LESSON 1

INTRODUCTION TO HUMAN ANATOMY AND PHYSIOLOGY

Studying anatomy and physiology allows us to understand what our bodies are made of and how they work.

Have you ever wondered what happens to the food you eat, or why your mom tells you to eat your vegetables? Have you considered why your body forms scabs over certain injuries? Are you curious about your brain, your heart, or your bones? Well, even if you haven't thought of these questions, I think you'll enjoy this book about human anatomy and physiology. It will answer all these questions and many, many more.

Have you heard the words **anatomy** (uh nat' u mee) and **physiology** (fiz' ee awl' uh jee) before? Most people have some idea what the word anatomy means, but they aren't quite sure about physiology. Is that true for you? Well, anatomy and physiology have two different meanings, but they're really quite similar. Anatomy is the study of the human body, all its parts, and how it's put together. Physiology is the study of how all those parts work. For example, anatomy looks at how your heart and lungs are designed, while physiology studies how they work together to carry oxygen to your entire body.

Studying the human body is important because you live in your body. You need to know all about how it works, but remember, you are actually more than just a human body! You see, God made lots of creatures, but when He made people, He did something different. *He made humans in His image*. What does that mean? Well, the Bible says that God is spirit. And those who worship Him must worship in spirit and truth (John 4:24). So, when He made man, He gave us a spirit that was created in His image. The spirit that God gave you allows you to have a relationship with Him. It gives you the ability to know God and communicate with Him. Your spirit

We will learn more about ourselves and God as we study how He made us.

makes you unique from all the other creatures God made. Isn't that wonderful? So the next time someone says we are just animals, you'll know the reason that's not true.

The Bible tells us that God specially chose each one of us to be born and that we were carefully put together by Him. We didn't come into this world by accident or as a mistake. Psalm 139:13-14 tells us, "*For you formed my inward parts; you wove me in my mother's womb. I will give thanks to You, for I am fearfully and wonderfully made; wonderful are Your works, and my soul knows it very well.*" Do you understand what that means? All of God's works are wonderful. You are one of God's works. That means *you are wonderful!*

God made your body in such a marvelous and complex way that scientists are always, even today, discovering new things about how your body works. People have been interested in discovering more about this marvelous miracle, the human body, since the beginning of time. Soon after their creation, Adam and Eve were likely fascinated by their beautifully designed and incredibly useful bodies. Perhaps they were amazed at the strength they had or how long they could run. Perhaps they wondered why they felt better when they ate certain foods, but not as good when they ate others. Indeed, ancient writings tell us that people have been studying the human body since the earliest recordings of history.

History of Anatomy and Physiology

Before we get into the nuts and bolts of this course, let's take a quick look at what people once believed about the human body and how we became much more knowledgeable about it over time.

Ancient Egyptians

Perhaps you've already studied the ancient Egyptians. If so, what are some things you remember about them? What did they do with people when they died? Even as far back as 3400 BC (before Christ), the Egyptians preserved dead bodies. They used salt and other chemicals to keep them from rotting and decaying. This process dried the bodies, making them into mummies (mum' eez). The Egyptians did this because they believed that a person needed his or her body to get to heaven.


The ancient Egyptians knew a lot about the human body and were able to preserve it by mummification.

In order to mummify the body, they first dissected (or cut apart) the body and removed some of the organs: the brain, liver, stomach, and intestines. They left the heart because it was thought that the heart was needed in the next life. The Egyptians' religion taught that a person's entrance into heaven was based upon the weight of his heart. They believed that when a person died, the gods would weigh his heart, and if it were heavier than a special feather one of the gods kept, the person wouldn't get into heaven.

Even though the Egyptians had religious beliefs that did not recognize God as their Creator, their ability to dissect and preserve bodies shows how far ahead they were in their understanding of anatomy. In fact, the Egyptians' writings reveal they could do simple surgeries and even fix broken bones! That's pretty amazing. However, because they did not understand the true God, they could not get very far in their understanding. For example, they believed that magic performed by their gods made people sick and made the body function as it did.

You can use the same basic chemicals that the Egyptians used to mummify a piece of fruit. Let's experiment!

Try This!

