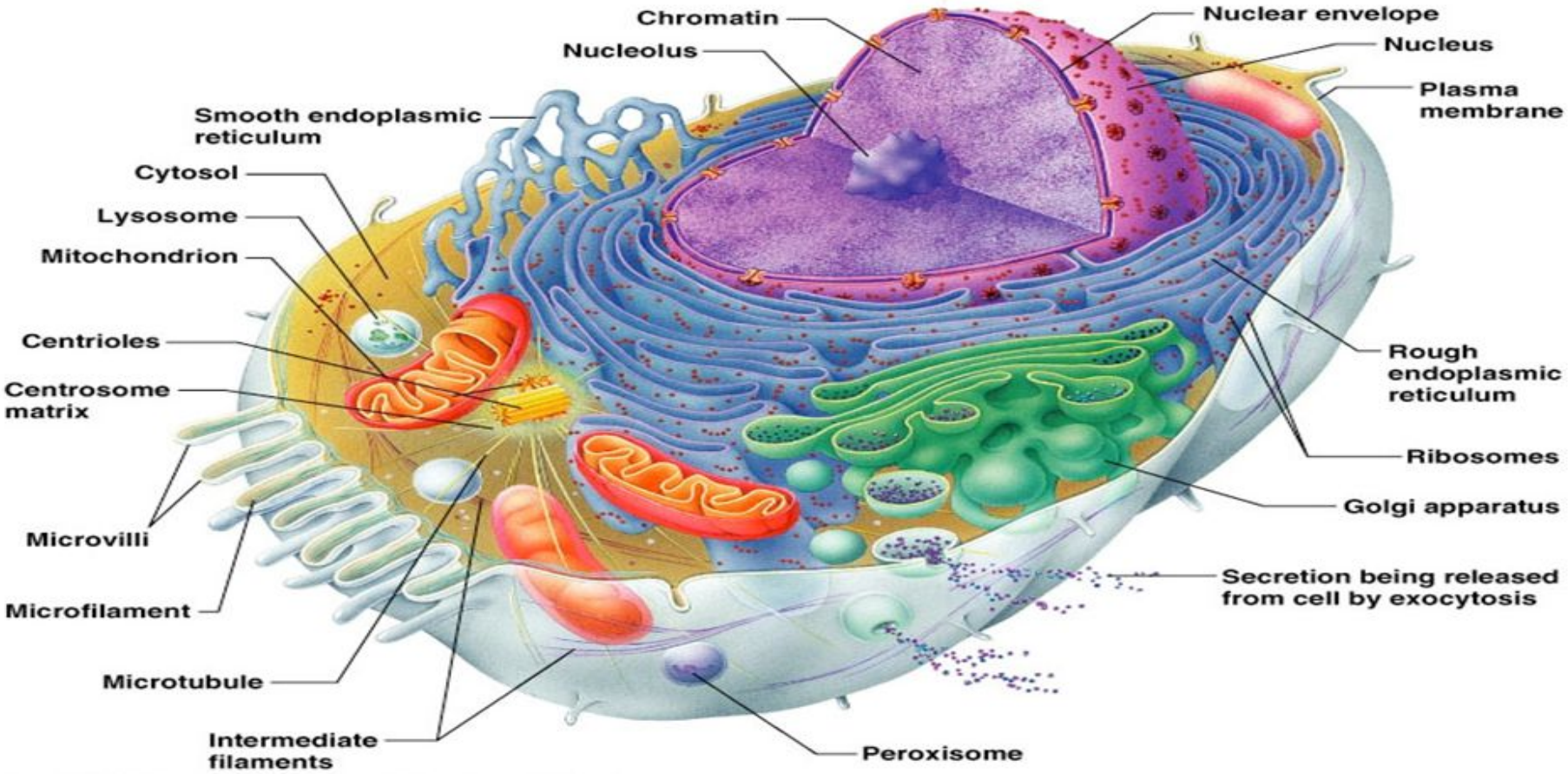


Cell Organelles

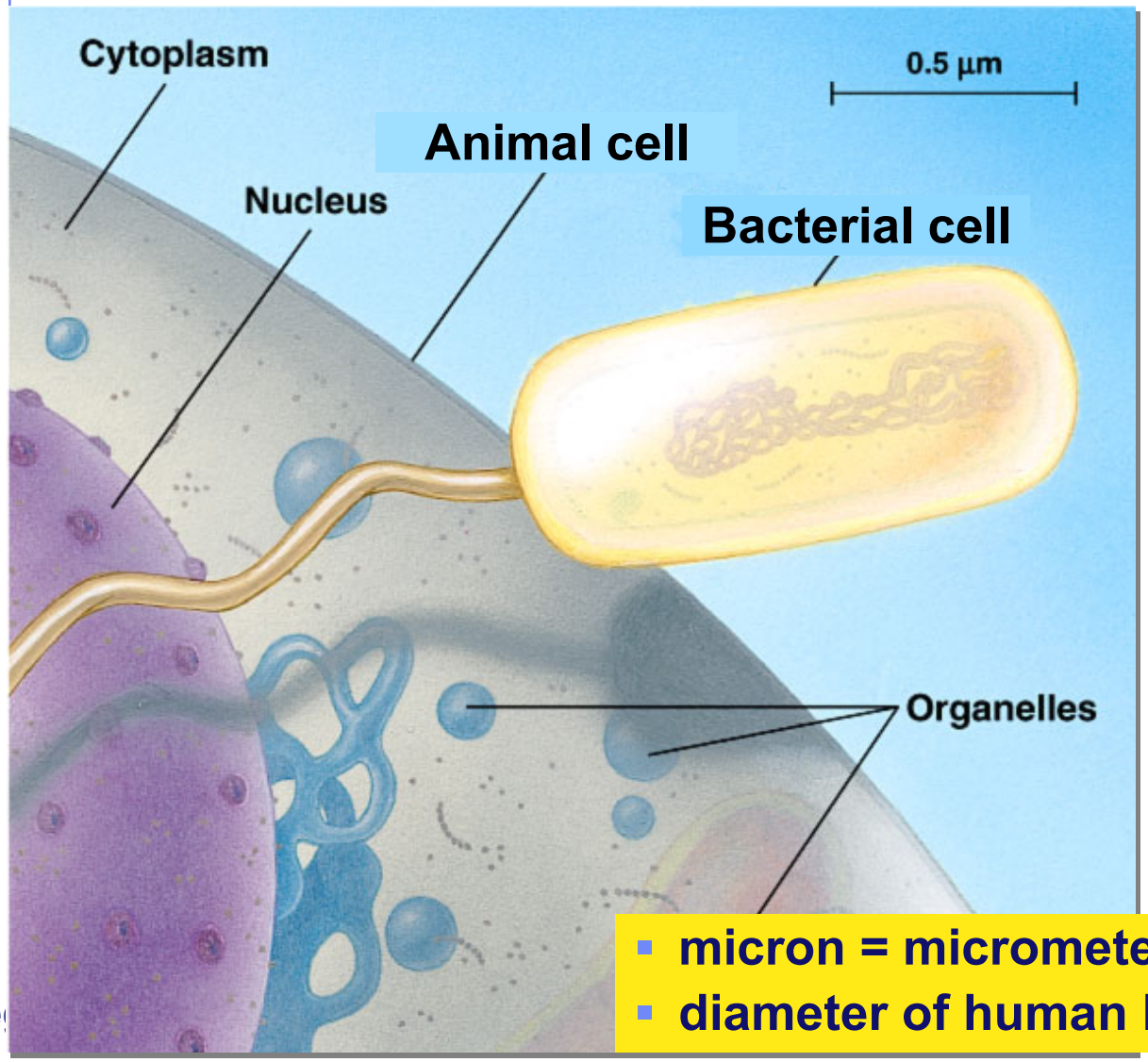
Dr. Abdul Rahman Al-Fahdawi
Ph.D.



Cell Organelles



Cell size comparison



most bacteria

- **1-10 microns**

eukaryotic cells

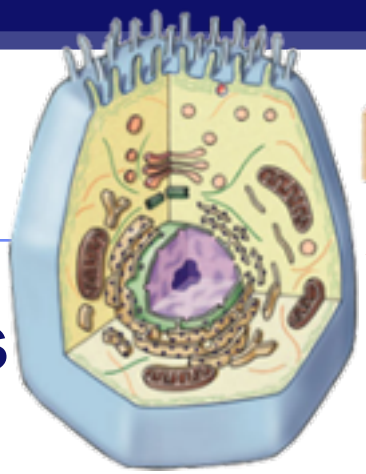
- **10-100 microns**

- **micron = micrometer = 1/1,000,000 meter**
- **diameter of human hair = ~20 microns**

The Work of Life

- What jobs do cells have to do for an organism to live…
  - "breathe"
    - gas exchange: O_2 in vs. CO_2 out
  - eat
    - take in & digest food
  - make energy
    - ATP
  - build molecules
    - proteins, carbohydrates, fats, nucleic acids
  - remove wastes
  - control internal conditions
    - homeostasis
  - respond to external environment
  - build more cells
    - growth, repair, reproduction & development

The Jobs of Cells

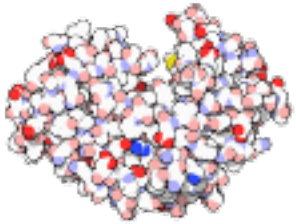


- Cells have 3 main jobs
  - make energy (E)
    - need energy for all activities
    - need to clean up waste produced while making energy

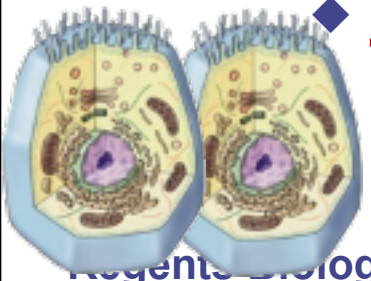
Our organelles do all these jobs!

