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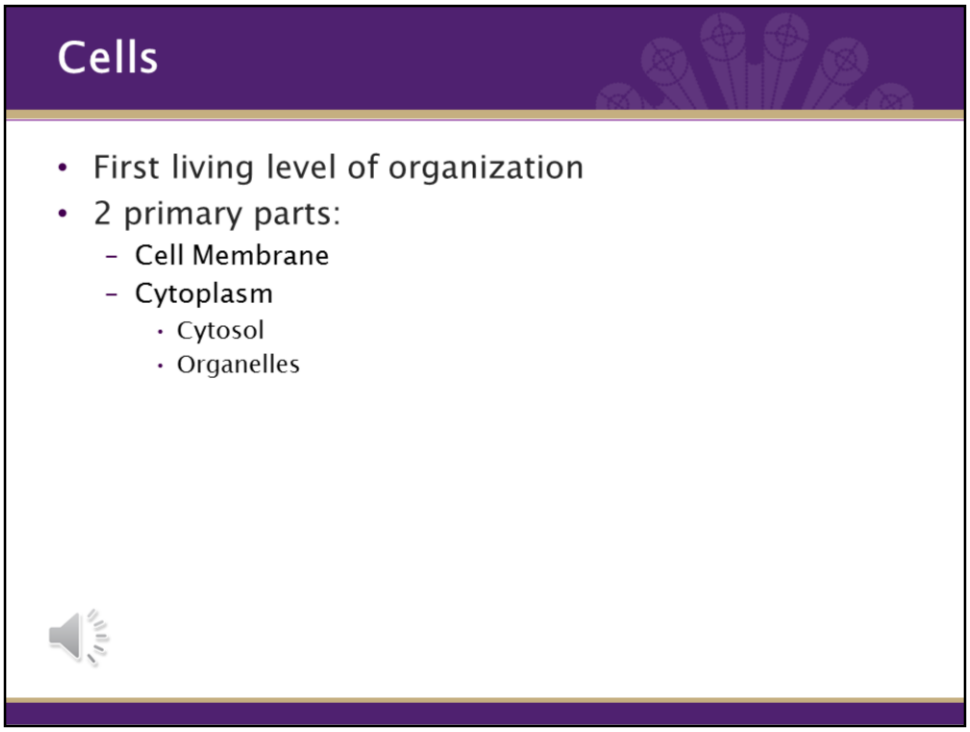
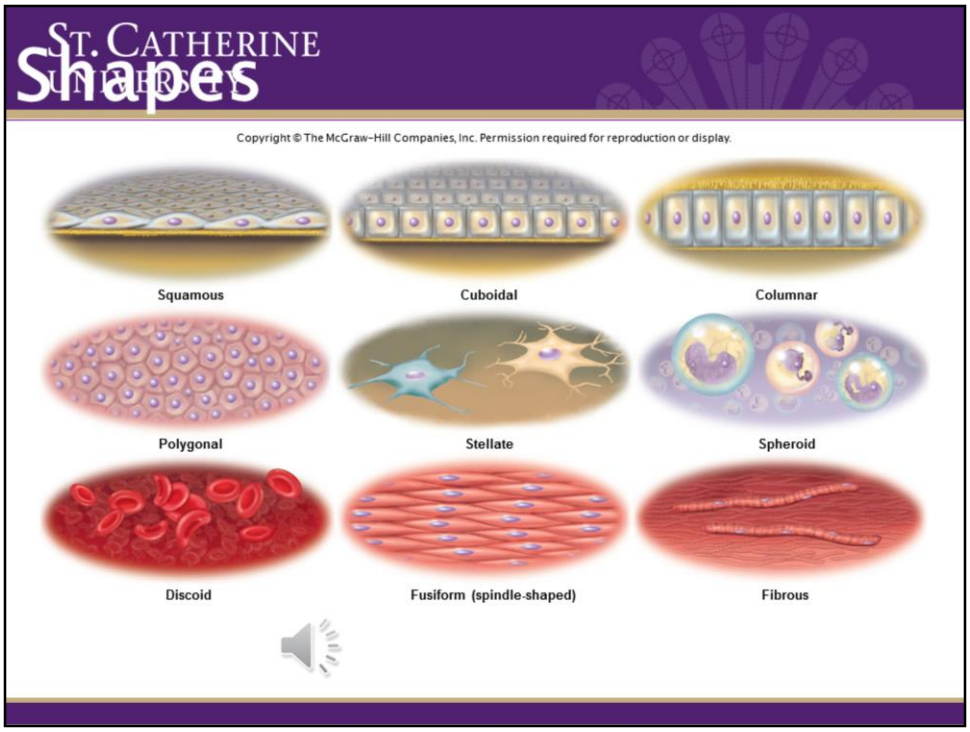
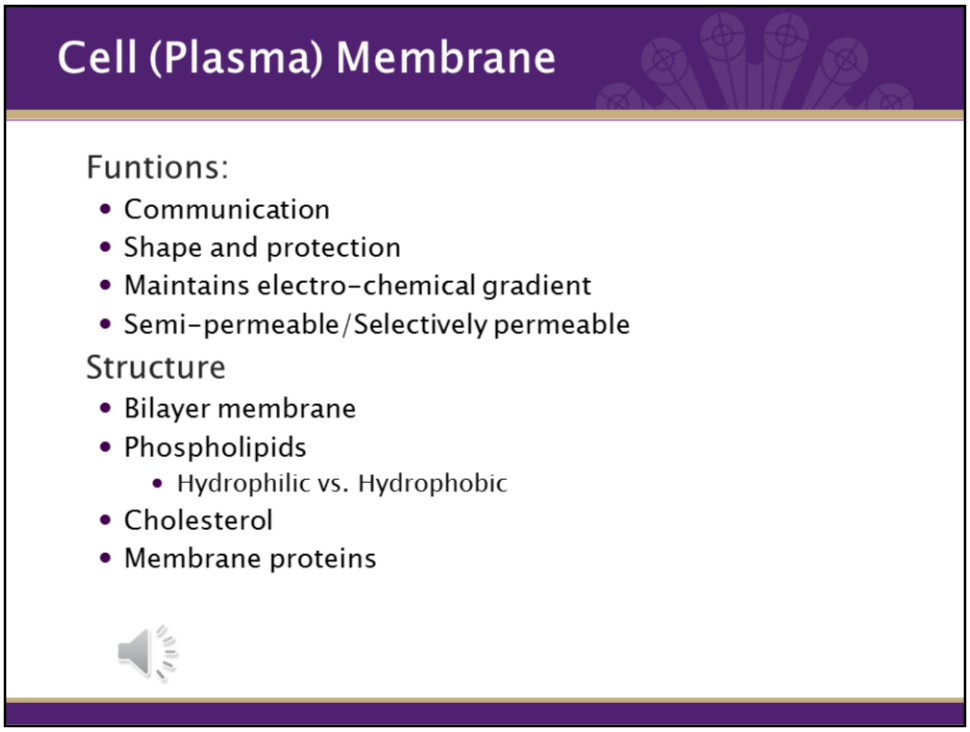
Cytology: The Study of Cells



Cytology is the study of cells. Referring back to our hierarchy, cells are the first living level of organization. There are two parts to a cell, the cell membrane and the cytoplasm. The membrane encapsulates the cell and the cytoplasm is everything inside of the cell. The cytoplasm is divided into two components: the cytosol and organelles. They cytosol is the fluid inside the cell and the organelles are the functioning parts. They are like mini organs of the cell.



Cells can come in a variety of shapes:
1. Squamous cells are flat and thin.
2. Polygonal are irregularly shaped, they are not quite round, but not quite square and are often asymmetrical.
3. Stellate are star shape.
4. Cuboidal are like a cube, they are the same height and width. Even though they are cubed shape, sometimes the corners are rounder and so they can be a bit deceiving. The key is that they are the same height and width.
5. Columnar are tall columns or rectangles. They are taller than they are wide.
6. Spheroid are round or oval.
7. Discoid are disc shape.
8. Fusiform are thick in the middle and thin at the ends.
9. Fibrous are long and thread like.



The cell membrane, also referred to as the plasma membrane, has a number of functions.