You will need an apple sliced into 8 equal slices, table salt, Epsom salt, baking soda and 8 cups for each apple slice. Weigh each slice with a kitchen scale. Put the slice into a cup and record the weight on the cup. Pour the following ingredients into each cup and label the cup accordingly: Cup 1: ½ cup baking soda. Cup 2: ½ C. Epsom salt. Cup 3: ½ C. table salt. Cup 4: ¼ C. Epsom salt & ¼ C. table salt. Cup 5: ½ C. table salt & ½ C. baking soda. Cup 6: ½ C. baking soda & ½ C. Epsom salt. Cup 7: 1/3 C. baking soda & 1/3 C. Epsom salt & 1/3 C. table salt. Cup 8: control apple with no ingredients. Let cups sit for 7 days. Then remove, dust off, and weigh each apple slice. Which mixture removed the most moisture and preserved the apple the best?

Ancient Hebrews

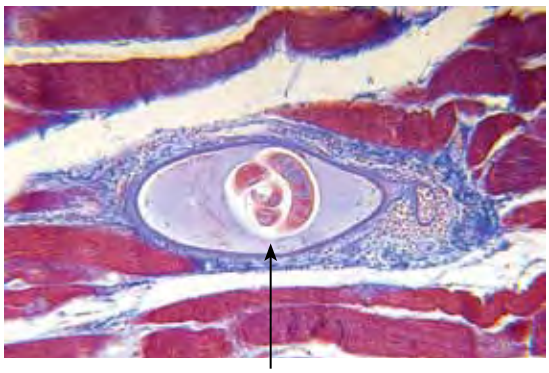
If you've read the Bible, you've probably heard of God's chosen people, the Israelites. In the Bible, they are also called the Hebrews. Though they didn't study the human body like the Egyptians, the Hebrew people had the benefit of good health when they kept God's laws. You see, God gave the Hebrews a lot of rules; some of those rules had the advantage of protecting the Israelites from tiny organisms (or' guh niz' uhmz – living things) called germs. These rules can be found in the Old Testament. This part of the Bible tells the story of God's people before Jesus came to earth. Thousands of years before scientists knew that germs existed, God's rules helped the Israelites keep them away!

The Israelites were given God's laws in the Old Testament, which they kept on scrolls in beautiful cases.

Creation Confirmation

By examining some of the rules that God gave the Israelites, we have even more evidence that our God is real. Let's take a look at an example of one rule.

In the passage below (Leviticus 13: 3-4) God has given the Israelites specific rules for how to handle someone with a rash. Let's read it together:



This microscopic photograph shows you muscle tissue infected with a parasite that is common in pigs.

The priest is to examine the sore on his skin, and if the hair in the sore has turned white and the sore appears to be more than skin deep it is an infectious skin disease. When the priest examines him, he shall pronounce him unclean. If the spot on his skin is white but does not appear to be more than skin deep and the hair in it has not turned white, the priest is to put the infected person in isolation for seven days.

We see here that God knew that rashes are contagious (meaning other people can catch them). In fact, the instructions to isolate the man with a serious rash are called a quarantine (kwar en teen). Even today, we quarantine people by keeping them in one place, separated from others, so they cannot spread disease. The Israelites may not have known about germs and how disease was spread, but God sure did!

There are many laws that God gave in the Old Testament that we can now see are helpful for keeping ourselves safe, healthy and clean. Some of God's laws included instructions for washing the body and clothing. Today, we know that germs can live on the body and in clothing.

Does your mom tell you to wash your hands before you eat? Wise mom! Who knows what germs you may have come in contact with during the day! Maybe you touched a doorknob that someone with the flu touched. Perhaps you picked up a nickel in the dirt that had pinworm eggs on it, or high-fived your best friend who, unknowingly, was contagious with strep throat. It's important that you wash your hands to keep from getting sick. Would you believe that there are people on this earth who rarely (if ever) wash their hands? It's true, especially in places where people are not educated. Yet, thousands of years ago, the Israelites were washing regularly. When people met with the Israelites, they considered them extremely strange for all the washing they did!

This is great evidence for those who do not believe in God. If God did not exist, how is it possible that the instructions given to the Israelites of the Old Testament are scientifically accurate and beneficial? The answer is: God is the Original Scientist of the world. Although we know today that one of the benefits from following the many rules that God gave the Israelites protected them from getting sick, God's reason for giving the Israelites these specific laws involved much more than we could talk about here.

You will remember what you have just learned a little better if you explain it to someone else. Throughout the course, you will do this often. Take time now to explain all that you've learned so far.

Ancient Greeks

Long after God gave His laws to the Israelites, a group of people along the Mediterranean Sea were pondering grand things in their minds. These men were called the ancient Greek philosophers. Around 500 years before Jesus was born, they were fascinated by the natural world. After close inspection of plants and animals, they carefully wrote down what they learned. Although the Greeks, like the Egyptians, believed in many gods, they also believed that by using their brains, they could understand more about the world around them. By doing this, they ended many of the superstitious beliefs that the Egyptians had passed on about the human body.

