We are going to talk about the plasma membrane, the components of the cytoskeleton, the organelles, and introduce the different types of membrane transportation. We will review membrane fluidity, fluid mosaic model, and cell theory.

Heeeey!

I'm going to start this episode with a little story. When I decided I was going to be crazy and start this podcast, I was trying to think of a name for it, and I came up with the name Cellfie Life. I was running it by my best friend who is a social media manager. She does social media for a living, and she wasn't exactly a fan of the name because she thought it sounded like a prison podcast, which is not at all what I was going for, but I was excited and proceeded to tell her all about Robert Hooke.

Robert Hooke was looking through a microscope at a desiccated cork, and he thought that it looked like the little cells that the monks slept in, and so he used the word "cells" for what he saw through the microscope.

I was thrilled to be able to share the connection between the two types of cells with my bestie. My friend wasn't particularly entertained, but, nonetheless, welcome to the Cellfie Life! I am very excited this episode is on cells—kinda its namesake.

Robert Hooke - Biography, Facts and Pictures

Before we jump in, I want to thank you for listening. Please subscribe, and if you're going to find the script notes, you can find them on the website at cellfielife.com.

I also want to give a special thanks to Emily, and Abby, they messaged me on insta earlier this week about the podcast. It honestly meant so much that you guys contacted me. I told Emily that I usually just feel like a crazy person sitting in my closet talking to myself, so it's really nice when people reach out and give me feedback. So thanks, ladies.

Okay, let's just dig in today.

Eukaryotes

We will specifically be reviewing eukaryotes today. So, we, as humans, have a lot of cells, so it makes sense that we have an understanding of how they are organized and how they communicate and react.

Pop quiz from the last episode:
***Q*:** What is the main difference between prokaryotes and eukaryotes?
***A*:** Prokaryotes don't have membrane-bound organelles, and eukaryotes have membrane-bound organelles.

Another difference between the two is that prokaryotes are always going to be single-celled organisms where eukaryotes can be unicellular or multicellular with multicellular organisms, such as ourselves. Eukaryotes can form tissues and have a division of labor between the cells. This means that cells will be specialized with form following function.

Some cells might need more mitochondria or have more of a rough ER, depending on what type of work they are specialized in performing. I want to mention here that there are *four* types of tissue: *nervous, muscle, connective,* and *epithelial*. We won't be covering tissue in this episode, but I wanted to mention the types since we talked about eukaryotes being multicellular organisms and forming tissues.

When I was first learning all the science stuff, I really had a hard time keeping the cell types associated with the right name. I switched majors from creative writing to biology, so the change was a big one. Anyway, I was having a hard time keeping prokaryotes and eukaryotes associated with the correct types of cells. I knew that one was the cell with membrane-bound organelles, and the other was the one that didn't have membrane-bound organelles.

So, of course, I turned to my root words.

So “karyon” is essentially the Greek word for “nut” and “eu” is the word for "well." So, Eukaryotes are well-nutted. I know, I know. I'll let you insert the dirty joke. But, it makes sense the old school scientists were looking at these cells for the first time, and they see that they have well-formed kernels, (as in the nucleus) so that's what they called them. Eukaryotes have membrane-bound organelles.

I'm going to say that again. Eukaryotes, well-nutted, have membrane-bound organelles and contain a true nucleus.

Let's start from the outside of the cell and work our way in; Starting with the membrane.

Membranes

Membranes are responsible for some crucial things.
They define cellular boundaries; provide intracellular boundaries like the mitochondria and the nucleus. Remember, we are talking about eukaryotes that have membrane-bound organelles, so these lipid membranes can be found around the nucleus and lysosomes and other organelles. These membranes organize the cell and contain chemicals. They also regulate the flow of information and transport things into the cell.

One more time.

They:

- ➔ Define cellular boundaries
- ➔ Provide intracellular boundaries like the mitochondria and the nucleus.
- ➔ Organize complex reactions, receptors, ion channels, for example.
- ➔ Regulate the flow of information
- ➔ [Have] dynamic structures.

Components of Cell Membrane

Starting with the components of the cell membrane.

Pop quiz
Q: What are the 3 main components that make up the cell membrane? (this is a quiz question)
A:

1. Phospholipid bilayer
2. Cholesterol
3. Proteins

Let's review each starting with the phospholipid bilayer, which also has three parts:

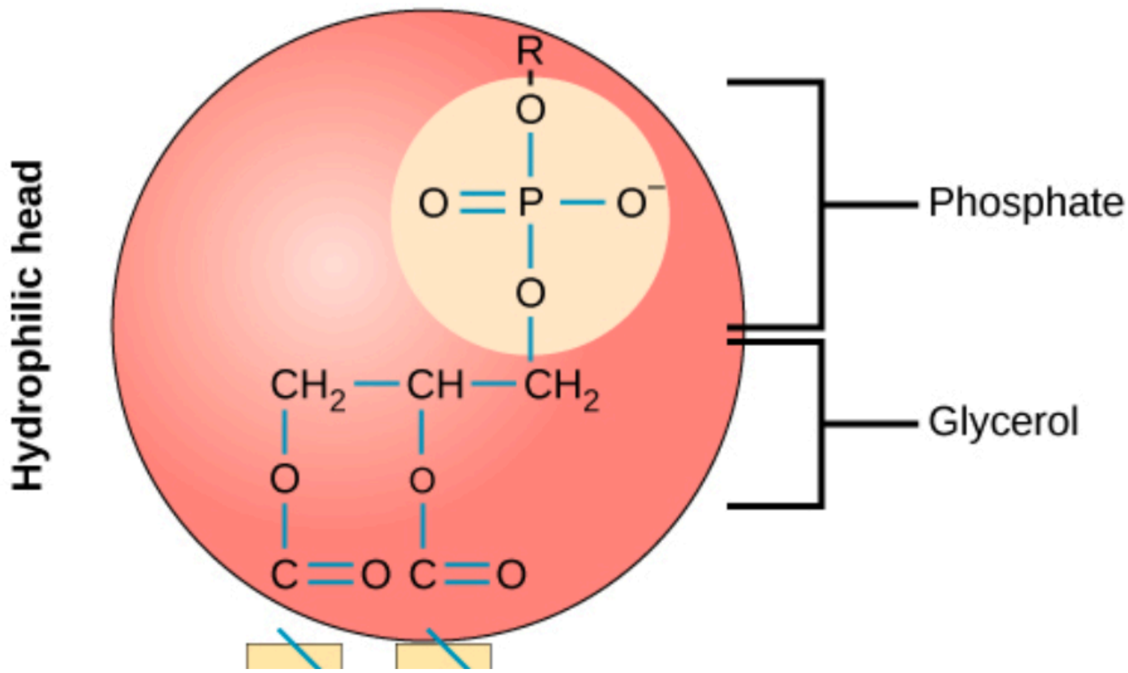
1. Phosphate head
2. Glycerol backbone
3. Fatty acid tails

I'm sure you have seen the phospholipids sketched-out. They look like a stick figure that is only a head with two legs sticking out. I always kinda envisioned it like a jellyfish with only two tentacles hanging down, or, it could be a balloon with two streamers. Pick your phospholipid poison.

@Nikaela +++drawing of phospholipid poison

So, the head is the phosphate head. It literally is called a head, so this should be easy to remember. And, [the head] is hydrophilic. It loves water and, remember, water is polar, and the phosphate heads can carry a charge, so it makes sense.

What does a phosphate head look like? What is its chemical structure? It is a phosphate surrounded by four oxygens. And, what do you know about oxygen and water? Oxygen and hydrogen are what make up water and that oxygen is 1 of 3 elements that can form hydrogen bonds. So, these phosphate heads *LOVE WATER*!



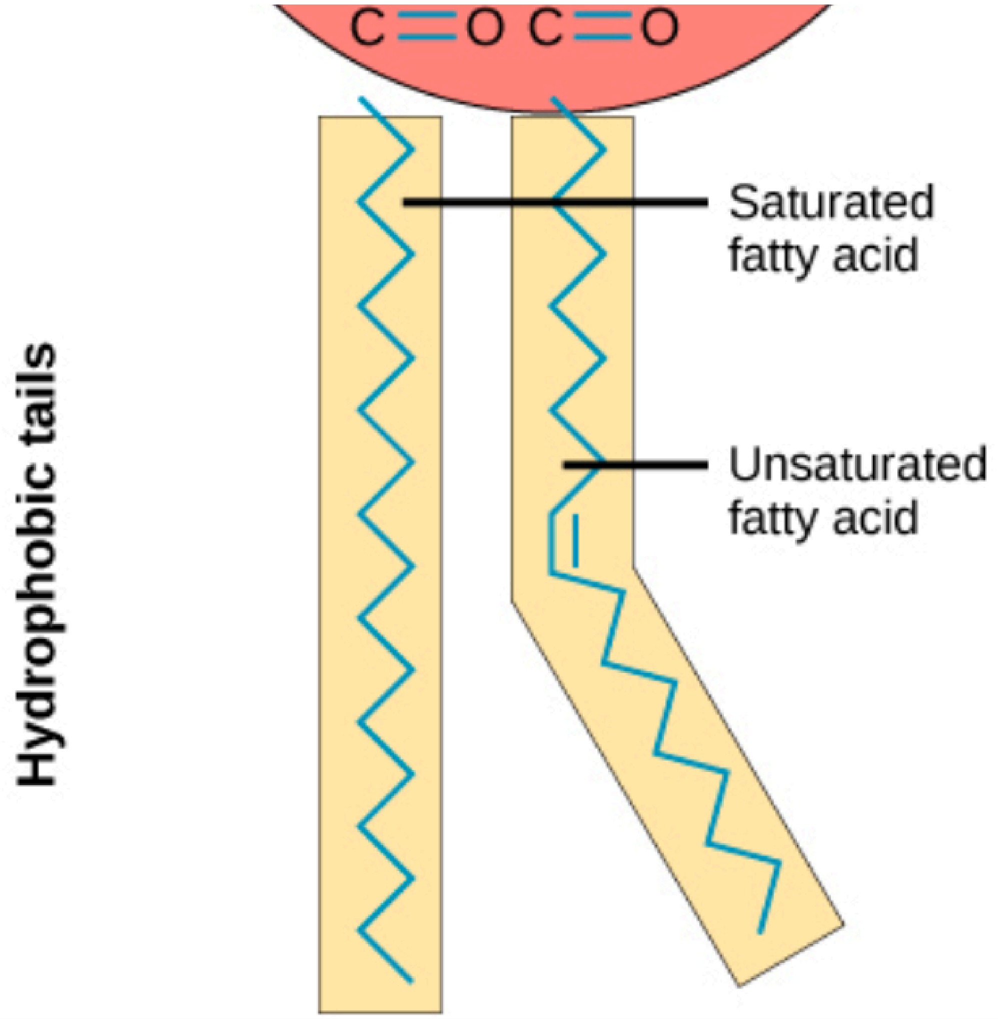
https://courses.lumenlearning.com/introchem/chapter/phospholipids/