EPC

  - make proteins (P)
    - proteins do all the work in a cell, so we need lots of them

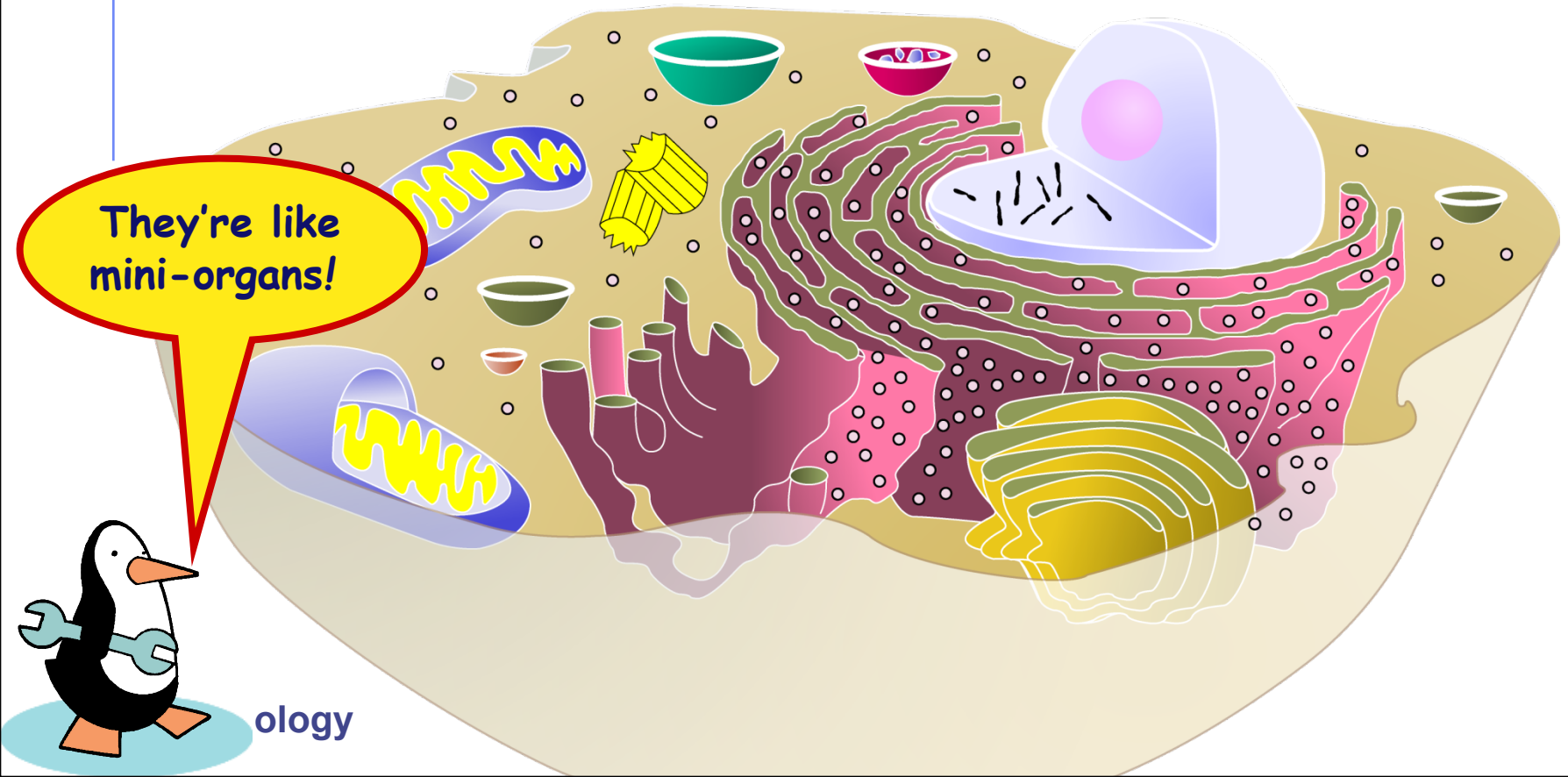


  - make more cells (C)
    - for growth
    - to replace damaged or diseased cells



Organelles

- Organelles do the work of cells
  - each structure has a job to do
    - keeps the cell alive; keeps you alive

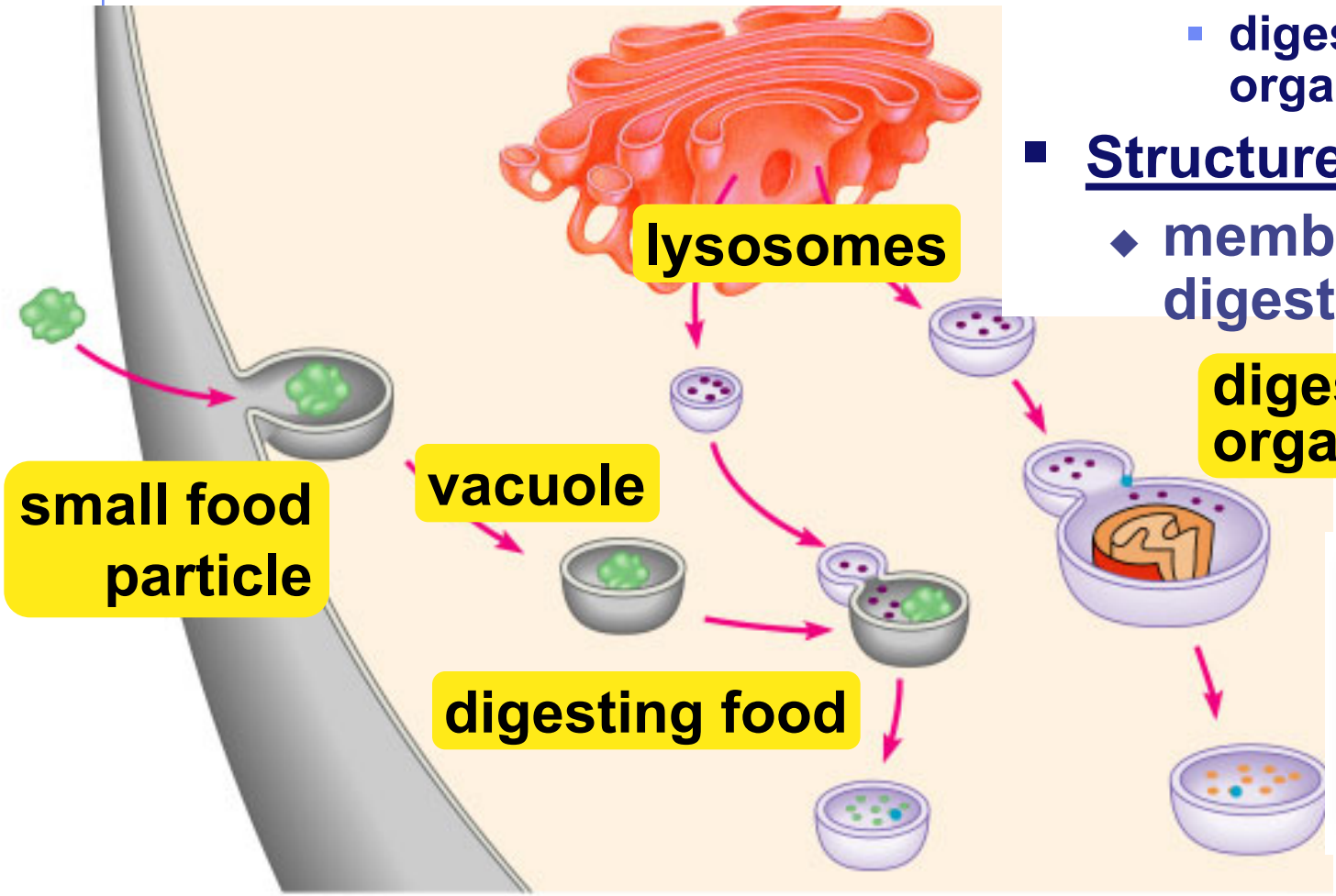


1. Cells need power!

- Making energy
  - to fuel daily life & growth, the cell must…
    - take in food & digest it
    - take in oxygen (O_2)
    - make ATP
    - remove waste
  - organelles that do this work…
    - cell membrane
    - lysosomes
    - vacuoles & vesicles
    - mitochondria