As part of their discovery process, the Greek philosophers would come up with a **hypothesis** (hi pah' thuh sus – an educated guess) that they hoped would explain something they saw. After a lot of discussion, if the hypothesis seemed correct to everyone, they would claim it as a **theory** (theer' ee). A theory in ancient Greece made something a belief. These beliefs were developed after lots and lots of debates and discussions.

This statue of Hippocrates is in Larissa, Greece, where he died.

Unfortunately, this way of deciding a belief left out a very important step in scientific studies – experimentation. They preferred to find answers by thinking about and discussing their ideas. Although these ancient philosophers produced valuable knowledge with their discussion, sometimes that knowledge could have been expanded and understood better with the use of scientific experimentation. Experiments are designed to test hypotheses to see if they hold true.

Imagine what happens when people don't experiment to test their ideas. Do you think the Greek philosophers developed a lot of really good theories this way? As you may have guessed, many of their theories weren't correct. For example, a very famous Greek Philosopher named **Hippocrates** (hi pah' kruh teez) believed that in order to be healthy, your body needed equal amounts of four liquids. They called these liquids **humors** (hyoo' murz), and they listed them as black bile, yellow bile, **phlegm** (flem), and blood. If you got sick, they thought it was because you had too much of one of these humors. So, they tried to cure you by removing some of the humor.

This ancient manuscript records the Hippocratic oath in the form of a cross.

If they thought you had too much blood, they would remove some blood from you – usually by applying leeches to your body.

The Greeks even believed that a person's personality was affected by his humors. If someone was very calm and relaxed, they thought he had a lot of phlegm, which made him more patient. If he was very energetic and full of ideas, they thought he had extra blood. If he was very controlling and always in charge, they thought he was full of yellow bile. If he was a deep thinker and very emotional, they thought he was full of black bile.

Sadly, the theory of the four humors was believed all the way from Hippocrates's time until the 1800s, when most historians think modern medicine was developed. In fact, Hippocrates is considered the Father of Modern Medicine, even though he was mistaken about the four humors. This is because he was the first major philosopher to reject the idea that supernatural forces caused illnesses. In addition, doctors today are required to take an oath created by Hippocrates, himself. This Hippocratic oath states that doctors should always do good and never harm to anyone.

Try This!

Many personality tests still use the four humors to describe different types of people, even though we know that these "humors" don't determine personality. Here is how they are broken down:

Phlegmatic (fleg mat' ik – phlegm): Easy going and easy to get along with, usually happy
Sanguine (sang' gwin – blood): Excited, full of energy, usually happy
Choleric (kol' uh rik – yellow bile): Controlling, leader, likes to be in charge
Melancholy (mel' uhn kol' ee – black bile): Thoughtful, artistic, emotional

Now, think of the people in your family or friends you know. Consider which one of the personalities they have. Write it down and see if others agree with you.

Aristotle

Aristotle (ar' ih stot' uhl), another famous Greek philosopher who lived about 100 years after Hippocrates, was one of the first true scientists and one of the greatest thinkers of all time. He believed that you needed to conduct experiments, not just discuss your thoughts. He dissected plants and animals to learn about their inner parts, and some think he even dissected dead people, although not all historians agree about that. He helped others understand how important it was to examine and test everything they believed. Unfortunately, because Aristotle was not taught about the one true God, many of his theories were not correct.

One of Aristotle's theories we now know to be wrong was **spontaneous** (spon tay' nee us) **generation** (jen' uh ray shun). This theory said that life could come into existence from nonliving things. You see, Aristotle noticed that within a few days of leaving raw meat out, maggots suddenly appeared on the meat. He thought that living things could suddenly spring forth from nonliving things, like maggots springing forth from meat. He saw it happen so often, he was certain it was true. Of course we now know that maggots come from eggs

laid by flies that land on the meat. The eggs were so small that Aristotle couldn't see them. Today we know that life does not come from things that are not living. Just as the Bible says, life only comes from life; maggots come from flies, not dead meat. Yet because Aristotle was such a great thinker, his idea of spontaneous generation was accepted as true for hundreds of years.

This famous painting by the Italian artist Raphael has Plato (left) and Aristotle (right) as its central figures. It is called "The School of Athens."