So, you have the hydrophilic phosphate head, and then you have the glycerol backbone, which attaches the fatty acid tails to the phosphate head. I like that they appropriately named the glycerol "the backbone." It's the backbone: it holds it all together. It connects the head to the rest of the body.

Attached to the backbone are the fatty acid tails. The tails are hydrophobic—"phobic" as in *fear*—like arachnophobia, fear of spiders.

Or, this one is one of my favorites, arachibutyrophobia, which is the fear of peanut butter sticking to the roof of your mouth. I Googled that one. You're welcome.

Back to plasma membranes. So, we have two layers of these phospholipids with the hydrophobic tails facing in towards one another with the phosphate heads facing the water (A.K.A. the extracellular and intracellular fluids).



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If you forget which is hydrophobic and which is hydrophilic, think about the cell being a water-filled bubble in a pool of water. The part that likes water would be on the outside, interacting with the water, and on the inside.

The phospholipids have a hydrophobic portion and a hydrophilic portion which makes them, what is called, “amphipathic.”

What would be able to pass through the phospholipid bilayer? It is semipermeable. As a rule of thumb, small and nonpolar molecules will be able to pass through.

@Nikaela ********But what about

Quick note: Do you all remember cis and trans bonds from O-Chem?

Quick reminder: A **cis** is a double bond with the attached carbons coming off the same side. So, if it were a scale of some sort, it wouldn't be balanced. **Trans** is when the carbons coming off the double bond are on the opposite sides. Keep this in mind when we talk about membrane dynamics. But, first, we are going to talk about the other two main components of cell membranes: cholesterol and proteins.

And, there are actually carbohydrates or glyco's that attach to proteins (e.g. “glycoproteins”) or lipids (e.g. “glycolipids”), and, these play a huge role in communication.

Cholesterol

Okay, so, cholesterol in the membrane helps to maintain fluidity. It really works to keep the cell in a happy, chill state. So, what keeps you in your chill state? Is it by chance a food, a food that is high in cholesterol? For me, it’s sweet potato fries.

Proteins

Two groups of proteins are in the cell membrane: Integral proteins and peripheral proteins.

Integral proteins, or, transmembrane proteins, go throughout the membrane. They're *integrated* into the membrane.

Peripheral proteins sit on the periphery. So, they are on top, or just *slightly* into the membrane.

Integral proteins are often used to transport things in and out of the cells. They are *integrated* into the membrane.

There are two types of transport proteins:

1. Channel
2. Carrier

These transport proteins are very selective of what is permitted to pass through into the cell.

Channel proteins are exactly what they sound like; they are proteins with holes that go through them, so that things can move into and out of the cell. They are hydrophilic tunnels through which hydrophilic ions and molecules can pass.

Carrier proteins hold on to molecules and change shape in such a way that molecules are shuttled across the membrane. So, carrier proteins are transforming to move things into the cell.

What kind of molecules will be transported through these proteins?

So, to review, our membranes are made of:

- Phospholipid bilayer
- Cholesterol
- Proteins

Now that we have talked about what the outside of the cell membrane has on its surface, let's try to imagine how it might look. To do this, think back to when you were a kid—like kindergarten-age—and you would go to school, and make that macaroni art where you would glue macaroni, and maybe beans and sting to a piece of colored paper. Perhaps you even glued on little triangles of different colored paper. You'd take it home, and your parents would praise you for the mosaic you created.

Now, imagine you are looking down at a cell, but let's make the phospholipid's heads red beans, and the cholesterol is now the string, and the proteins are the macaroni, and the glycoproteins are the paper triangles.

Now, looking down on this cell, it looks pretty close to that mosaic you brought home back in the day. This is the ***fluid mosaic model***. The fluid mosaic model describes the structure of the plasma membrane as a mosaic of components.

The fluid part of the molecule is because there is a lot of potential for movement. Up/down, sideways, back and forth—I think if it as sitting in a wave pool or the ocean with your friends. You're all on floaties and hanging on to one another, so you don't get pulled apart, but overall, you go with the movement.

Three things influence membrane fluidity:

1. ***Temperature***
2. ***Cholesterol***
3. ***Saturation***

Temperature is the easiest. When the temperature decreases, fluidity decreases. When the temperature increases, fluidity increases. This is rather intuitive. Think about coconut oil. When it's cold, that thing is solid. As the temperature increases, the fluidity increases.

Cholesterol is a buffer in the cell membrane. I mentioned earlier it helps to maintain fluidity, but it does this by inserting itself, so that there is space between the lipids. It works to maintain homeostasis in membrane fluidity.