Lysosomes

- **Function**
  - **digest food**
    - used to make energy
  - **clean up & recycle**
    - digest broken organelles
- **Structure**
  - membrane sac of digestive enzymes



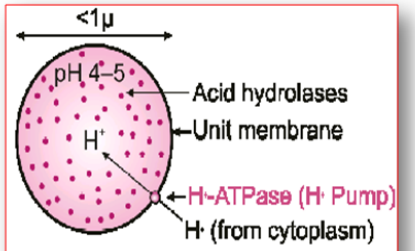


Fig. 2.16: Lysosome

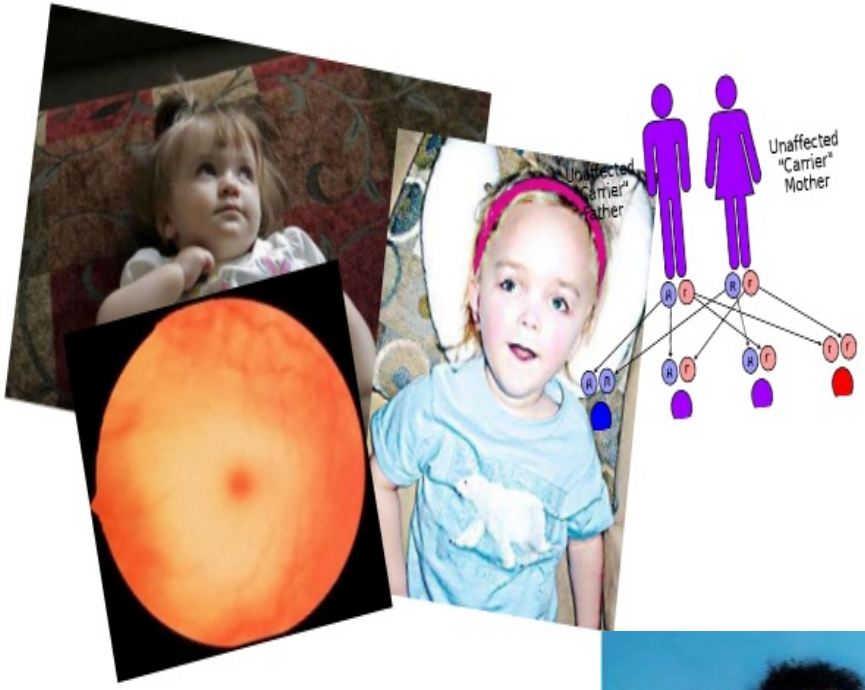
Tay Sachs disease

- The enzyme **HEXA** (beta-hexosaminidase A) is located in lysosomes.
- The *HEXA* gene (**chromosome 15**) provides instructions for making part of an enzyme called beta-hexosaminidase A, which plays a critical role in the brain and spinal cord .
- Mutations in the ***HEXA*** gene cause **Tay-Sachs disease.**
- beta-hexosaminidase A helps break down a fatty substance called GM2 ganglioside.
- Mutations in the *HEXA* gene disrupt the activity of beta-hexosaminidase A, which prevents the enzyme from breaking down GM2 ganglioside.
- So, this substance accumulates to toxic levels, particularly in neurons in the brain and spinal cord. Progressive damage caused by the buildup of GM2 ganglioside leads to the destruction of these neurons,

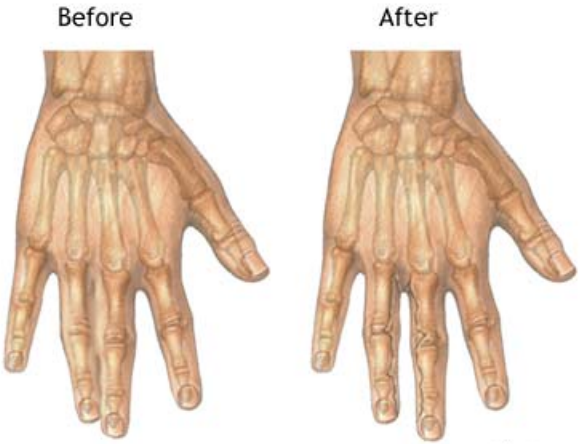
Signs and symptoms

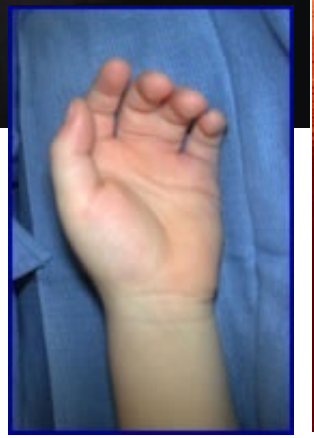
- The most common form of Tay-Sachs disease becomes apparent in infancy. Infants with this disorder typically appear normal until the age of 3 to 6 months
- Affected infants lose ***motor skills*** such as turning over, sitting, and crawling.
- ***Cherry red spot*** in eye. An eye abnormality called a cherry-red spot, which can be identified with an eye examination, is characteristic of this disorder.
- children with Tay-Sachs disease experience ***seizures, vision and hearing loss, and paralysis.***
- Children with this severe infantile form of Tay-Sachs disease usually live only into early childhood (mostly 4 years)
- Other forms of Tay-Sachs disease are very rare and mild in adults.
- Characteristic features include muscle weakness, loss of muscle coordination (ataxia) and other problems with movement, speech problems, and mental illness

Tay – Sachs disease



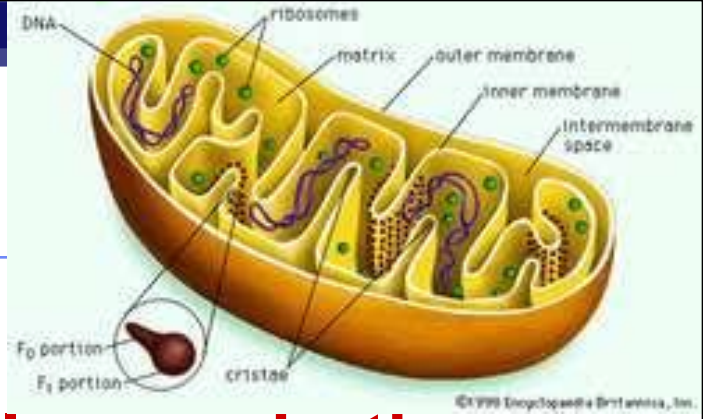
A Job for Lysosomes



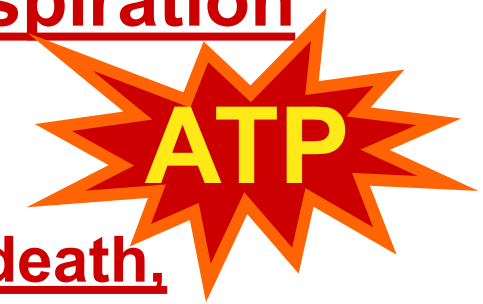


Mitochondria

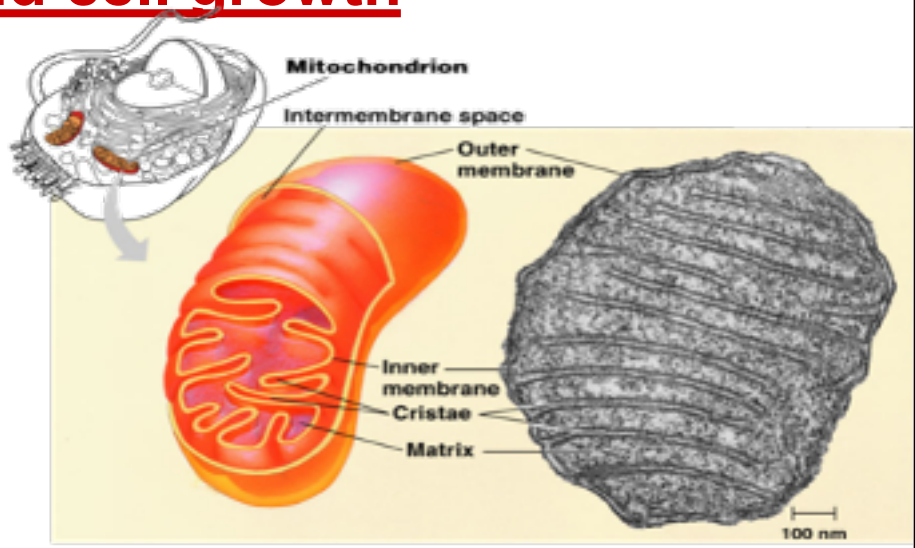
RBCs



- **Function**
  - **make ATP energy from cellular respiration**
    - **sugar + O_2 → ATP**
    - **fuels the work of life**
  - **Signaling, Cell differentiation, and Cell death,**
- **Control of the cell cycle and cell growth**



- **Structure**
  - **double membrane**



in both animal & plant cells

Plants make energy two ways!