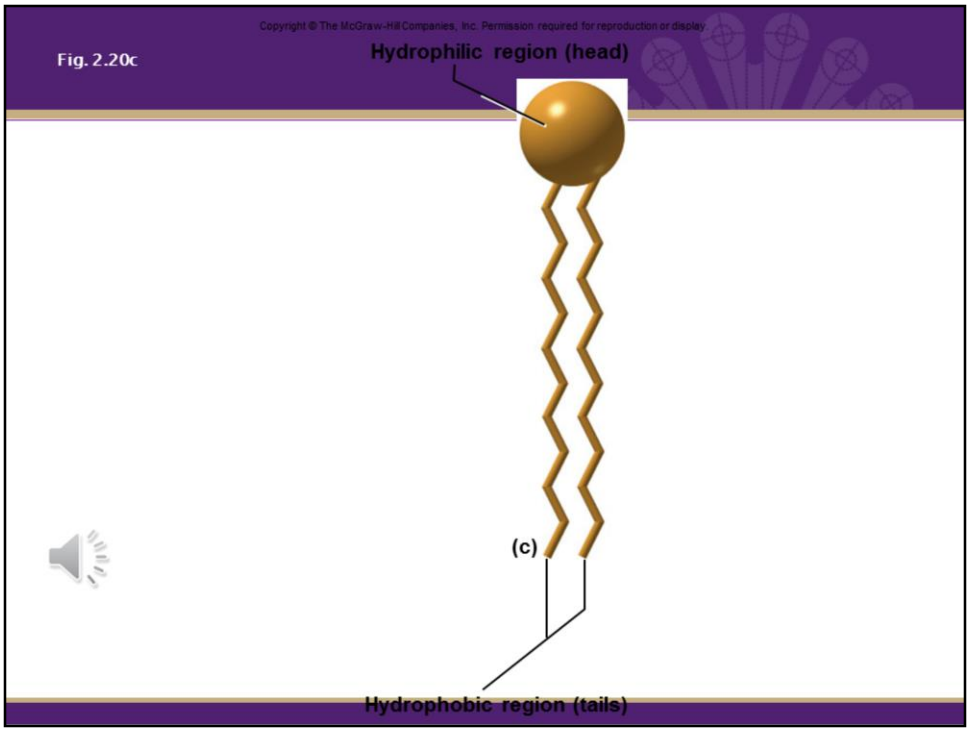
1. Communication: the membrane allow cells to communicate with one another.
2. Shape and Protection.
3. Maintains elctro-chemical gradient: this is the difference in ion concentration from one point to another.
4. Semi-permeable/Selectively permeable: this means that the membrane allows some things to enter or leave the cell while prohibiting others.

The membrane is formed by a phospholipid bi-layer. Or, by two layers of phospholipids.

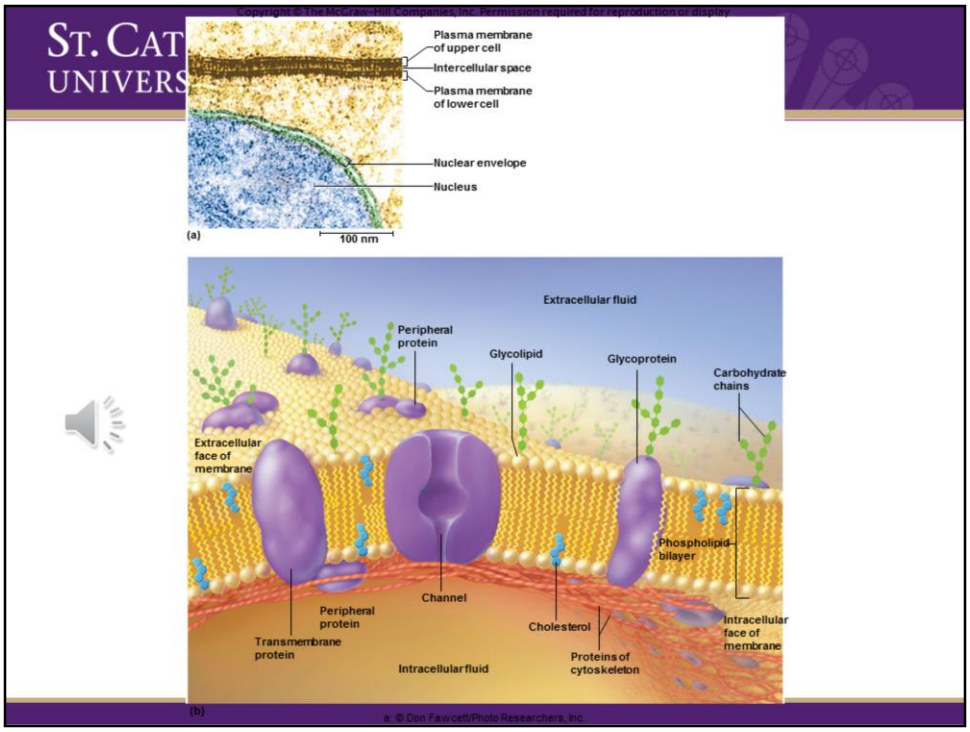
Phospholipids have 2 parts: a hydrophilic portion and a hydrophobic portion. The hydrophilic portion is the phosphate heads and can interact with water while the hydrophobic portion is made of 2 fatty acid tails and doesn't interact with water. The ECF and ICF both contain water, so the phospholipids turn their heads toward the ECF and ICF while their tails point away. Phospholipids do not attach to each other, but move independently next to each other. This allows the membrane to be fluid and flexible.

Although we want a membrane that can adapt its shape, we do not want it too fluid.

This is where cholesterol comes into play. Cholesterol provides some rigidness to the membrane.
There are also a number of proteins found in the membrane. Membrane proteins act as receptors for communication; are part of the Second-Messenger System (they relay messages); work as enzymes for various processes such as digestion, breaking down hormones, and signaling; they also form Transportation Channels and act as Carriers for molecules that need assistance to be transported across the membrane; they are essential for Cellular-id (which allows the body to recognize that this cell belongs here); and finally, they are important for cell adhesion which allows neighboring cells to stick to one another.

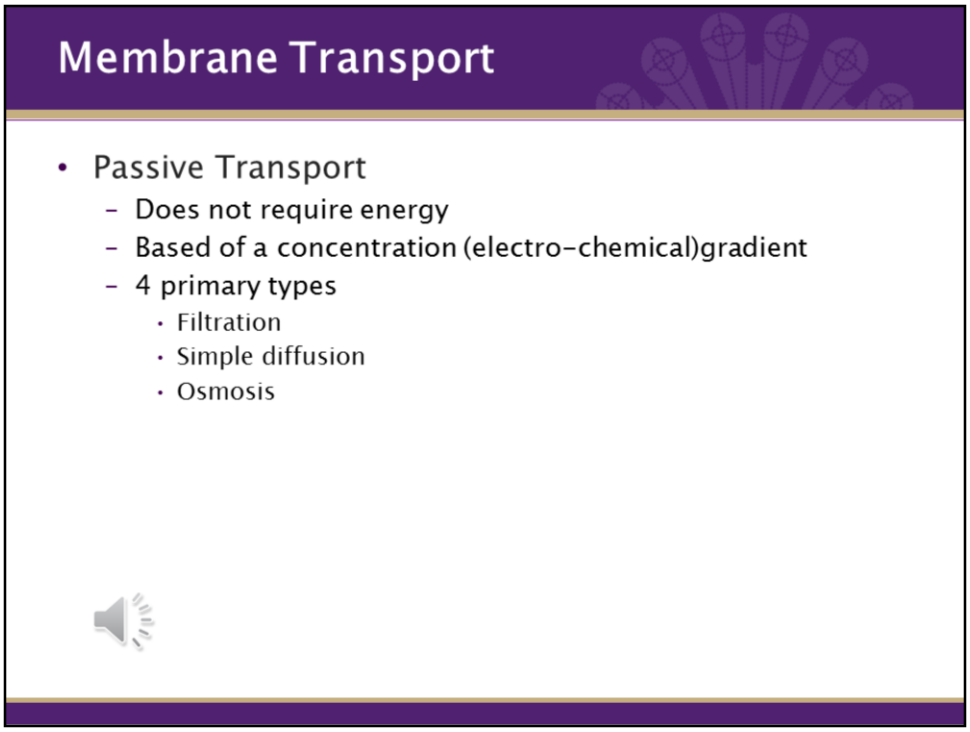


Here is our phospholipid. The round hydrophilic head is formed of phosphates (hence the name phospho) and the tails are made of fatty acids.



Here is a diagram of the entire membrane. You can see the cholesterols and proteins. Also, notice that the phosphate heads form the internal and external surfaces. The surfaces will come into contact with water. Since the heads are hydrophilic and attracted to water, they line up on the outside and the tails being hydrophobic face the middle of the bi-layer.

As mentioned, due to the membrane structure, somethings pass more easily than others. Small particles such as water, oxygen, and carbon dioxide can slip between the phospholipids without any problem. Also, nonpolar (like carbon dioxide) and hydrophobic (like many lipids) molecules can pass between the phospholipids as well. Think a like “dissolves” like kind of concept. Substances that are more similar to phospholipids will meld into the membrane and pass through more easily than substances that are different. Substances that have a harder time passing through can be large in size, have a charge or are hydrophilic. These molecules will need the help of channels or carrier proteins to get into the cell.



Membrane transport is one of the most important functions of the membrane. Recall, cell membranes are selectively permeable. Meaning, they are the gatekeepers into and out of the cell and only allow certain items to pass.

There are two ways we can categorize membrane transport: passive transport and carrier-mediated transport.

Passive Transport does not require ATP (energy). There are a few types of passive transport we need to think about.

1. Filtration is transport that uses hydrostatic pressure to move particles. Pressure from water drives water and particles across membrane, it works like a coffee maker.