Saturation. Saturation has to do with the bonds of the lipids. If you remember some O-Chem here, double bonds create weird kinks in carbon chains, and fully saturated carbon chains are predictable in pattern. Think of the saturated fatty acid tails as Pringles. Pringles stack very nice and tight in a can because they are all the same shape. This is what happens to the fatty acid tails. They can get packed tightly so that they can't move, and fluidity is low.

[Pringles 'flavor-stacking' back at the Super Bowl with depressed Alexa ad]

Unsaturated fatty acid tails are like the chips that come in bags. They have weird shapes and kinks, so they don't pack as tightly together. Unsaturated fatty acid chains have increased fluidity.

Rosemary-Olive Oil Potato Chips Recipe | Food Network Kitchen

Now, let's talk about how things get through this freaking amazing, and simple yet so complex, membrane.

Random piece of trivia, massive organisms, *like whales*, and tiny organisms, *like ladybugs*, have relatively the same size of cells. I know that that's pretty basic, but I think it's rather cool to think about.

Now, back to how things get through the membrane.

Passive Diffusion
Let's start with passive diffusion.

Passive diffusion means they don't require energy or ATP. When you hear passive diffusion, think movement down the concentration gradient. There are two types of passive diffusion.

1. ***Simple diffusion***
2. ***Facilitated diffusion***

Quick review: Diffusion is simply the spreading out of molecules and downing their concentration gradient until an equilibrium is reached.

Simple diffusion is the simplest type of membrane transport. The solute will move down the concentration gradient across a semipermeable membrane.

Q: What is an example of something that would be able to get through our lipid bilayer?
A: Gases such as O^2 and CO^2 will be able to pass through the layer and will be able to move through it at a relatively fast rate because they are small and non-charged.

Facilitated diffusion. Remember, facilitated diffusion is still a type of passive diffusion; energy isn't required. With facilitated diffusion, we are going to take advantage of some of the proteins we mentioned earlier.

Pop quiz
Q: What were the two types of protein categories we mentioned being associated with the cell membrane?
A: Integral and periphery.
Q: And, with integral proteins, what are the two groups?
A: Channel and carrier.

Facilitated diffusion uses the concentration gradient and proteins to move molecules that have a charge, like $Na+$ or H_2O.

Remember that the phosphate heads, of the phospholipid bilayer, have a charge. The lipid tails don't have a charge and are hydrophobic, so molecules aren't going to easily diffuse through the layers. The channel proteins allow the small charged particles to move down their concentration gradient. The proteins can be gated or just open. We will talk more about this when we talk about the nervous system.

Channel proteins are hydrophilic channels through which hydrophilic molecules can pass.

Carrier proteins hold onto the molecules and transform shape in such a way that they are shuttled across the membrane.

While we are talking about diffusion, let’s review osmosis.

Osmosis & Tonicity
If water is what is moving along the concentration gradient, we have a select name for this osmosis. So, water is diffusing from an area of high water concentration to an area of lower water concentration.

There are three stages of tonicity when comparing different solutions. Here, we are talking about a solute that is not permeable. So, the solute is not able to go through the membrane, and since we want to be doctors, we are going to look at cells in the discussion of tonicity.

Hypertonic. A hypertonic solution contains more non-penetrating solutes than the solution it is being compared against. So if we have a cell that is only permeable to water and we drop it into a solution that is super salty, what is the water going to do? The water from the cell will leave and go into the solution. Which will, in turn, shrivel the cell.

Isotonic. There is no net movement of water. They are equal, or, iso.

Hypotonic. A solution that contains fewer non-penetrating solutes. So, if we drop a cell that is permeable to water, and the cell has a higher concentration of solutes, water will rush in, which can lead to osmotic rupture. I remember these by thinking *hypooo*-tonic is a hippo—a cartoon hippo that is insanely round because of all the water that has gone into him.

Active Transport. Molecules move against the concentration gradient which requires energy. That is super important, so I'm going to repeat it. Active transport is *ALWAYS* required when you are moving something against its concentration gradient.

ATP can bind to a carrier protein which will pump the molecule against the concentration gradient.

Secondary Active Transport is sometimes called *co-transport*, but it is still an active transport, so it will require energy. But, there is no direct coupling with ATP. I think this way of transporting things across the membrane is pretty cool.

Co-transport is a team sport: you can't play unless both are in the game. The actions of person A allows person B to complete their task so that both will win.

Okay, I didn't want to give this example, but this is what came to mind probably because my sister is 10-feet away watching a cop show.

LOL, okay. In a drug deal—on TV!!!—you give one person the money, and they make a call, and then another person shows up and hands you the merchandise. That's cotransport. One person is given the energy, which causes an action that makes the other person perform a specific task.

We will be covering membrane transportation in greater detail in a future episode, but I wanted to introduce the membrane transport in this section on cells since that is where this is happening.

So, all of these are great for small molecules. But what about larger things that need to be brought into the cell?

Endocytosis and ***exocytosis*** are for larger transportation. You might ship a car part in the mail, but you wouldn't send a car through the postal service. Endocytosis is the process of taking things into the cell. This is further divided into *phagocytosis* and *pinocytosis*.

Phagocytosis means 'cellular eating,' and pinocytosis means 'cellular drinking.' Phagocytosis is the cellular intake of large particles, and ***pinocytosis*** is the cellular intake of liquid.

So, both phagocytosis and pinocytosis are forms of *endocytosis*.