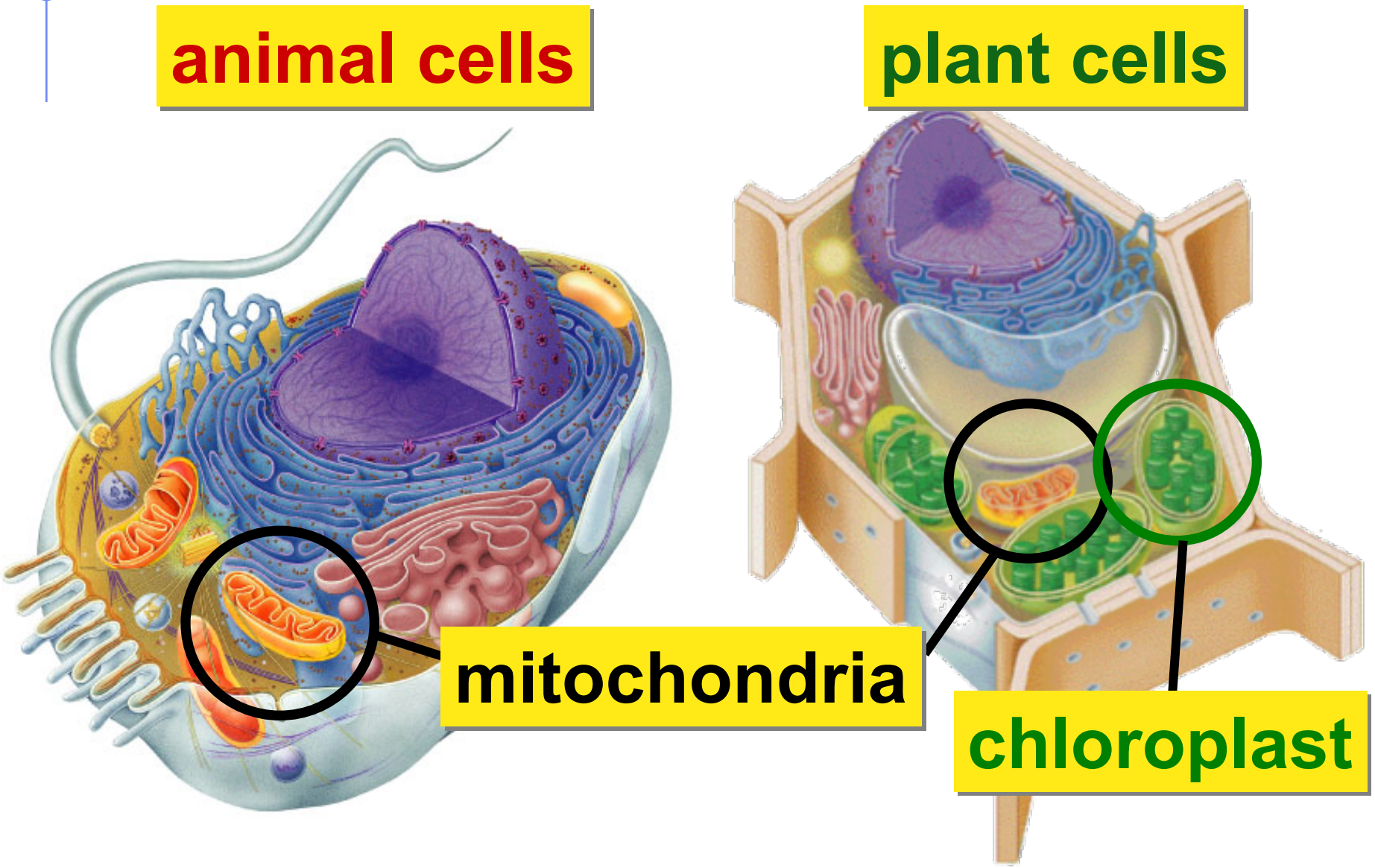
- **Mitochondria**
  - make energy from sugar + O_2
    - **cellular respiration**
    - sugar + $O_2 \rightarrow$ ATP
- **Chloroplasts**
  - make energy + sugar from sunlight
    - **photosynthesis**
    - sunlight + $CO_2 \rightarrow$ ATP & sugar
      - ATP = active energy
      - sugar = stored energy
        - build leaves & roots & fruit out of the sugars

ATP

sugar

ATP

Mitochondria are in both cells!!



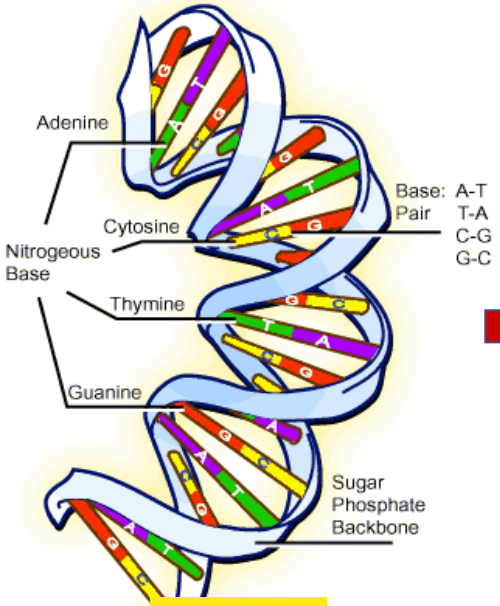
2. Cells need workers = proteins!

- **Making proteins**
  - to run daily life & growth, the cell must…
    - read genes (DNA)
    - build proteins
      - structural proteins (muscle fibers, hair, skin, claws)
      - enzymes (speed up chemical reactions)
      - signals (hormones) & receptors
  - organelles that do this work…
    - nucleus
    - ribosomes
    - endoplasmic reticulum (ER)
    - Golgi apparatus

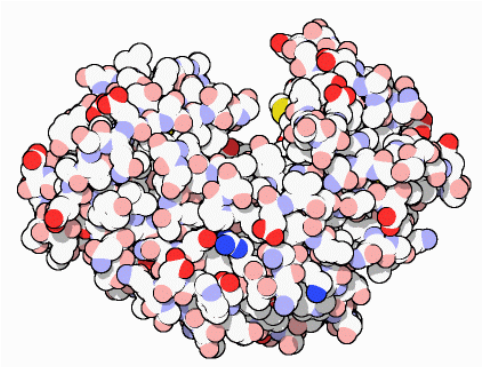
Proteins do all the work!

one of the major job of cells is to make proteins, because…

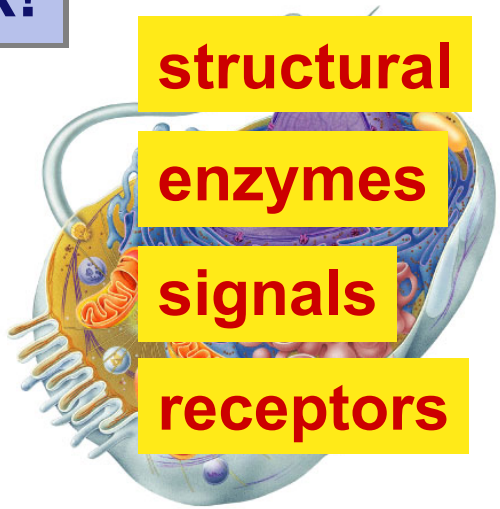
proteins do all the work!