2. Simple Diffusion is the movement of particles down the concentration gradient. This is movement from high to low concentration. Think about what happens when someone sprays perfume. It is rather potent right away near the site where it was sprayed, but give it a few moments and the scent will diffuse throughout the room. Diffusion is effected by a number factors.

a. Temperature: increase the temp and you will increase the rate of diffusion (think of scented candles, the sent is stronger and travels further when you light the candle)

b. Molecular weight: heavy particles don't move as fast

c. Steepness of gradient: if there isn't much difference between point a and point b, diffusion will be slower

d. Membrane Surface area: the larger the surface area, the more places there are for diffusion to occur

e. Membrane Permeability: some substances can pass easier than others based on their chemical composition

3. Osmosis is diffusion of water. It follows the same principles of simple diffusion and moves water down the concentration gradient.

Membrane Transport Con'td

- Carrier-mediated transport
  - Requires assistance to move substances
- There are two types we are going to talk about:

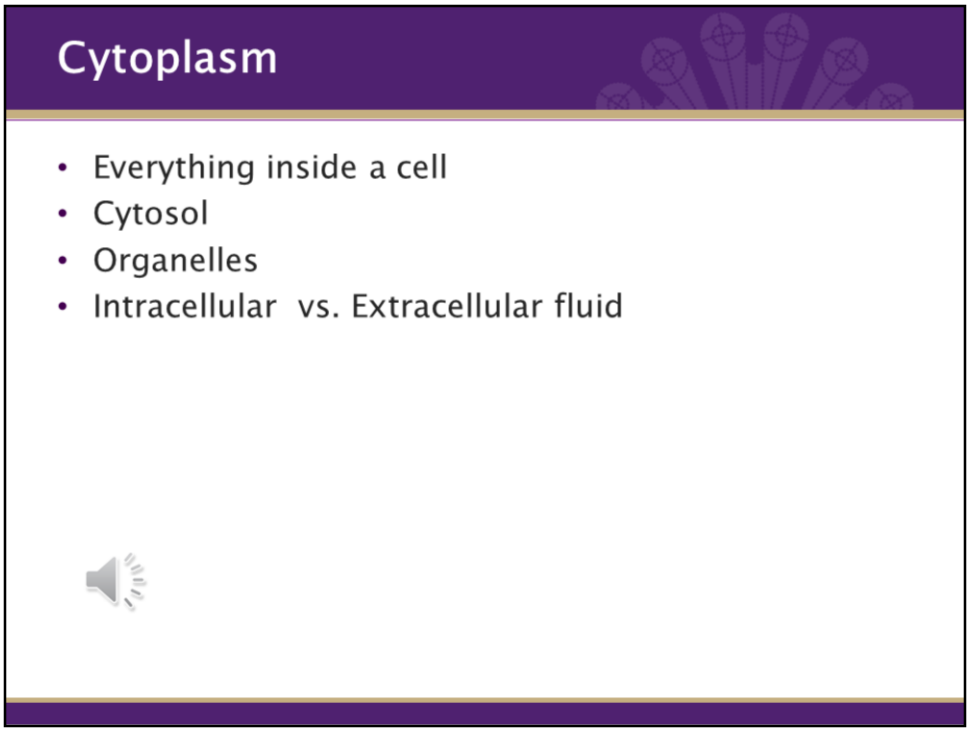
1. Facilitate Diffusion
   - Diffusion of large substances
   - Passive transport
   - Proteins to assist the movement of large substances
2. Active Transport
   - Requires ATP!!!!!!!!!!!
   - Usually moves AGAINST a concentration gradient (low to high).
   - Example: Sodium-Potassium Pump

The next category, carrier-mediated transport, is employed when substances need assistance to move across the membrane. There are two types we are going to focus on.

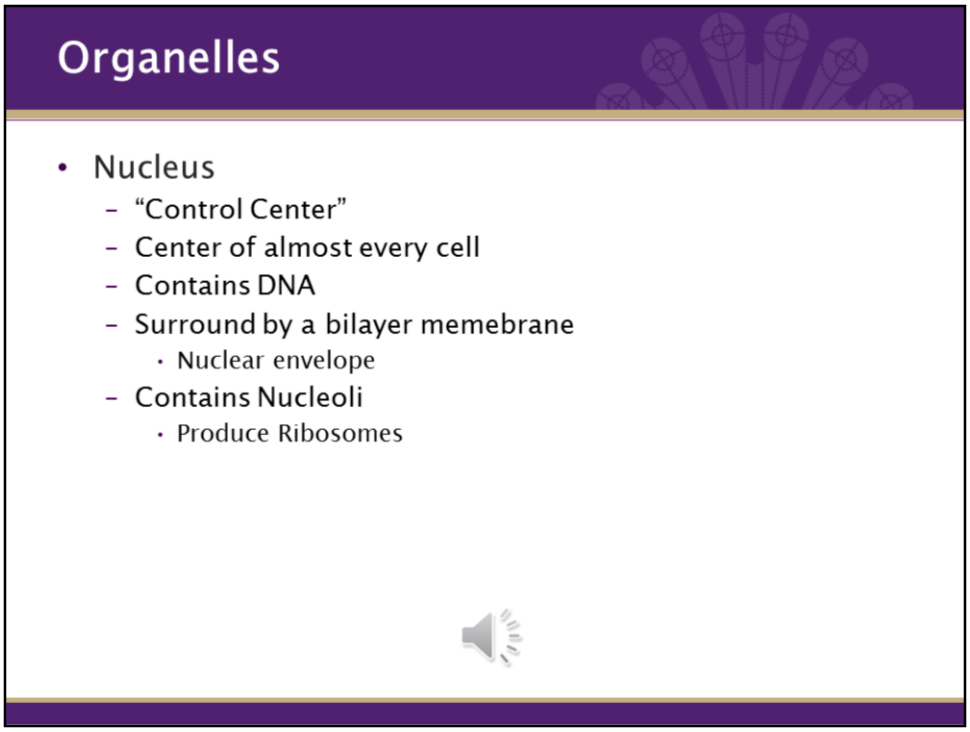
The first is facilitated diffusion. Some particles are too large to flow across the membrane without help, so the membrane employs proteins to help these particles move across the membrane. This movement is still down the concentration gradient, from high to low. I always think of this type of transport as like cross walk guards. They help shuttle people, or particles, from one side to the other. This type of carrier-mediated transport is passive, or does not require energy.

Active Transport is the second category of carrier-mediated membrane transport. It requires the use ATP, or energy, to move particles across the membrane. It is also moving the particles against the concentration gradient, or from low to high. It is kind of like trying to paddle a canoe up stream. If you do not put some energy into it, you are not going to go anywhere. One example is that of the Sodium-Potassium Pump. We are going to go into detail on how this works when we discuss nerve impulses, but for now just now that it is an example of active transport and requires ATP.

This video gives a quick review of the structure of the cell membrane, osmosis, and active transport.



As mentioned, cytoplasm is all the stuff inside a cell. There is the cytosol and the organelles. The cytosol is the fluid everything floats in, sometimes referred to as intracellular fluid (ICF). This is compared to extracellular fluid (ECF), or all the fluid outside of the cell. There are also the organelles, the small, organ like structures of the cell. Combined, I think of them as jello salad. They cytosol is the jello, the organelles are the bits of fruits and nuts, together the whole salad is the cytoplasm.



The first organelle to discuss is the nucleus. I think of the nucleus as the control center. It is the center of the cell and holds the DNA, or the blue prints for our bodies. The nucleus is also surrounded by a bi-layer membrane, similar to the plasma membrane, called the nuclear envelope. The nucleus also contains nucleoli, which produce ribosomes. We'll talk about ribosomes shortly.