Endocytosis, phagocytosis, and pinocytosis (video)

Cell-mediated endocytosis allows for bulk transport of *SPECIFIC* particles. A vesicle would form around the thing being brought into the cell only after particular ligands have bound to proteins on the cell membrane.

Exocytosis is the process of releasing larger molecules from the cell. So, let's say the endoplasmic reticulum makes a protein. The protein is going to go to the Golgi apparatus for further processing, and then it's going to go to the cell membrane to be released.

Exocytosis is the stuff being expelled out of the cell.

Organelles Review

Speaking of the endoplasmic reticulum and Golgi apparatus, let's review the organelles in cells.

The ***cytoplasm*** is the gel-like substance that is the material of a living cell.

We're going to start with my favorite organelle: the ***mitochondria***—which everyone has heard is the powerhouse of the cell since elementary school, which means that it makes the energy. It's where glucose is converted into ATP via cellular respiration. The biochemistry will be talked about in a later episode, but I wanted to remind you all of it in this episode.

Mitochondria are kinda bean-shaped and have their own phospholipid bilayers; two of them. They have an *outer membrane* and an *inner membrane*.

The inner membrane has a bunch of folds to increase surface area. These folds are called *cristae*. The ***cristae*** (the inner membrane) is where the enzymes for the electron transport chain are located. In the middle of the inner membrane is the *matrix.* So, on the inside of the inner membrane is the ***matrix***; the space between the membranes in the inner membrane space.

Okay, starting from the cell cytoplasm and working our way through the mitochondria layers to the center, let's go through the layers.

Outermost: outer membrane (phospholipid bilayer) → intermembrane space → Inner membrane (bilayer), called the cristae → matrix.

Remember how in the last episode, we talked about the endosymbiotic theory that suggests that mitochondria evolved from aerobic prokaryotes? So, it makes sense that mitochondria are semi-autonomous. They contain their own genes that replicate independently of the nucleus. This means the DNA replication in the mitochondria is not relying on the rest of the cell.

Guess what the transmission of genes that occur outside the nucleus is called. So, think about a cell and just go for it…

(pause)

It's called ***extranuclear inheritance*** or ***cytoplasmic inheritance*** because the genes are occurring in the cytoplasm, not in the nucleus.

See, aren't mitochondria so cool!? I also have a favorite organ, which we will talk about in another episode. I feel like if you are my level of a dorky nerd, you have favorite organelles and organs. I even have favorite bacteria. What can I say? I'm cool like that.

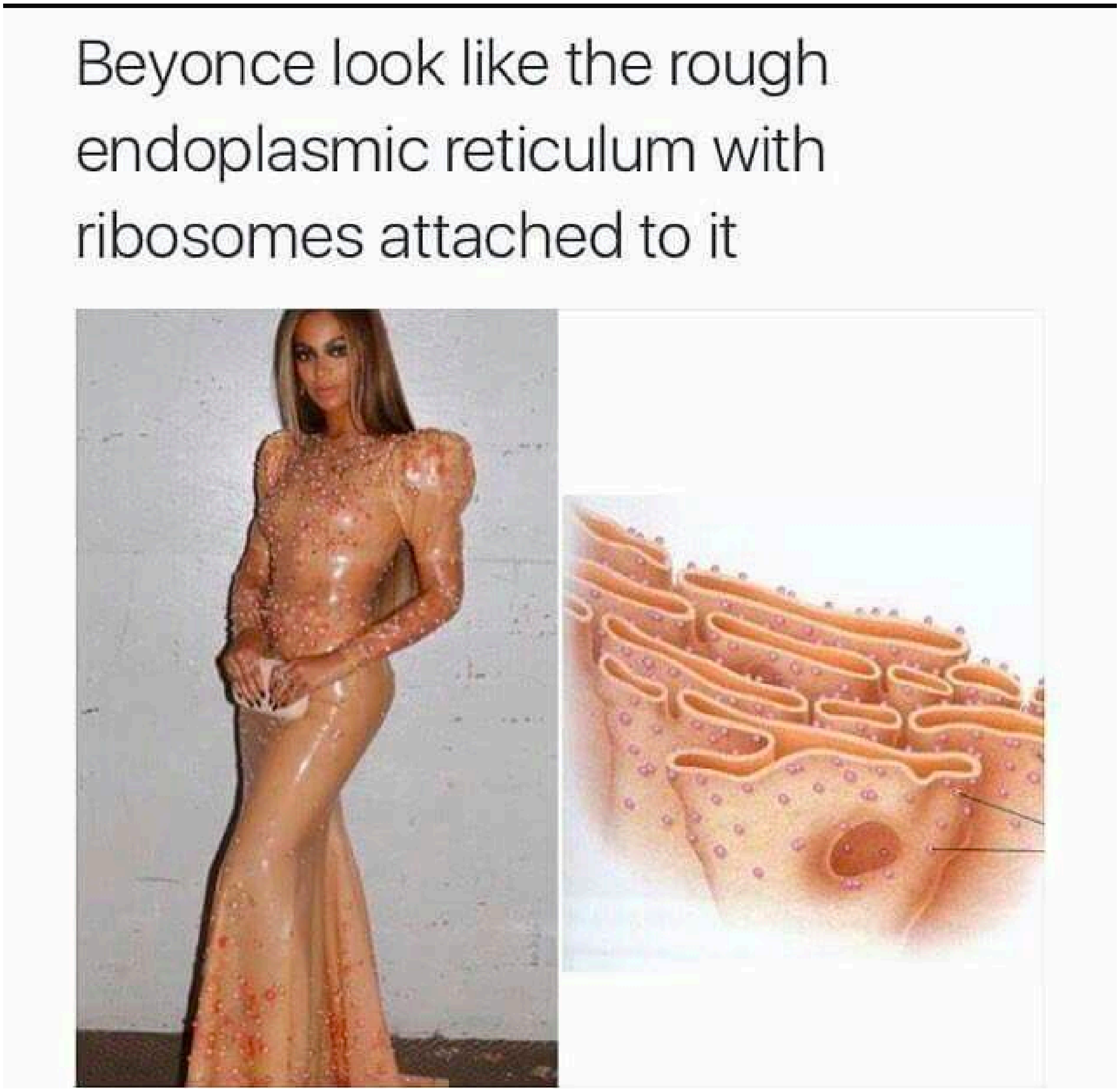
Okay, we are moving right along on our review of organelles.