DNA



proteins



structural

enzymes

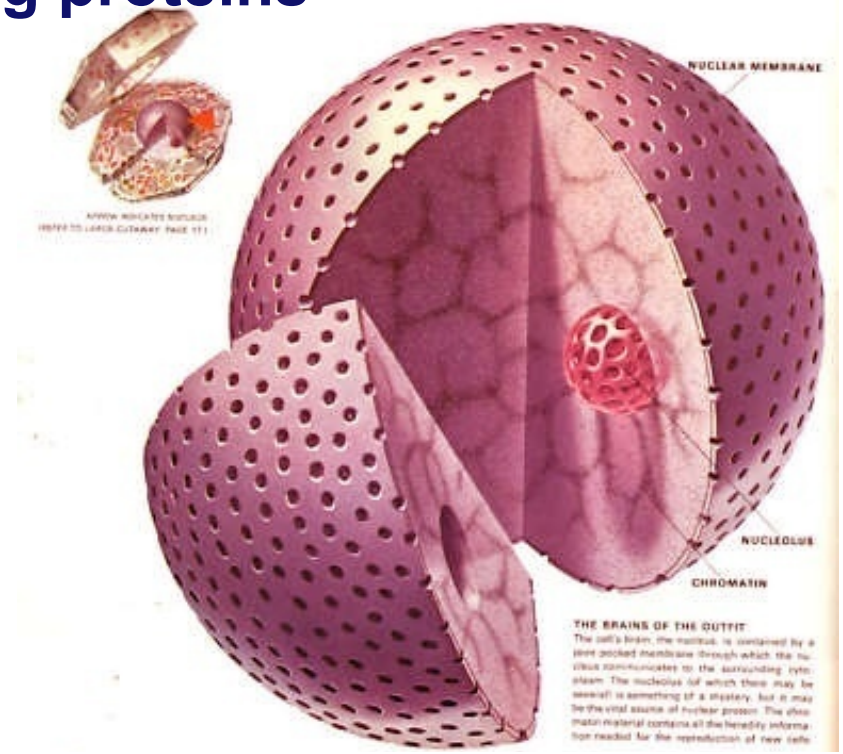
signals

receptors

cells

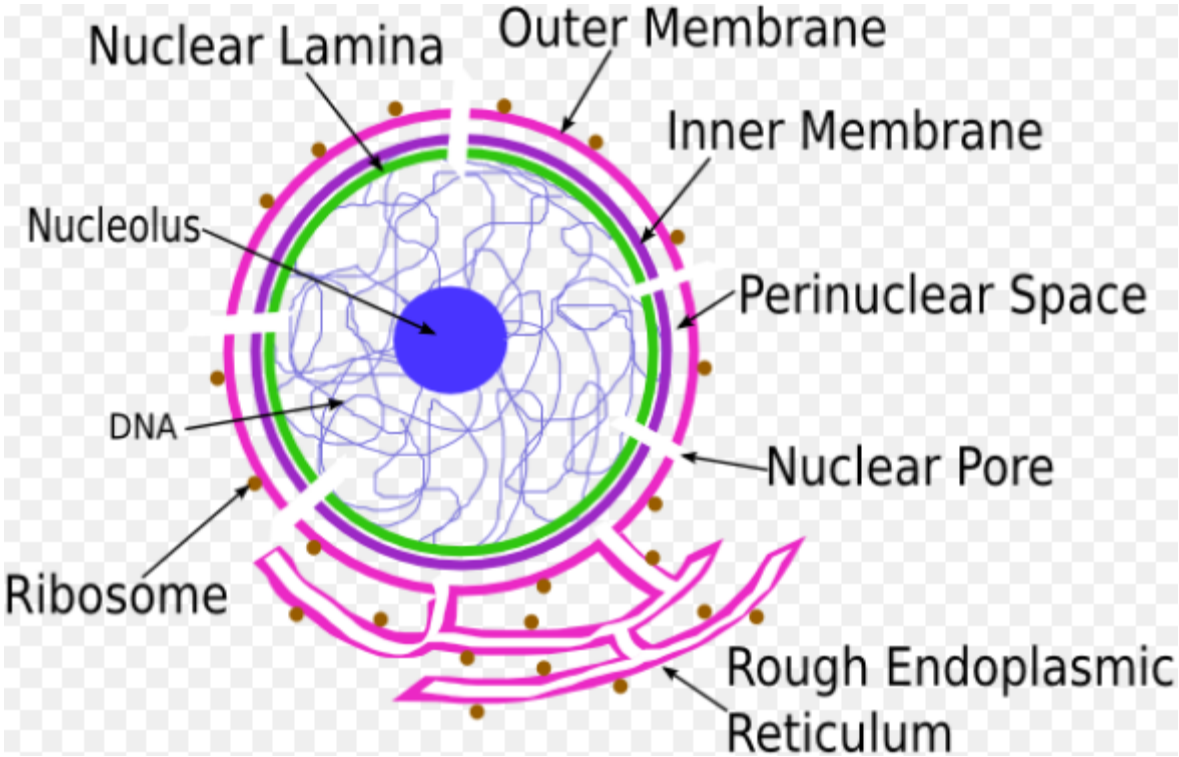
Nucleus

- **Function**
  - control center of cell
  - **protects DNA**
    - instructions for building proteins
- **Structure**
  - **nuclear membrane**
  - **nucleolus**
    - ribosome factory
  - **chromosomes**
    - DNA



Nuclear Membrane

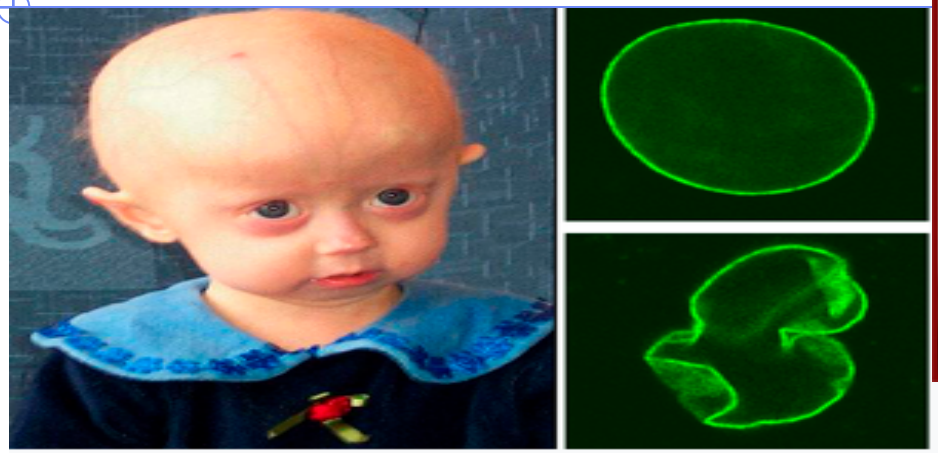
- The nuclear envelope consists of two membranes. The inner membrane faces the nuclear space and DNA. The outer membrane faces the cytoplasm and is continuous with the endoplasmic reticulum.
- The nuclear envelope separates the nuclear space from the cytoplasm. The nuclear envelope provides mechanical support to protects DNA and regulates gene expression by controlling access of transcription factors to their target genes.


Nuclear Lamina
Outer Membrane
Inner Membrane
Nucleolus
Perinuclear Space
DNA
Nuclear Pore
Ribosome
Rough Endoplasmic
Reticulum

Nuclear lamins

- Beneath the inner membrane is a mesh of intermediate filaments called nuclear lamins.
- Lamins provide mechanical **support to the nuclear envelope** and may help **organize chromosomes** by forming interaction with DNA.
- There are two major lamin genes: lamin A and lamin B. Lamin B is essential for life, and mutations in lamin A alter the structure of nucleus.
- Medically, lamins are important because over 200 disease have been associated with mutations in the lamin genes (A)
- Muscular dystrophy, dilated cardiomyopathy, peripheral myopathy and premature aging (progeria).
- How mutations in lamins cause these diseases is unclear. Recent work indicates that the lamins are connected to the cytoskelelton in the cytosol (actin filaments, microtubules). These connections may be important for positioning the nucleus in the cell and linking mechanical stress of the cell to gene regulation. .

Progeria



A young girl with progeria (left). A healthy cell nucleus (right, top) and a progeric cell nucleus (right, bottom).

Pronunciation	/prəʊˈdʒɪərɪə/[3][4]
Specialty	Medical genetics
Symptoms	Growth delay, short height, small face, hair loss[5]
Complications	Heart disease, stroke, hip dislocations[5]
Usual onset	9–24 months[5]
Causes	Genetic[5]
Diagnostic method	Based on symptoms, genetic tests[5]
Differential diagnosis	Hallermann–Streiff syndrome, Gottron's syndrome, Wiedemann–Rautenstrauch syndrome[5]
Treatment	Mostly symptomatic[5]
Medication	Lonafarnib[5]
Prognosis	Average age of death is 13 years[5]
Frequency	Rare (1 in 18 million)[5]

a small face with a shallow recessed jaw, and a pinched nose

atherosclerosis, kidney failure, loss of eyesight, and cardiovascular problems

Diagnosis is suspected according to signs and symptoms, such as skin changes, abnormal growth, and loss of hair. A genetic test for LMNA mutations can confirm the diagnosis of progeria

No treatment has yet proven effective. Most treatment options have focused on reducing complications (such as cardiovascular disease) with coronary artery bypass surgery and low-dose aspirin.

Re

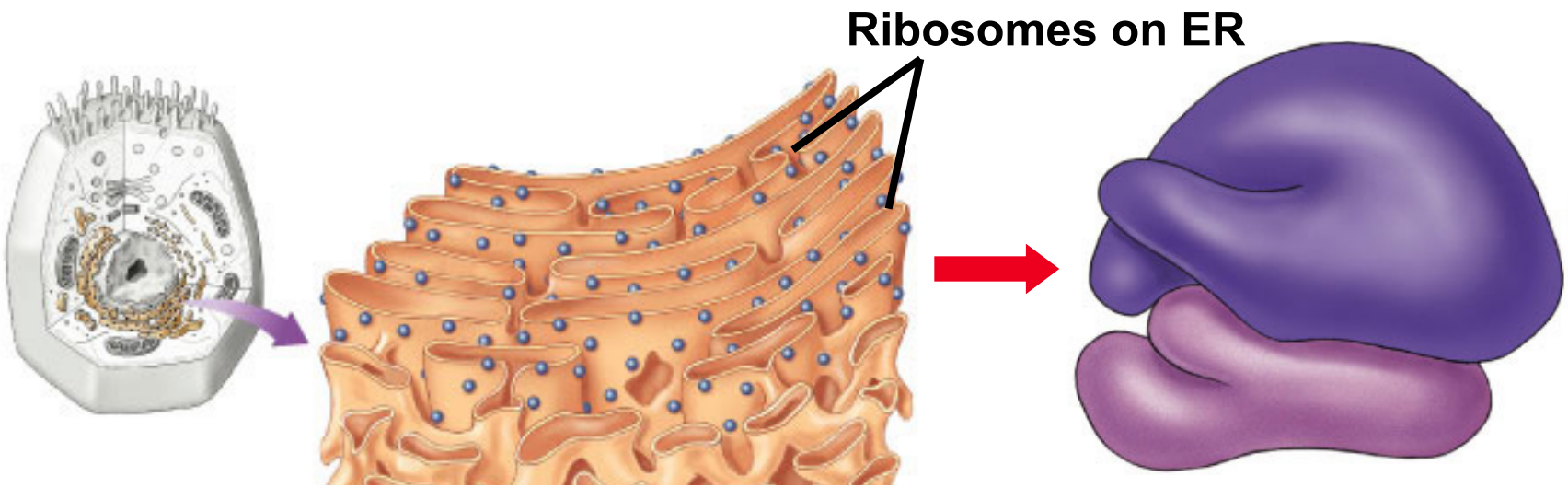
Ribosomes

Streptomycin bacteria
no human?