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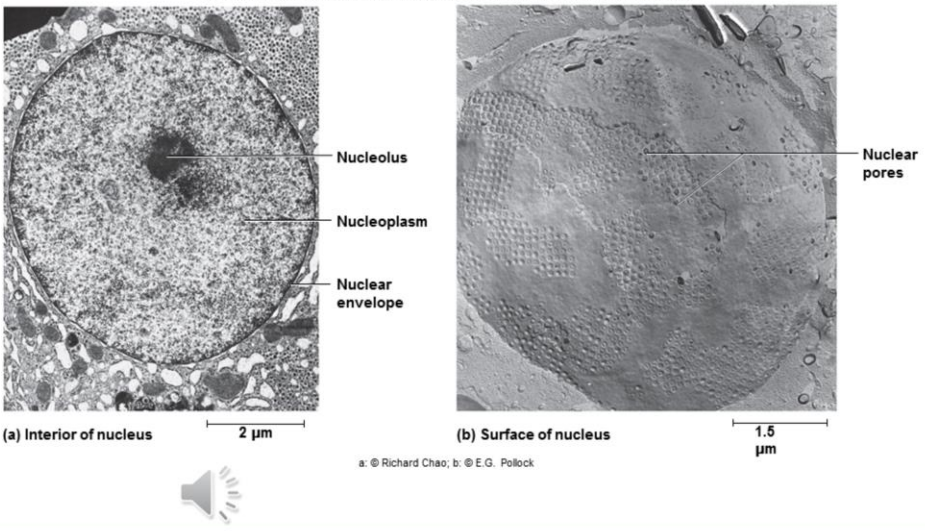
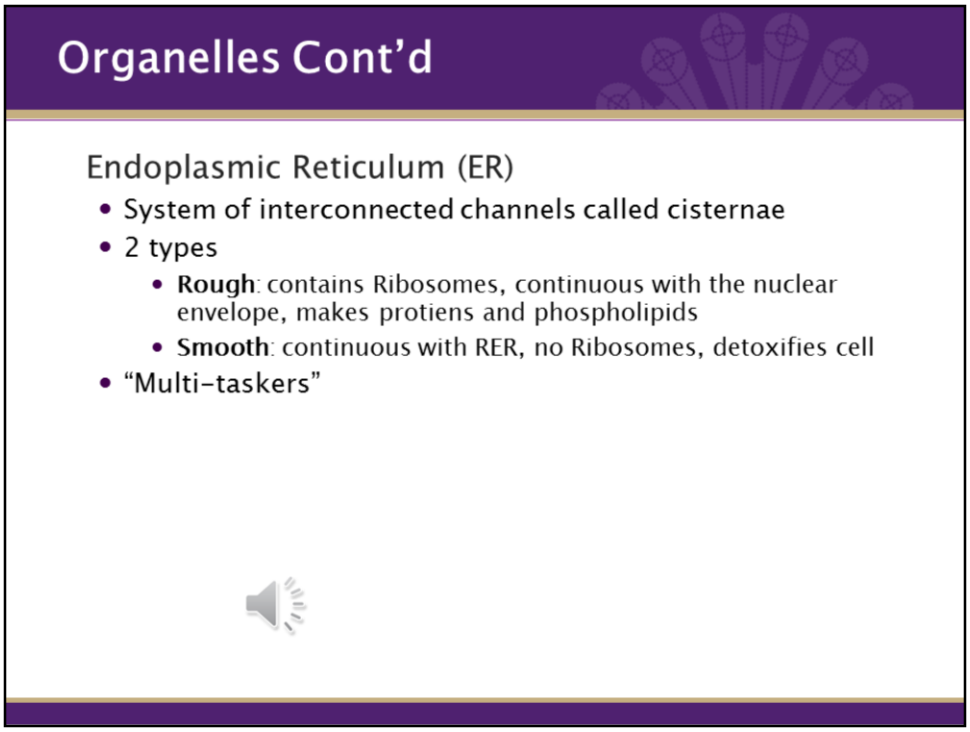


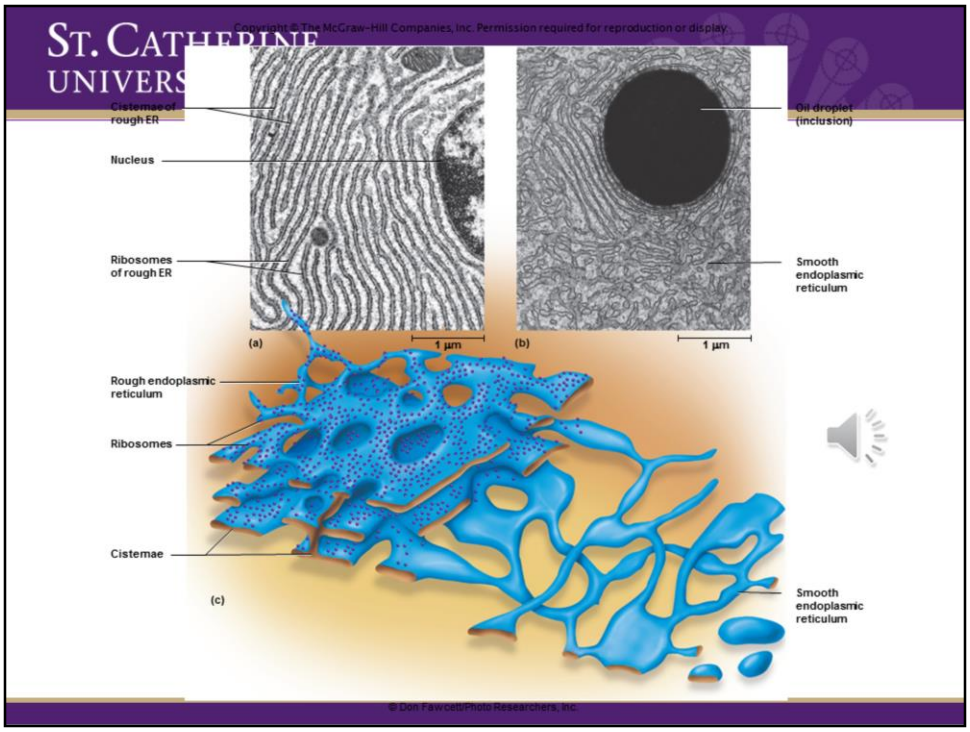
In this picture we can see the nucleus and the nuclear envelope that surrounds it. We can also see the nucleolus (singular for nucleoli), it is the darker dense dot in the middle of the nucleus.



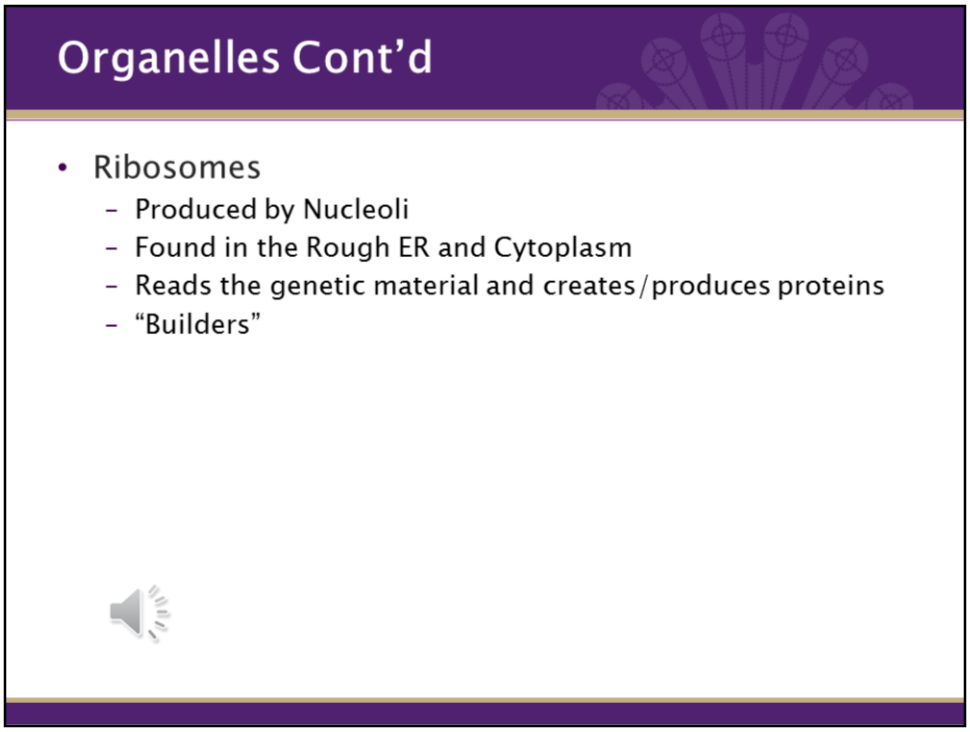
The next organelle is the Endoplasmic Reticulum. They are a system of interconnect channels called cisternae.

There are two segments of the ER, Rough and Smooth. Rough ER is continuous with the nuclear envelope and primarily responsible for making proteins and phospholipids and contains Ribosomes. The smooth ER is still a continuous tube with the rough, but functions more in the detoxifying aspect of the ER's roles and does not have ribosomes.

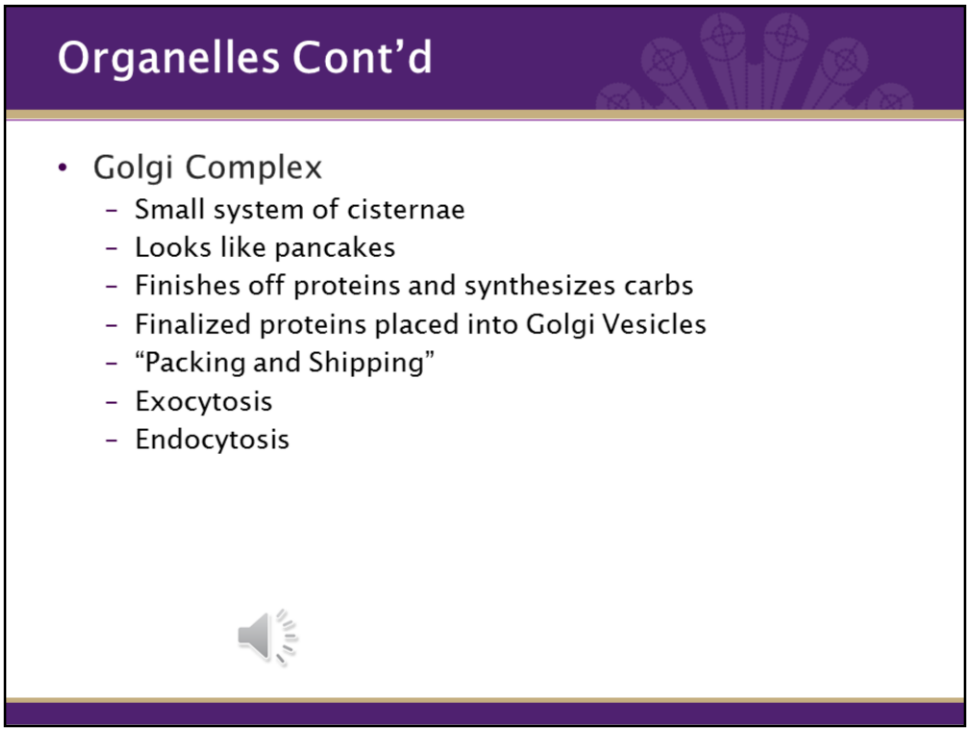
Combined, I think of the ER as the multi-taskers of the cell.