The Endoplasmic Reticulum. The ER is a bunch of membranes that are interconnected and contiguous with the nuclear envelope. It has a lot of folds. It always reminded me of chubby bulldog puppies.

There are two types of the endoplasmic reticulum. ***Smooth [ER]*** lacks ribosomes and is used for lipid synthesis, and the ***rough [ER***] has ribosomes and is used for protein synthesis. The smooth ER is the real all-star of the endoplasmic reticulum. The smooth ER not only synthesizes lipids, but it transports the proteins from the rough ER to the Golgi apparatus, and it also helps in the detoxification of drugs and poisons.

Hypothetically, and I honestly don't know this answer if someone is taking a little bit of poison every day to make themselves immune as they do in *The Princess Bride*. Are they teaching their body that they need more smooth ER? So, if you did an analysis of their cells, would they have an inordinate amount of smooth ER? Just a thought—maybe a future experiment, IDK.

Also, while we are talking about the ER, I have to bring this up. Do you guys remember, years ago, Beyoncé wore a dress, and the internet freaked out that she looked like the rough ER? I, no lie, still think about that every time someone mentions the endoplasmic reticulum. I'll put the pic in my script notes.



The Golgi apparatus—and, I had to look up where in the world “Golgi” came from. It's from an Italian person that discovered it, Camillo Golgi.

The Golgi looks like a bunch of circles that have been kinda smooshed together. It takes the items made in the ER and modifies them. So, the ER puts its little protein—which we are going to call a *white t-shirt*—in a package, a vesicle, and sends it over to the Golgi, where the Golgi takes the white shirt and modifies it, maybe adds some bedazzling or print to it.

So, the Golgi is modifying the cellular products by adding things like sulfates and phosphates and carbohydrates. After the Golgi has finished doing its modifications, it directs things where to go. So, it packages things back up in vesicles and gives them directions. In the elementary school diagram, the Golgi is the FedEx hub, where things are sorted and sent out to be delivered in the correct location.

Endosomes. Endosomes are membrane-bound vesicles that help shuttle things around the cell, specifically between the trans-golgi and the membrane, and the membrane and the lysosomes.

Peroxisomes. I always liked the name of this organelle. As a kid, did your parents ever pour hydrogen peroxide on your scraped elbows, or knees and it bubbles a bunch?
Peroxisomes contain hydrogen peroxide. Hydrogen peroxide helps to break down long fatty acid chains via beta-oxidation.

Lysosomes. Lysosomes are, of course, membrane-bound because, remember, organelles are membrane-bound in eukaryotes. Lysosomes are cells that have chemicals that can help break down different substances ingested by endocytosis and cellular waste from that cell. It is pretty easy to remember since it is called a lysosome—as in *lyse*, to break down. So, the lysosome contains these hydrolytic lytic enzymes. We mentioned just a minute ago, but remember that endosomes work closely with lysosomes, escorting waste out of the cell.

Pop quiz-ish
Q: Which two organelles that we have mentioned would you think would be able to cause, or apoptosis, cell death?
A: The cell can kill itself in a process known as ***apoptosis.*** There are several ways it does this.

1) The mitochondria can release some enzymes which trigger a cascade that results in cell death.
2) The lysosomes can release enzymes in a process called ***autolysis***, which results in cell death.

Now, I think it's time we talk about the nucleus. Did you guys think I was going to skip it? We are just going to go over a little bit about the nucleus because the next few episodes are going to be covering genetics, and, when we chat about genetics, we will obviously be talking more about the nucleus.

Okay, the basis of the nucleus. The nucleus is where the cell keeps its genetic material.

Pop quiz
Q: What other organelles contain DNA?
A: If you said my favorite organelle, the mitochondria, then, you are correct.

Back to the nucleus.

The nucleus contains the genetic material necessary for replication.

Pop quiz
Q: During what phases of the cell cycle does DNA replication take place?
A: S phase. Remember, it replicates during the synthesis phase of the cell cycle, so that when mitosis starts, all the nuclear DNA has been replicated. If you need to brush up on cell cycle and mitosis and meiosis, go give *Episode 1* another listen.