Ciprofloxacillin (DNA)
(gyrase)

- **Function**
  - **protein factories**
  - read instructions to build proteins from DNA
- **Structure**
  - some free in cytoplasm
  - some attached to ER

70s – 80s



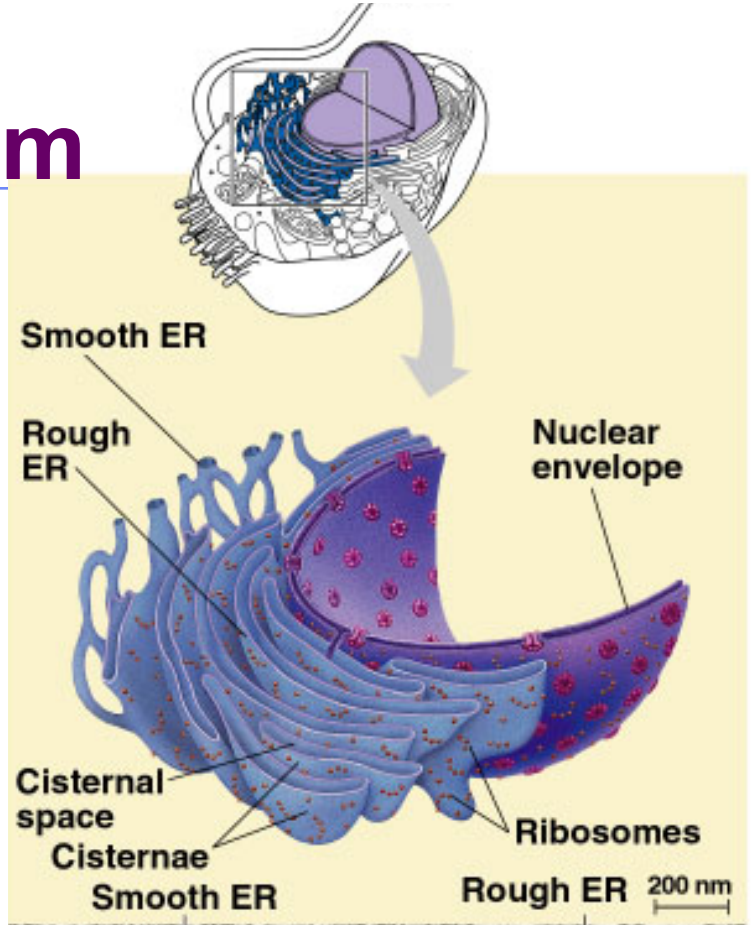
Reg

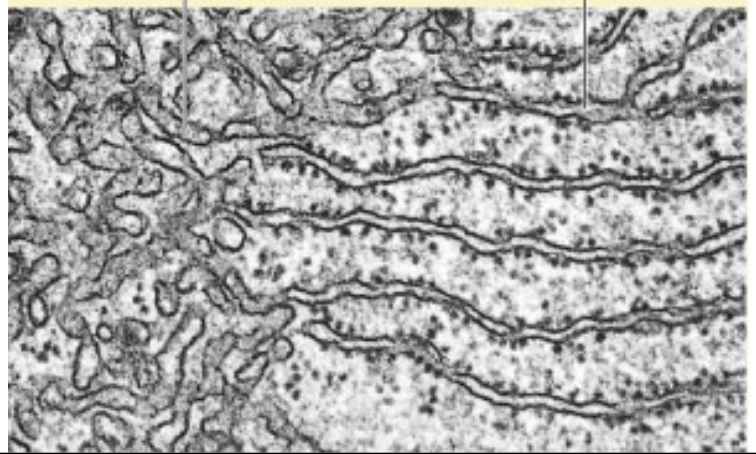
13

human	Disease	Clinical manifestations
TCOF1	Treacher Collins syndrome (TCS)	craniofacial abnormalities
UTP14c	male infertility	severe oligospermia or azoospermia
CIRH1A	Native American Indian childhood cirrhosis (NAIC)	neonatal jaundice progressing to biliary cirrhosis; lethal

Endoplasmic Reticulum

- No found in RBCs + spermatozoa
- **Function**
  - **works on proteins**
    - helps complete the proteins after ribosome builds them
  - **makes membranes**
- **Structure**
  - **rough ER**
    - ribosomes attached
    - works on proteins
  - **smooth ER**
    - makes membranes
    - in lipid manufacture and metabolism,
    - the production of steroid hormones, and
    - detoxification.
    - The smooth ER is especially abundant in mammalian liver and gonad cells