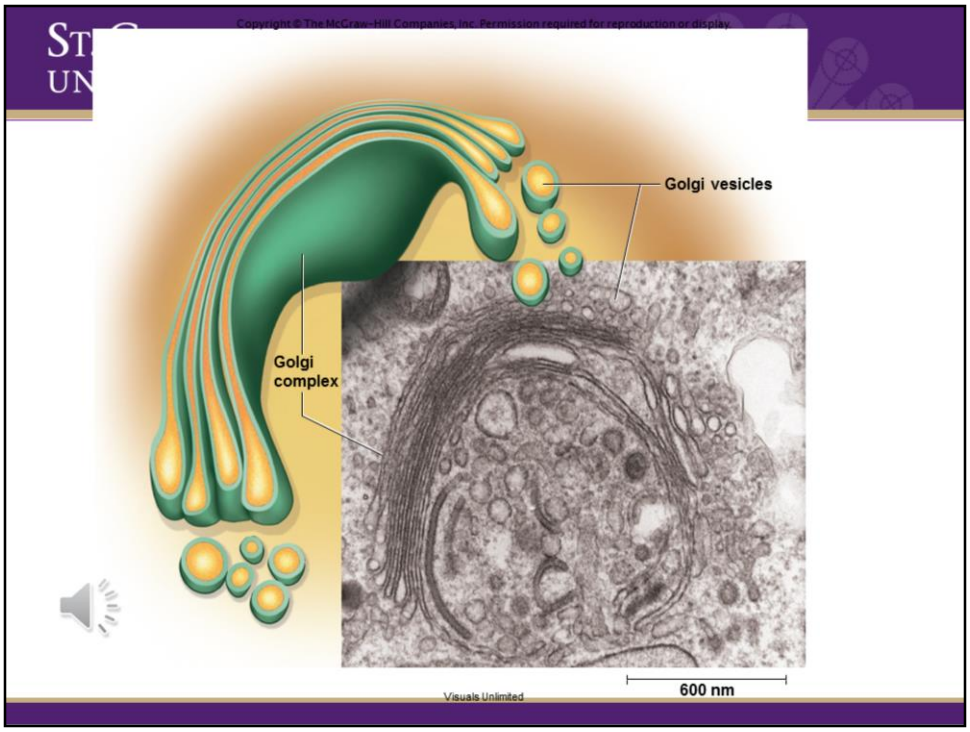
This is the picture of our smooth and rough er. All the little dots are the ribosomes and visually distinguish the rough from the smooth.



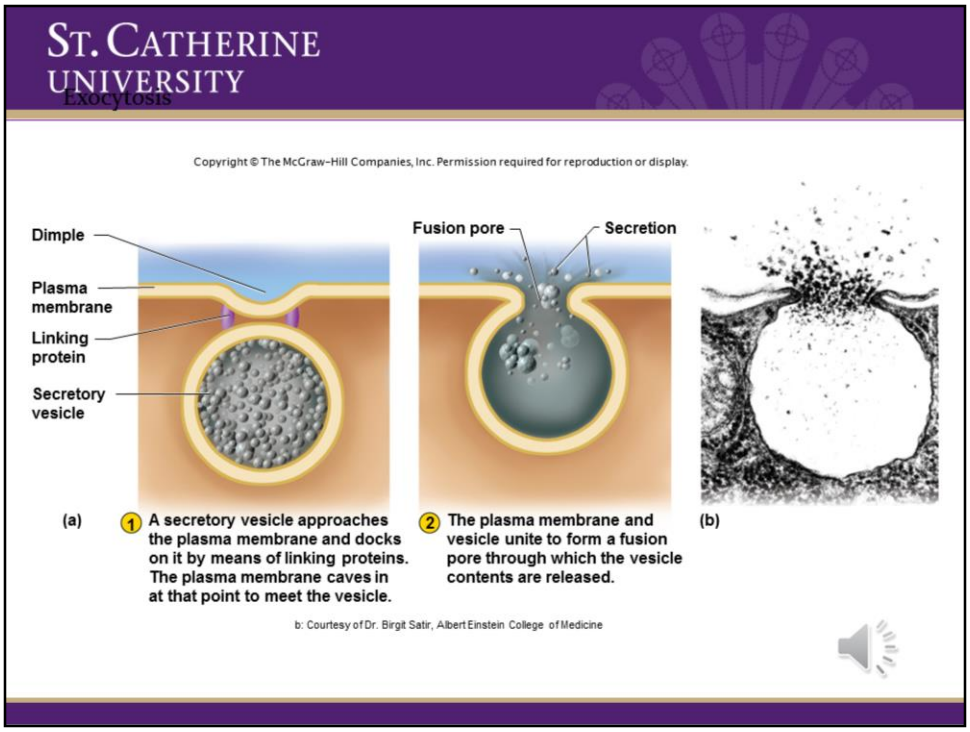
Finally, we come to the Ribosomes that keep coming up. Recall, they are produced by the nucleolus, but found in the rough ER and cytoplasm. They read genetic material and produce proteins based on the specific segment of code that is read. I think of the ribosomes as the Builders.



The Golgi Complex are a system of cisternae, like the ER, but smaller. They look like a stack of pancakes.
Their job is to finish off proteins and synthesize carbohydrates. When the proteins are finalized, they get put into golgi vesicles and migrate throughout the cell. The vesicles look like little bubbles and help transport substances. The vesicles can also help transport stuff into and out of the cell through exocytosis and endocytosis.



Here is your golgi complex and vesicles.



This slide is showing exocytosis by the vesicles. Exocytosis is when vesicles fuse to the plasma membrane and release their contents outside of cell.