As you can imagine—or perhaps have an intuitive understanding at this point—the nucleus of the cell is very important, so it's important to protect what is in the nucleus. So, the nucleus has a nuclear membrane, or ***envelope***, that is a double layer.

So, there is an *outer membrane* and an *inner membrane,* and communication between the nucleus and cytoplasm happens through nuclear pores. What's cool about the nuclear pores is they actually span both layers of the nuclear envelope. Because it spans both layers, it is very selective about what is allowed into and out of the nucleus.

I want to make sure that you understand the layers here.

Q: *So*, let's imagine you have a really itsy-bitsy—not a spider or a yellow polka dot bikini—an *itsy-bitsy needle*, and you need to go through the cell and into the nucleus. Assuming you don't puncture any other organelles, how many bilipid layers would you need to go through?

A: So, we have the regular cell membrane, and, then, we have the outer membrane of the nucleus and then the inner membrane of the nucleus. So, a total of three bilipid layers would need to be passed through.

Brian Hyland - Itsy Bitsy Teenie Weenie Yellow Polka Dot Bikini

The French one is better.

♪♬ Itsy bitsy petit bikini - Richard Anthony (French version) ♬♪

The nucleus has a subsection called the nucleolus. The ***nucleolus*** can be identified because it is the darker section of the nucleus. The nucleolus is where ribosomal RNA is synthesized.

I am going to leave the organelles now and talk about the cytoskeleton. If you are stressing because we barely talked about anything genetic related, I have a few episodes on genetics and evolution coming your way.

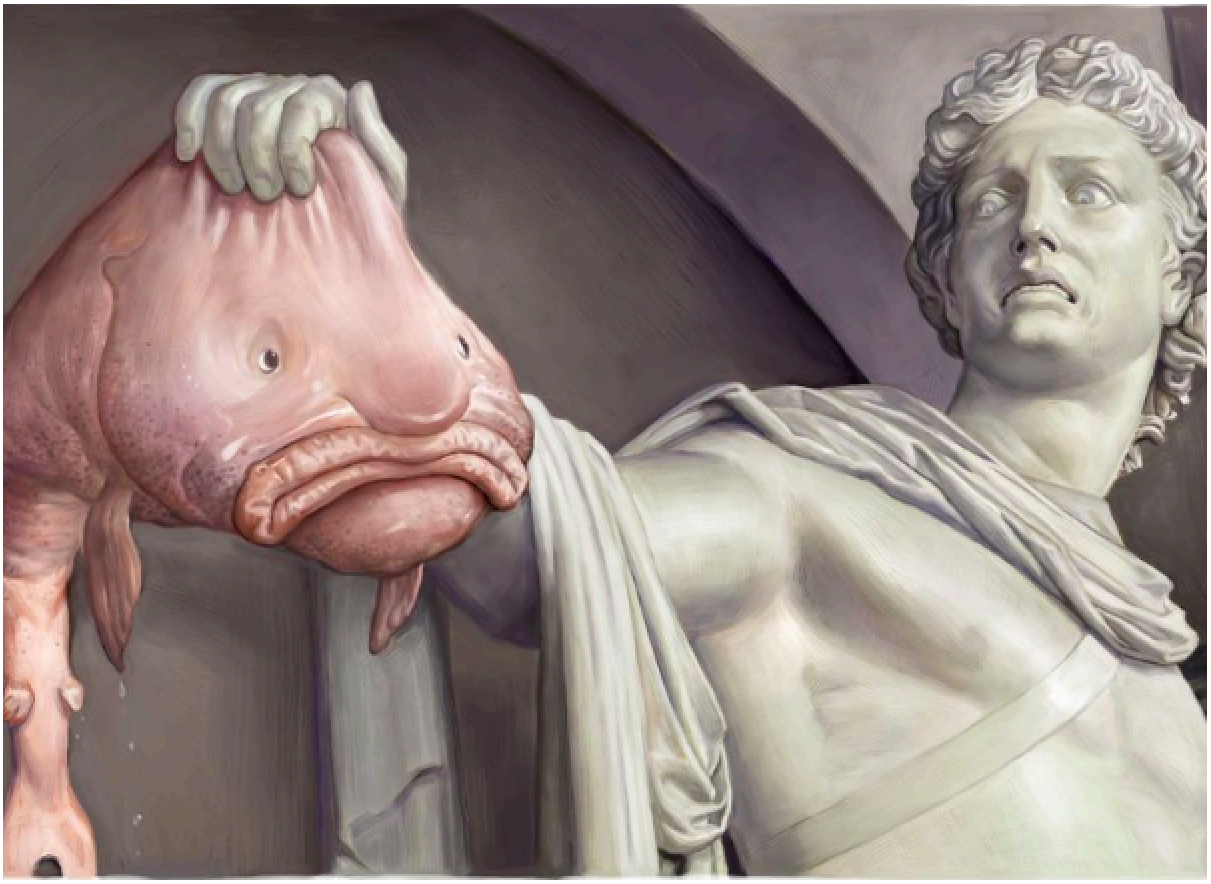
Actually, let's mention ***centrosomes***. Remember, centro-*SUM*s are *some* organelle where microtubules are organized, and help to pull sister chromatids in mitosis, and the chromosomes and sister chromatids apart in meiosis. Again, if this isn't super familiar, go give *Episode 1* another listen.

For review.