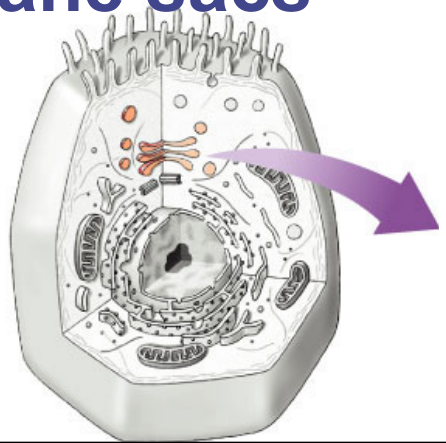


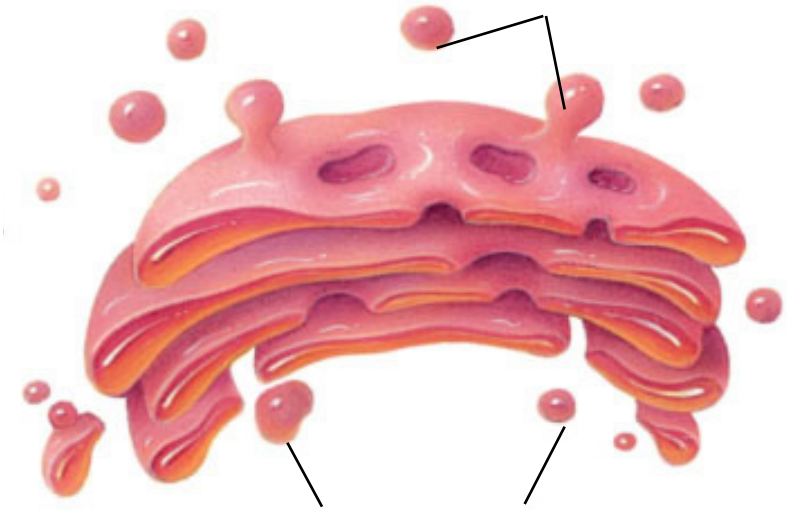


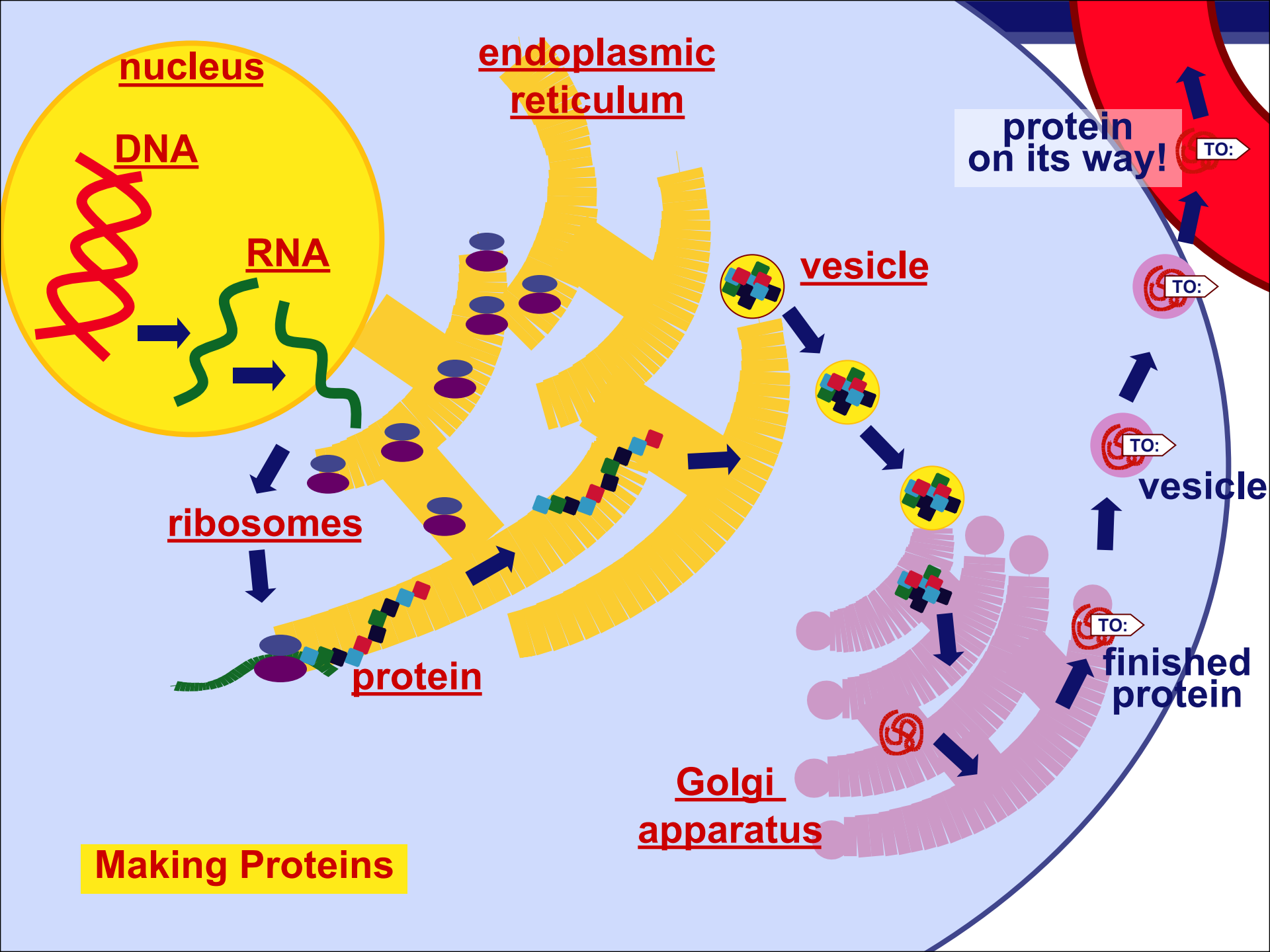
Reg

Golgi Apparatus

- **Function**
  - **finishes, sorts, labels & ships proteins**
    - like UPS headquarters
      - shipping & receiving department
  - **ships proteins in vesicles**
    - "UPS trucks"
- **Structure**
  - membrane sacs

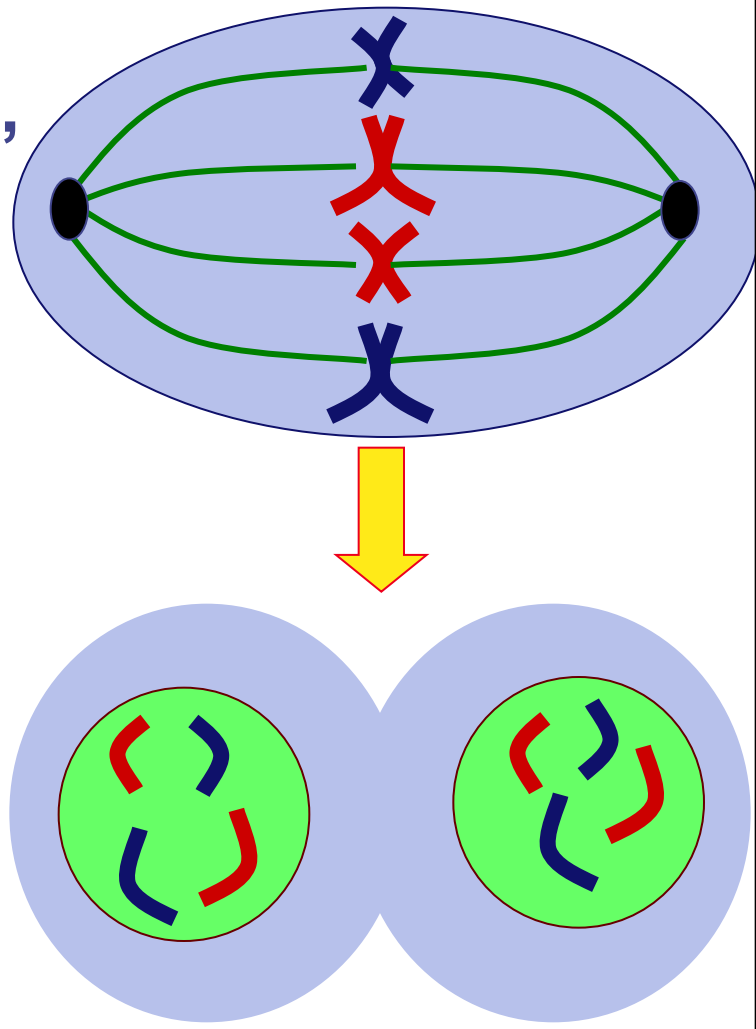





nucleus
DNA
RNA
endoplasmic reticulum
ribosomes
protein
vesicle
Golgi apparatus
protein on its way!
TO:
TO:
TO:
TO:
vesicle
finished protein
Making Proteins

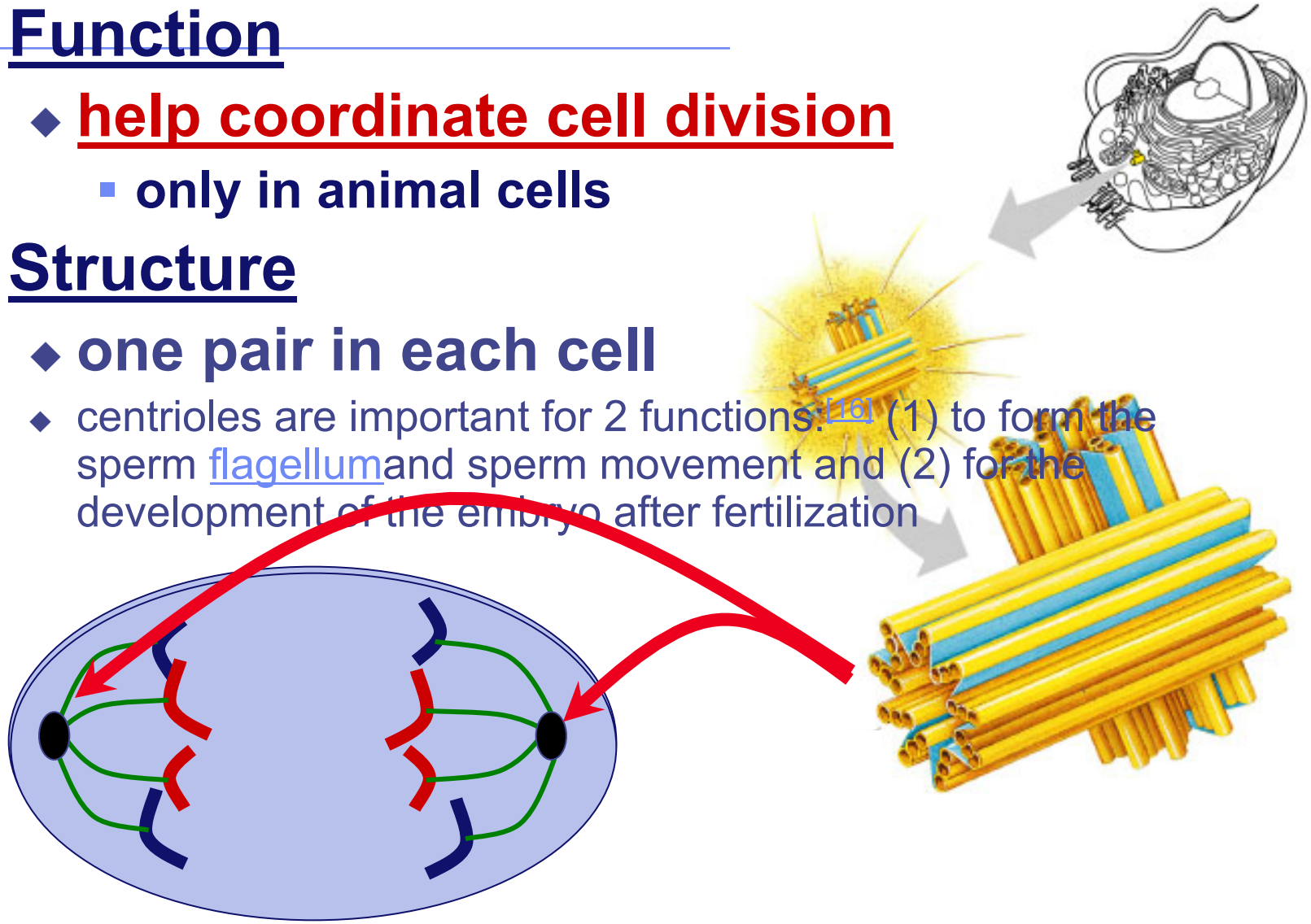
3. Cells need to make more cells!