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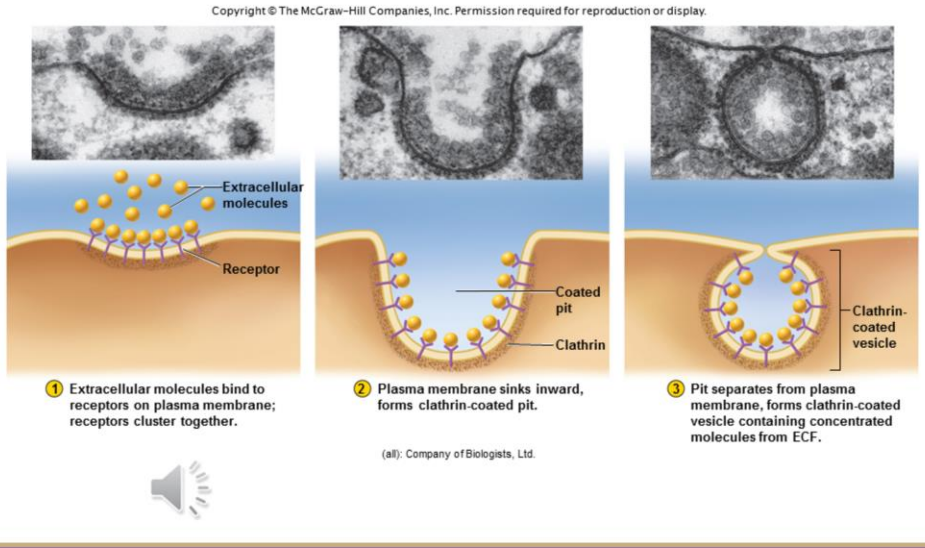
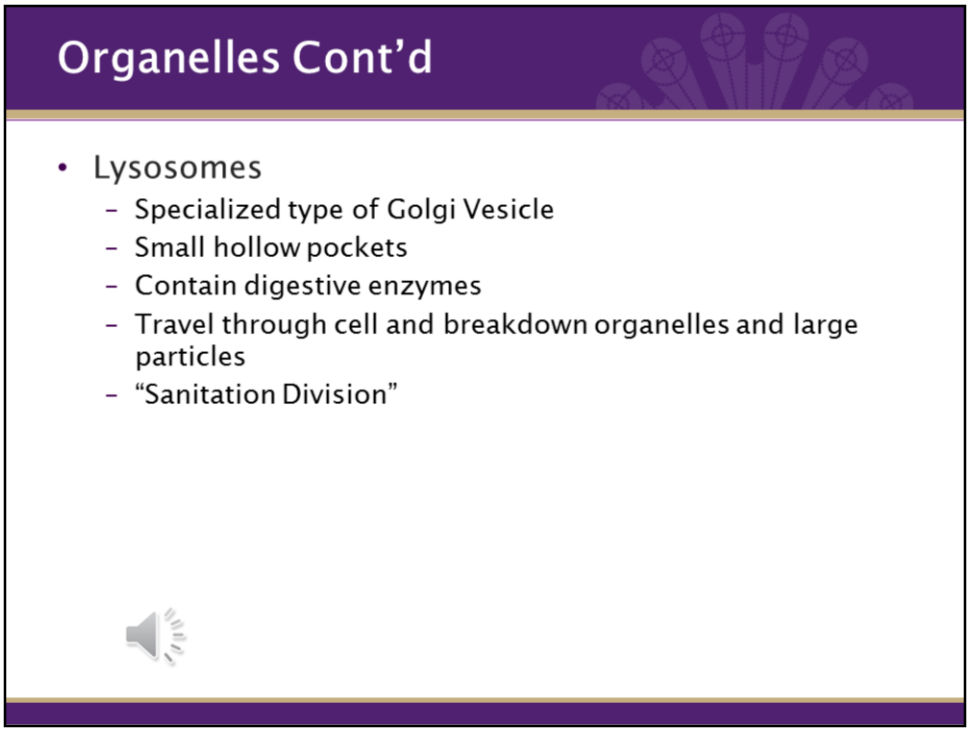
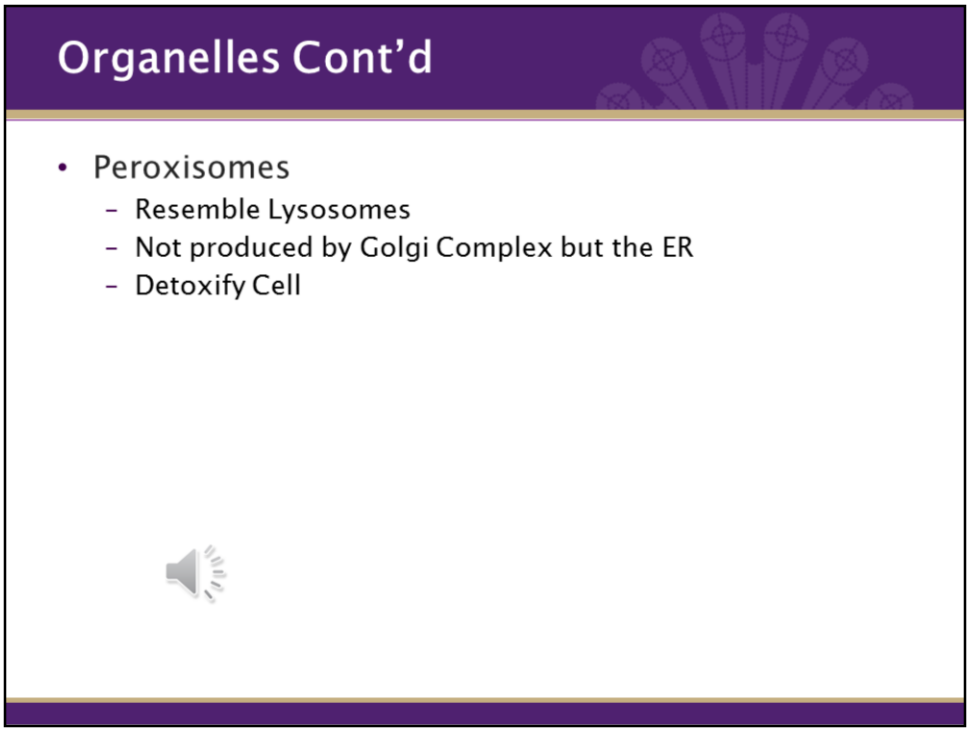
Endocytosis



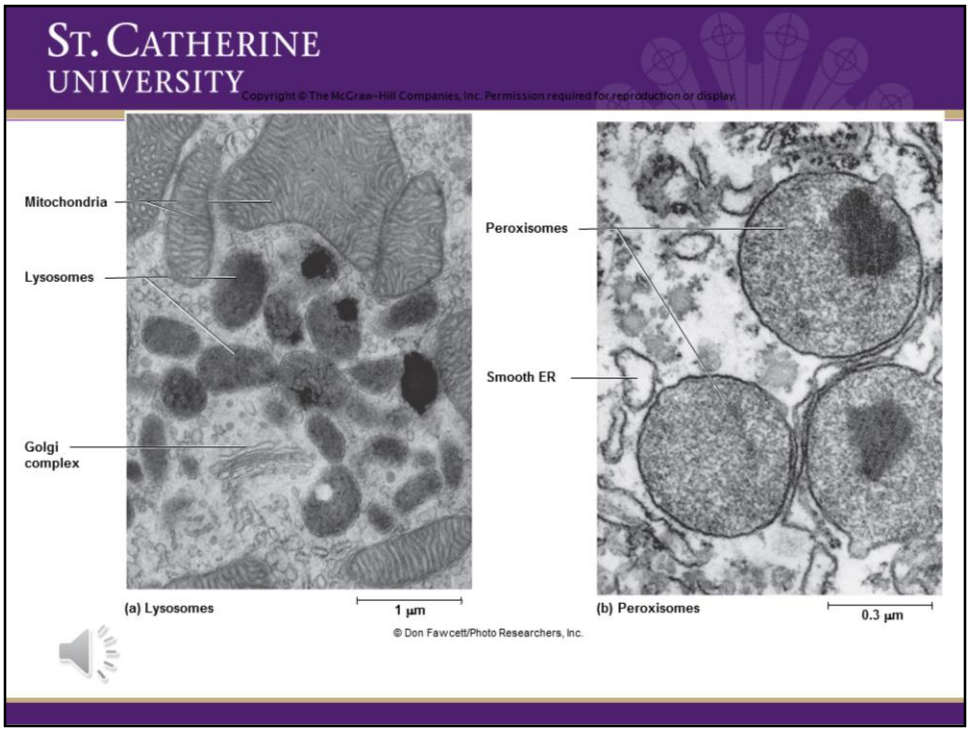
This slide is showing endocytosis. Endocytosis is when the membrane forms a vesicle of its own around an object or ECF and brings it into the cell. The membrane folds in and pinches off to create the vesicle to pull in the extracellular molecules.



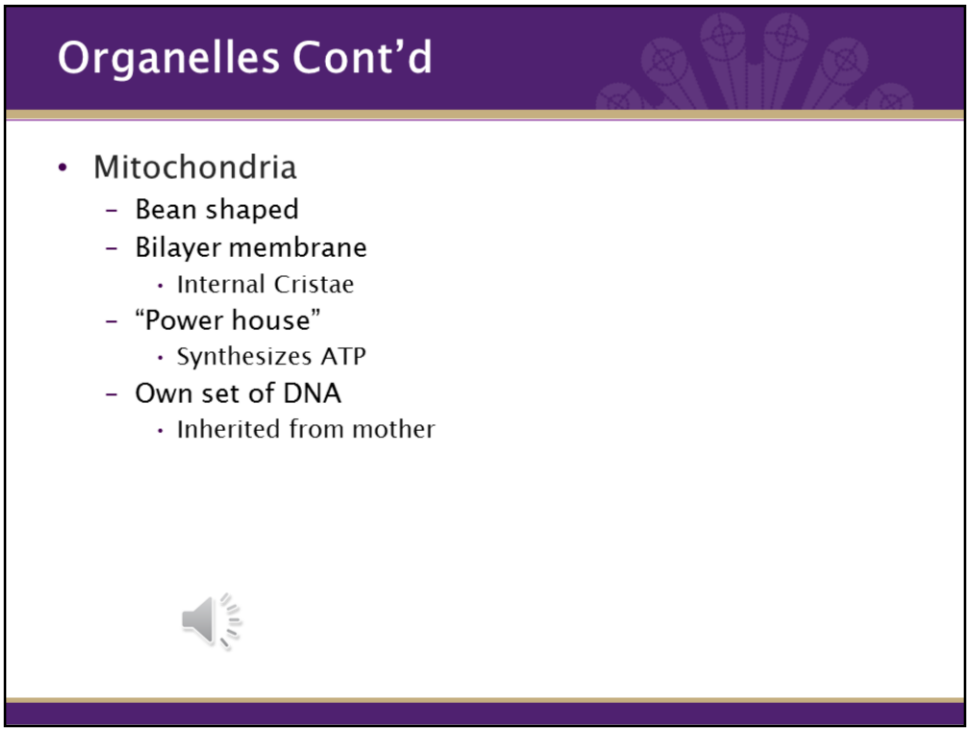
Lysosomes are a specialized type of golgi vesicle that travel around the cell and break down organelles and particles. White blood cells use them to break down bacteria inside the cell and liver cells uses them to release stored glucose into the blood. They are small pockets, or bubble like structures, and contain digestive enzymes (about 50 different types) to break down the various types of materials they encounter.



Peroxisomes resemble lysosomes but are not produced by the golgi complex, but the ER. They detoxify cells by producing hydrogen peroxide to breakdown particles.