The ***centrosomes*** (centro-SUMS): They are the little organelles close to the nucleus of the cell which will help in the physical splitting of the genetic material. When the chromosomes get pulled apart in mitosis, it is the spindle fibers that are made from microtubules that will pull the chromosomes to opposite sides.

During ***metaphase***, the chromosomes start lining up in the middle of the cell. The centrosomes, the organelles, are now on opposite sides of the cell. ***Centrioles*** exist inside the centrosomes. Each centrosome has *two* centrioles. Centrioles are mainly composed of *microtubulin*.

Microtubulin is a component of the *cytoskeleton*, which we are going to talk about right now. The ***cytoskeleton***, as the name implies “skeleton,” helps the cell to maintain its shape. I mean, if we didn't have our skeletons, we would probs look like blobfish.



Behold the Blobfish | Science

Along with providing structure, the cytoskeleton also helps transport materials around the cell. There are three components of the cytoskeleton: *microtubules, microfilaments,* and *intermediate filaments.*

Starting with microtubules—since we were just discussing their roles in mitosis and meiosis. Microtubules are hollow like a tube is hollow. Microtubule filament is composed of tubulin proteins. I know, duh, right.

Microtubules are the largest of the cytoskeleton filament with a diameter of approx 25 nanometers (nm). Microtubules [are known for]:

- ➔ mitotic spindle
- ➔ cilia
- ➔ flagella
- ➔ transport[ing] substances around the cell by providing pathways for motor proteins to carry vesicles.

Two examples of motor protein (that I saw mentioned in the Kaplan books) that work with microtubules to transport things around the cell are *kinesin* and *dynein.*

Cilia are projections from a cell that are involved with moving material along.

Q: Can you name the 3 locations where cilia are found in humans?
A:

1. Respiratory system (lung)
2. The nervous system (ependymal cells)
3. Reproductive system (uterine tubes)

Flagella are for the movement of the cell itself.

Q: Can you name a type of cell that has flagella?
A: The best example is sperm.

In eukaryotes, cilia and flagella have a 9+2 structure, which means they have *2* microtubules in the middle with *9* pairs of microtubules surrounding it. I mention it here because, as we talked about in the last episode, any location where humans differ from bacteria is a point of interest since this is a location that can be targeted by drug treatments. So, humans have the 9+2 configuration, and bacteria have a different configuration depending on the bacteria.

Q: What are centrioles mainly composed of?
A: Microtubules

Follow-Up
Q: Centrioles attach to what part of the chromosome? And, I'm not talking about the centromere. What is the specific location on the centromere [where] they attach?
A: This is a question from *Episode 1*. The centrioles attach to the kinetochores.

Intermediate filaments.
Intermediate filaments are 10 nanometers (nm) thick, and provide structural support to the cell. Intermediate filaments provide structural support to the cell so that it can resist mechanical stress. Intermediate filaments also do a lot with cell-to-cell adhesion, and anchoring the organelles in place in the cell.

Microfilaments are the smallest component of the cytoskeleton. I mean, come on it's called microfilament, and they are 3-6 nanometers (nm) in diameter. Microfilaments help with movement within the cell, which is different from cilia and flagella.

Microfilaments are made up of *actin* and then are organized into bundles that help the cell to resist compression. I think of rope here that is a bunch of small pieces wound together. The actin can use ATP and interact with myosin to help force the movement of the cell. In fact, do you remember cytokinesis from the first episode? When the cell starts pinching down to split the cytoplasm? It is the microfilaments that are responsible for this. It uses actin and myosin to pinch the cell together. Microfilaments are very dynamic; they can lengthen and shorten very frequently. It becomes longer in a process known as ***actin polymerization*,** and shorter in a process known as ***actin depolymerization***.

Cell Theory
Wooooo. We are very close to being done with this review. The last thing I want to go over is cell theory.

Cell theory has four basic parts:

1) All living things are composed of cells.
2) The cell is the basic functional unit of life.
3) Cells arise only from preexisting cells.
4) Cells carry genetic information in the form of DNA. DNA is passed on from parent to daughter cell.

I feel like after everything we have talked about, cell theory makes so much sense and is kinda like, yeah, duh.

To sum up…

- ★ ***Cell membranes*** are made of *phospholipid bilayers* and cholesterol and proteins with glyco's thrown in for good measure—and communication.
- ★ The membrane is *semipermeable*, and things get through via ***passive diffusion*** and ***facilitated diffusion***.
- ★ Transportation is aided via proteins.
- ★ ***Mitochondria*** have their own DNA and do their own thing.
- ★ We have a bunch of *membrane-bound organelles* that have specific functions.
- ★ The ***nucleus*** has a *nuclear envelope* that includes two layers of membranes and the nuclear pores.
- ★ The ***cytoskeleton*** is made of proteins and has three basic components: *microtubules, intermediate filaments*, and *microfilaments*.
- ★ ***Cell theory*** states that the basic unit of life is a cell. So, all living things are composed of cells. Cells can only come from preexisting cells, and cells carry genetic information.

Last quiz question
Q: What organelle is contiguous with one of the bilayers of the nuclear envelope?
A: The endoplasmic reticulum [ER]

That is all I've got for this episode. Thanks for listening. If these episodes are helping you to review for the MCAT, or just review the basic biology material, do me a favor and recommend it to a friend.

Study hard, friends.