- Making more cells
  - to replace, repair & grow, the cell must…
    - copy their DNA
    - make extra organelles
    - divide the new DNA & new organelles between 2 new "daughter" cells
  - organelles that do this work…
    - nucleus
    - centrioles

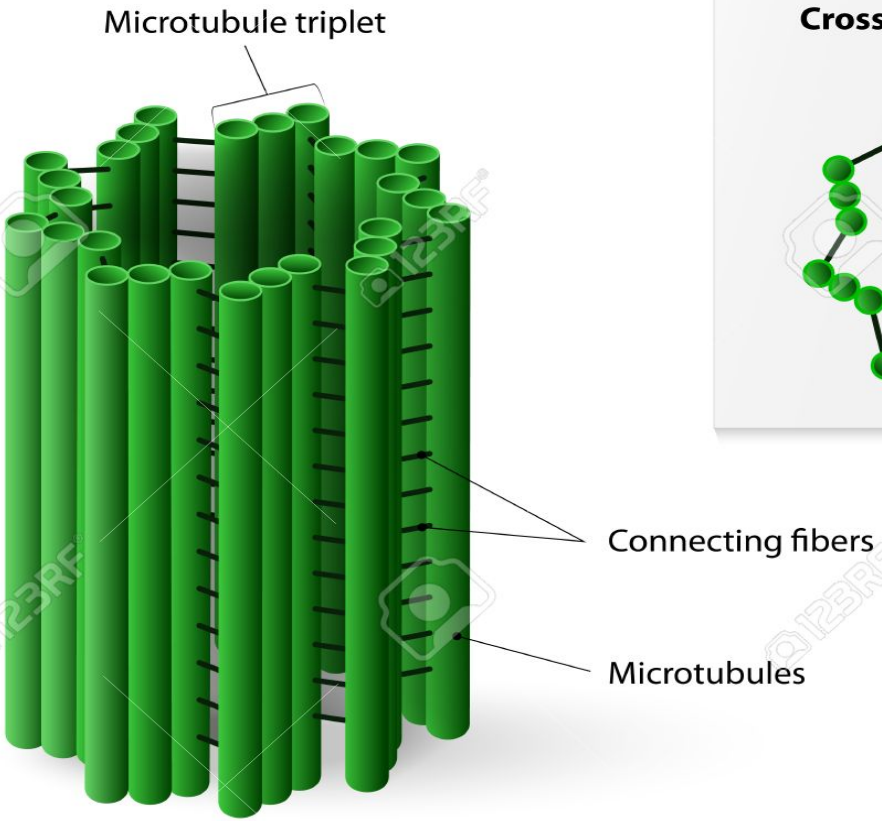


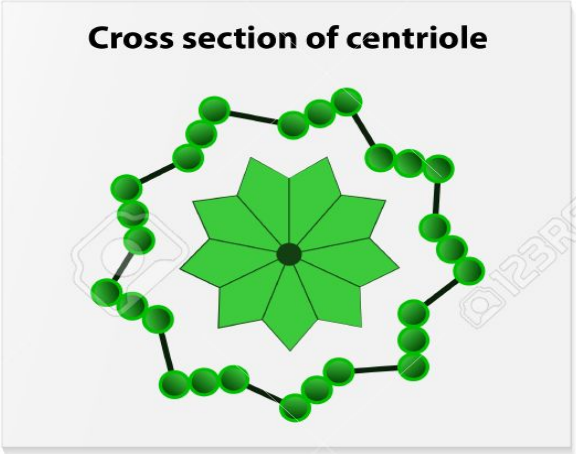
Centrioles

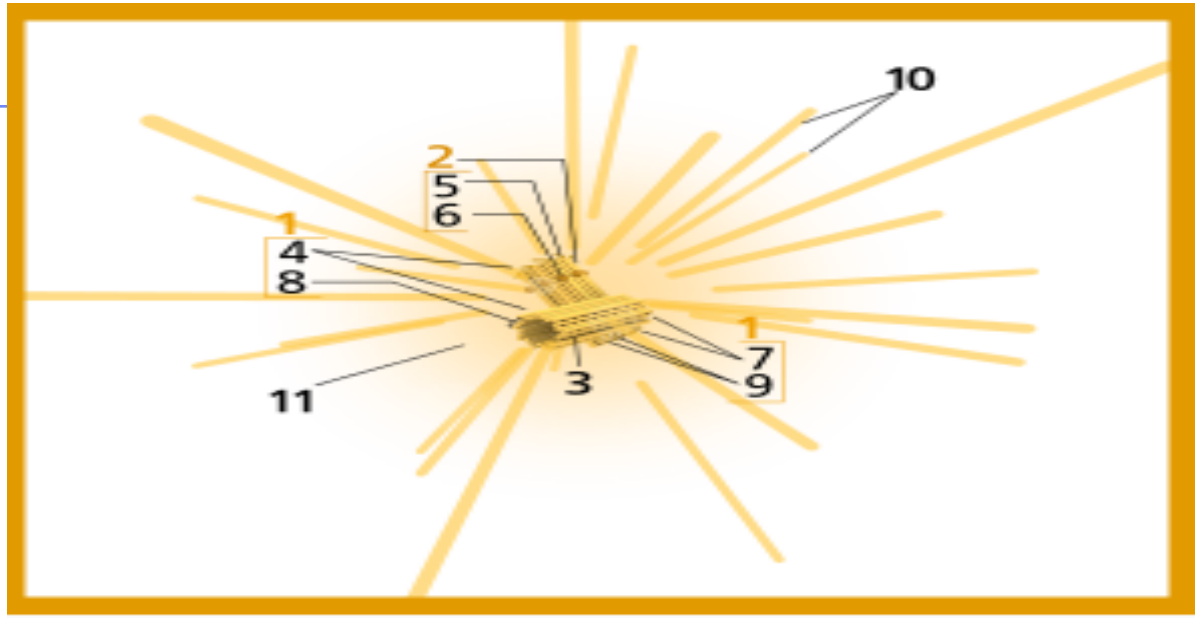
- **Function**
  - **help coordinate cell division**
    - **only in animal cells**
- **Structure**
  - **one pair in each cell**
  - centrioles are important for 2 functions:[16] (1) to form the sperm flagellumand sperm movement and (2) for the development of the embryo after fertilization



Centriole


Microtubule triplet
Connecting fibers
Microtubules

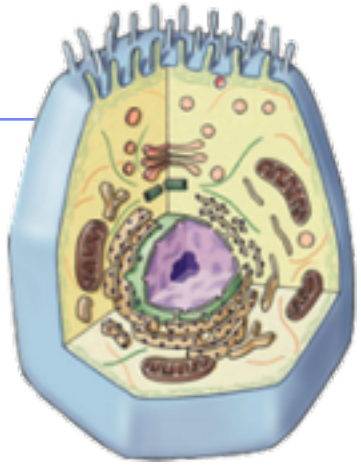

Cross section of centriole

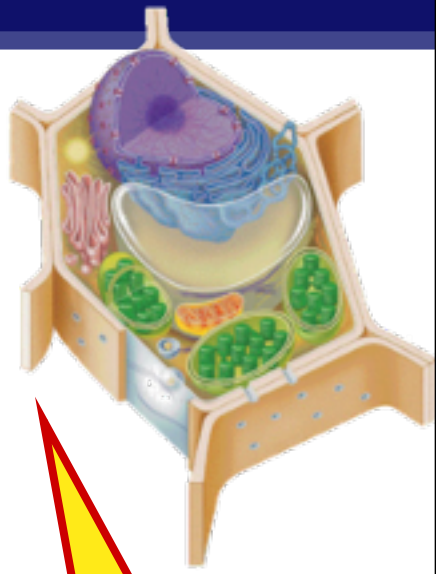


Components of a typical centrosome:

1. **Centriole**
2. Mother centriole
3. Daughter centriole
4. Distal ends
5. Distal appendages
6. Subdistal appendages
7. Proximal ends
8. Microtubule triplets
9. Interconnecting fibers
10. Microtubules
11. Pericentriolar material

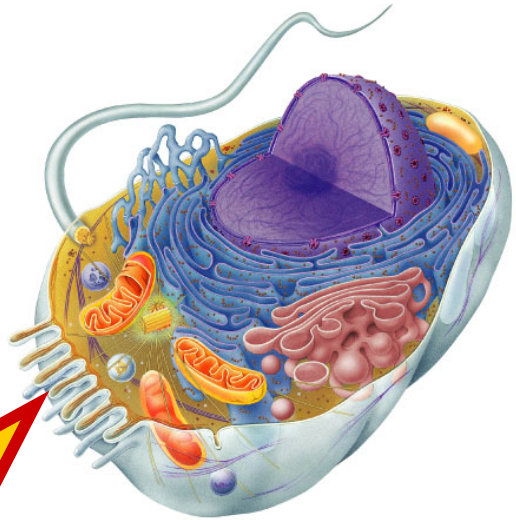
Cell Summary





- Cells have 3 main jobs
  - **make energy**
    - need food + O_2
    - cellular respiration & photosynthesis
    - need to remove wastes
  - **make proteins**
    - need instructions from DNA
    - need to chain together amino acids & "finish" & "ship" the protein
  - **make more cells**
    - need to copy DNA & divide it up to daughter cells

Our organelles do all those jobs!



That's my cellular story…

Any Questions?