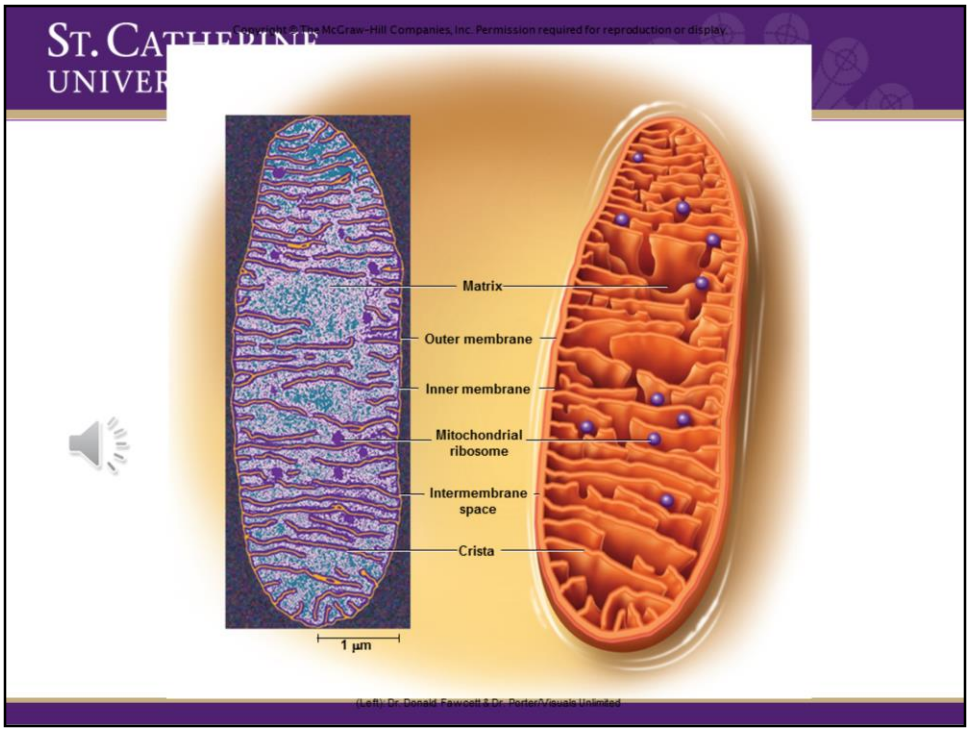


Here we have our lysosomes and peroxisomes.



Mitochondria are bean shaped organelles that have internal cristae (internal folds of the mitochondrial membrane which is also a bi-layer membrane). Their job is to synthesizes ATP. They produce the energy molecule that is used by cells. I think of them like a coal factory. The factory is processing and packaging coal, but they are not burning or using it. The same goes for the mitochondria. They are producing the ATP, but other parts of the cell are using it as energy. Because they produce the ATP, they are often referred to as the power house of the cell.

Mitochondria also have their own DNA. It is a small ring of DNA and is passed on from mother to child. So you can trace maternal lineages with mitochondrial DNA. One theory regarding why mitochondria has its own DNA is that it was once a single-celled organism that become incorporated into the cell and now functions only as an organelle.

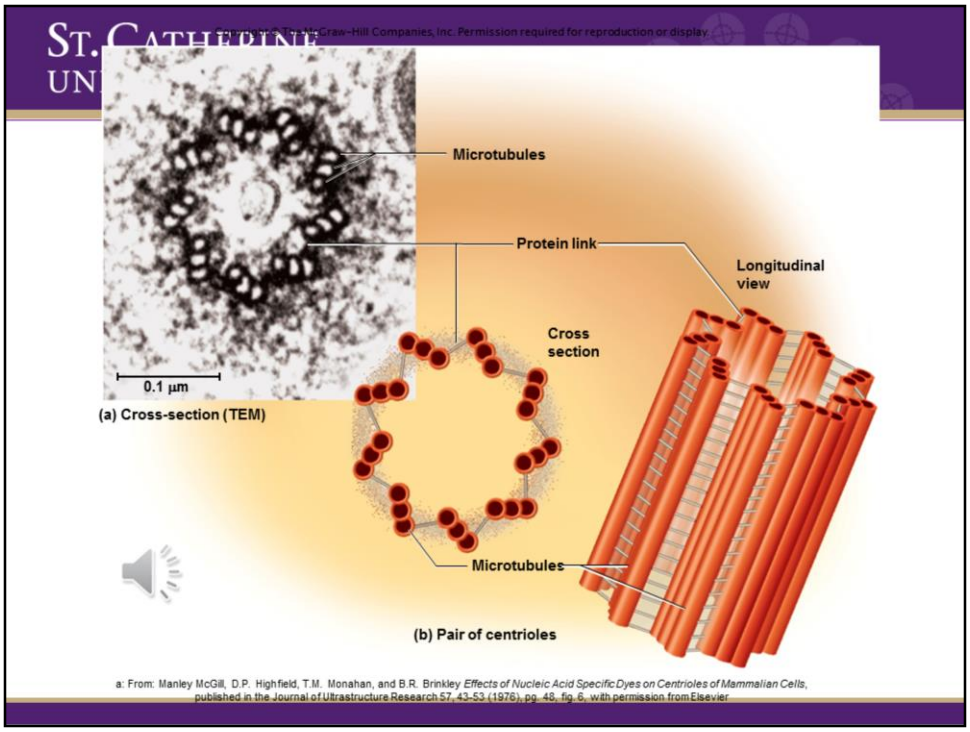


Here is your mitochondria. You may notice that there are ribosomes also found in mitochondria. Since mitochondria have their own DNA, they need their own ribosomes to read it and produce the corresponding proteins

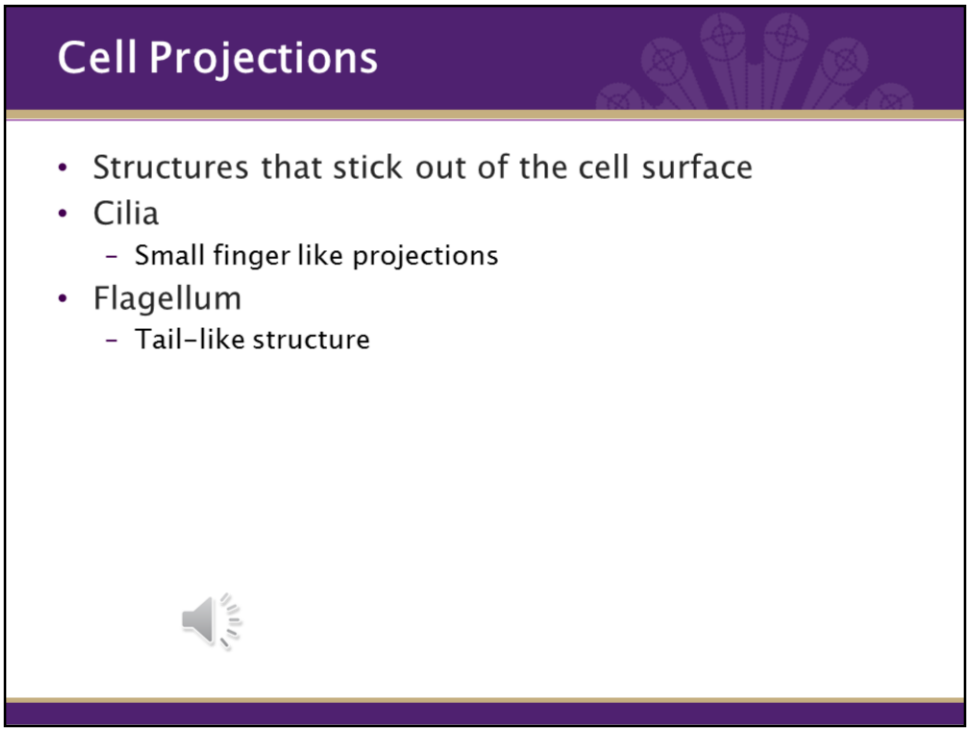
Organelles Cont'd

- Centrioles
  - Short cylindrical assembly of microtubles
  - 2 perpendicular to one another
  - Used in cell division

Centrioles are short cylindrical assembly of microtubules (proteins rods). There are two per cell and they lie perpendicular to each other. They are used in cell division.



In this picture, you can see the centrioles. Recall that they are perpendicular to each other. That is why you see the long side of one and the opening top of the other. The top opening looks star shaped and as if you are looking down a paper towel tube.



A variety of projections can also be found sticking out of the cell surface. Cilia are the most common and are small finger like projections. Flagellum are projections also found on the cell surface. They are a tail-like structure. Sperm are an example of cells that have flagellum.

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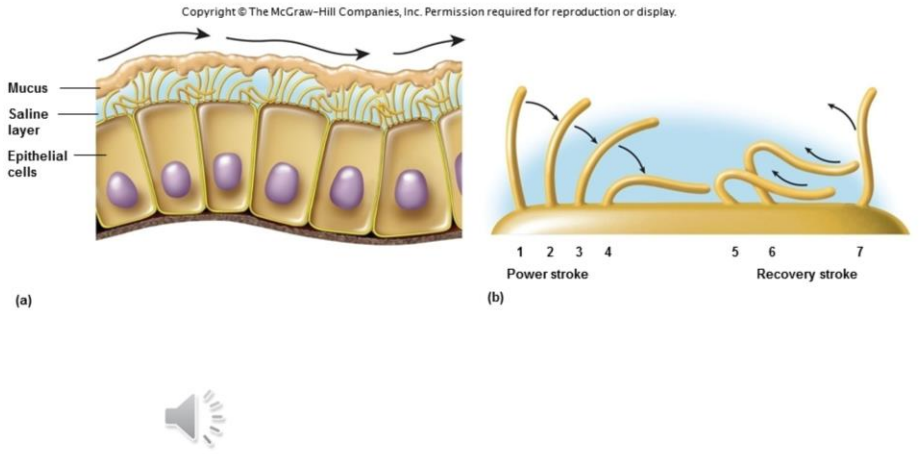
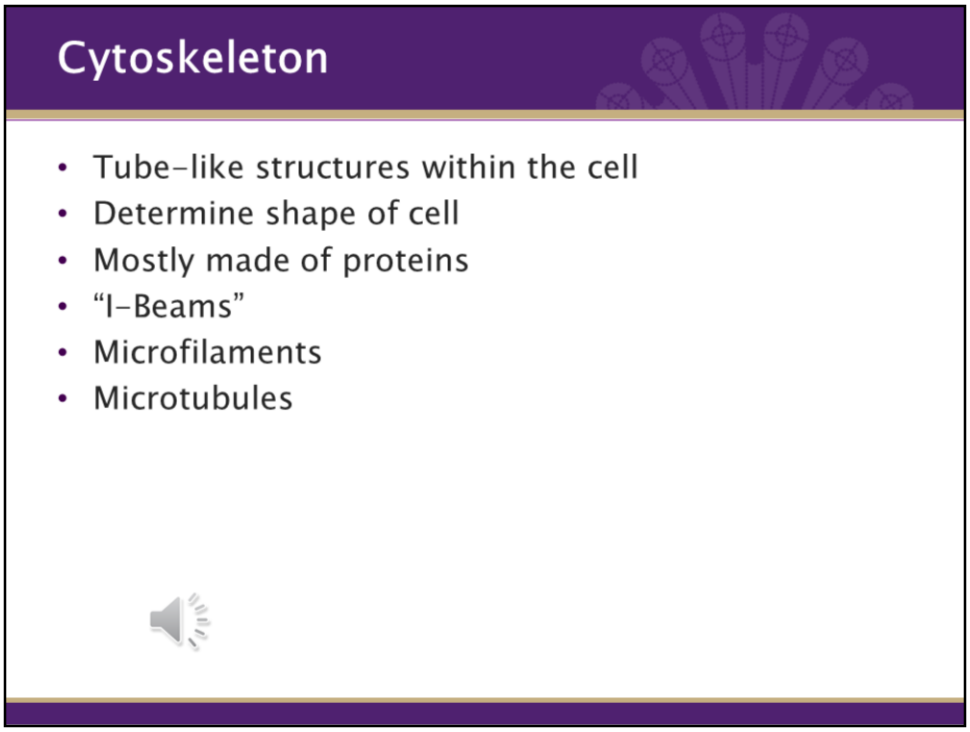
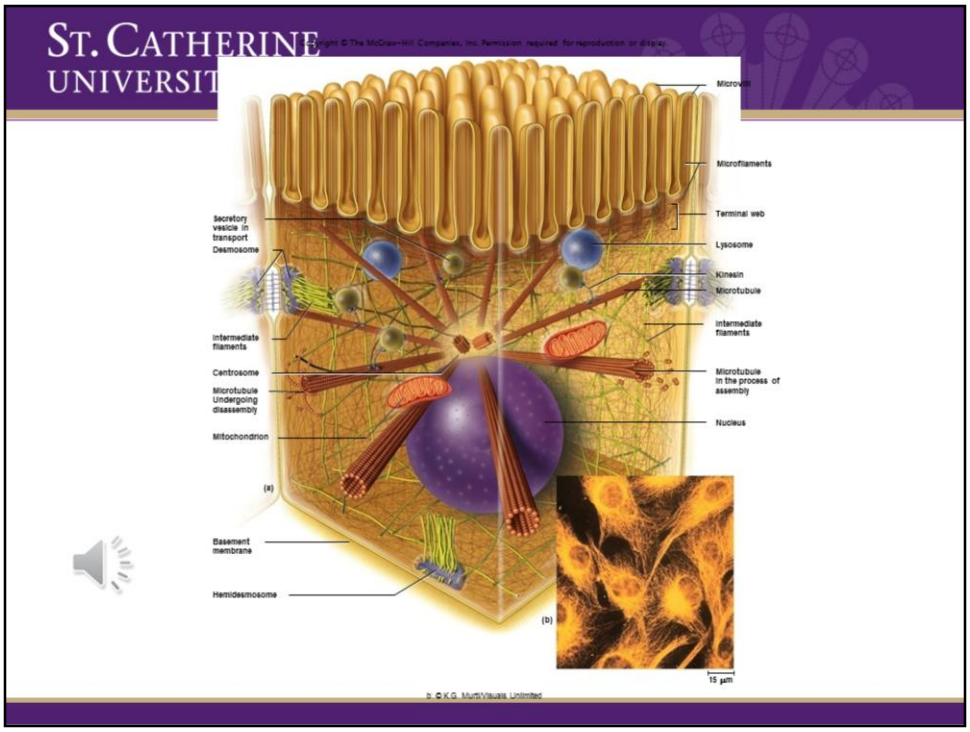


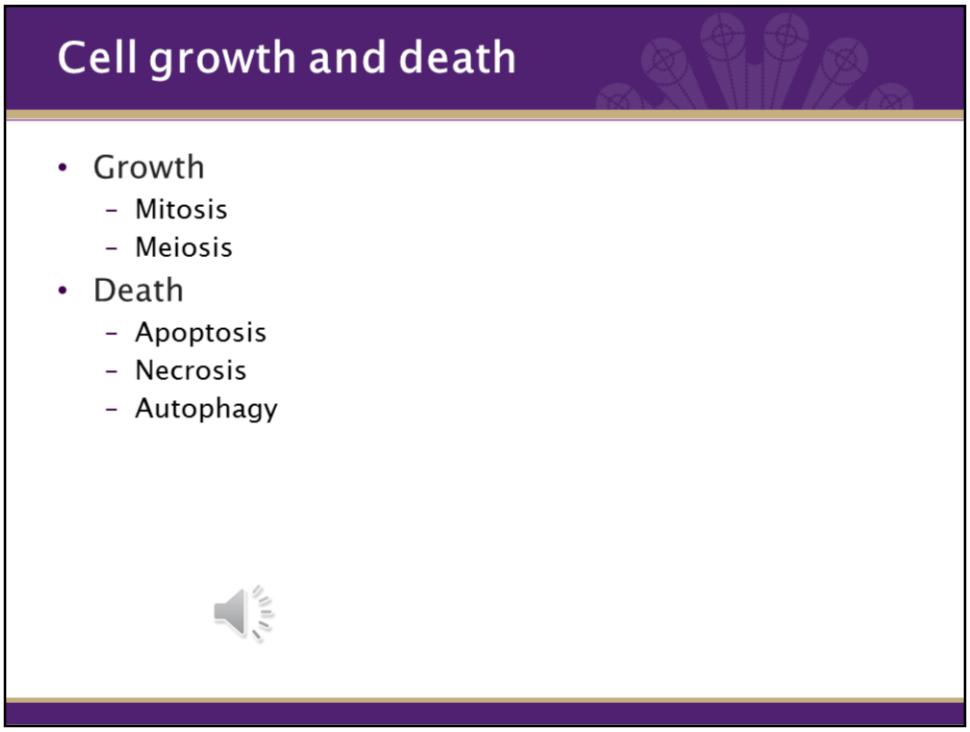
The cilia help to move mucus and particles along and work in a wave like function.



The cytoskeleton is a network of tube-like structures within the cell. They determine the shape, provide support, organize the cell, and aid in movement of motile cells. I think of them like the I-beams of the cell. They are mostly made of proteins. There are two types, microfilaments and microtubules.
Microfilaments form a skeleton like structure for the membrane and Microtubules are a protein cylinder that maintains the shape and rigidity of the cell and aids in cell division



If you look closely, you can see the microfilaments in the internal folds of the plasma membrane. The microtubules are the bigger, longer tubes of proteins radiating out of the center of the cell.



There are a few terms regarding cell growth and death that you need to be aware of. Mitosis is basic cell growth. After mitosis, you will have two identical cells. Meiosis is cell division that results in sperm and egg. We'll talk more about this during the reproduction chapters.

There are a few types of cell death. Apoptosis is programmed cell death, or the natural death of cell. Cells, like all living things, have a specific life span. Different types of cells will have different life spans. Necrosis is cell death due to trauma or infection. This is pathological and not part of the normal cellular life span. Autophagy is the break down of cellular components. For instance, when a lysosome will break down a mitochondria.