Creation Confirmation

In case you have not yet heard, there is a theory (or belief) floating around today that says all life sprang into existence spontaneously. Does that sound familiar? Yes, even today there are people who still hold on to Aristotle's theory. Some people believe that the entire world and everything in it came together accidentally from nonliving things that were floating around in space. They believe it happened without God, without a plan, and they believe that some life forms changed (or evolved) into different forms of life to become all that we see today. As you can see, it's obvious that some beliefs – like Aristotle's – are hard to remove from modern science.

In your own words, explain what you have learned about the history of anatomy and physiology. Include information about the Egyptians, Hebrews, and Greeks.

Ancient Rome

About 200 years after our Lord Jesus was born, a brilliant Roman physician named Galen (gay' lun) arrived on the scene, moving the study of anatomy along. Galen read all of Aristotle's works and followed much of his teachings. He had lots of opportunities to test his theories on actual people, because he was a doctor for Roman gladiators who were always getting hurt. People were stunned when the beaten, bloodied gladiators survived after being treated by Galen. One of Galen's secrets was to always use clean rags when treating his patients. Before this, doctors would use filthy rags filled with germs (that no one knew existed) to clean the wounds of injured people. Galen also soaked the rags in wine. He didn't know why this made his patients better, but it did. Of course, now we understand today why it worked. Wine contains alcohol, which kills certain germs!

This is what a 19th century artist thought Galen may have looked like.

Since Galen was much more successful at treating patients than most other doctors of his time, it was not long before the Emperor wanted Galen as his own personal doctor. To help himself understand anatomy, Galen dissected animals, especially monkeys. He never dissected a person, because it was against the law in Rome to do that. Galen wrote a great deal about his work and made many illustrations (scientists like to draw what they learn). These writings and illustrations helped other scientists better understand anatomy for a thousand years.

Creation Confirmation

Jesus, because He is God, knew a lot more about health than the people that lived during the New Testament times. For example, He knew the disinfectant properties of wine. We can see this in the parable of the Good Samaritan. As a part of the parable, Jesus said the Good Samaritan, "*came to him and bandaged up his wounds, pouring oil and wine on them*" (Luke 10:34). This is additional evidence that Jesus was God, as He had knowledge of the healing properties of alcohol even before it was known by others.

European Scientists

Much later, in the 16th century, a young French scientist named **Andreas** (ahn dray' us) **Vesalius** (vuh say' lee us) began to question Galen's ideas. Vesalius was an anatomy professor at the age of 23! What was your dad doing when he was 23? That's pretty young to be teaching anatomy at a university. Vesalius dissected human **cadavers** (kuh dav' urz – dead bodies), proving that many of Galen's teachings were wrong. He published a great big series of books on his findings. Remember, Galen's ideas were based on studying the insides of animals. By looking at the insides of people, Vesalius could correct some of Galen's mistakes. Many scientists were devoted to Galen's teachings, and they were angry that Vesalius was proving Galen wrong. These men made life difficult for Vesalius, so he left his teaching job and worked as a doctor for Emperors.

But it wasn't long before more and more people became interested in studying anatomy. Soon, the world was teeming with scientists. There were many people who began to discover how the human body works. We call this time in history the Renaissance period. You'll learn all about it in your study of history.

One very important discovery was made by a Dutchman named **Anton van Leeuwenhoek** (lay' uh wun hook'). He discovered a great use for glass lenses, which opened up a whole new world for scientists. He found that if he made a lens correctly, he could use it to magnify things. He was such a good lens maker that he could magnify things to nearly 200 times their natural size! In other words, this Dutchman built microscopes! Fascinated with what he saw, he studied everything he could get his hands on and made lots of detailed drawings of his findings.

What was van Leeuwenhoek able to see through his microscope? Well, one thing he saw was red blood cells flowing single file through a blood vessel in the tail of a tadpole. He also saw many microscopic organisms that he found in pond water and even in the saliva taken from a person's mouth! He called these organisms "animalcules," because he likened them to little animals. His invention enabled him to see things no human eye had ever seen before! Without the invention of the microscope, science would never have come as far as it has today!

Robert Hooke was a scientist who was interested in the same, tiny world that van Leeuwenhoek found interesting. He made a microscope that is much like the microscopes we use today. It is called a **compound microscope**, and it uses two lenses to magnify objects. If you position the lenses correctly, you can actually magnify things more than you can when you have only one lens. One object Hooke looked at under his microscope was a piece of cork. He saw that the cork was actually made up of many rectangular blocks. They looked like the cells (rooms) that monks slept in, so he called them **cells**. We still call them cells today! What Hooke saw were actually cell walls, which in plants (cork comes from a tree) are thick and sturdy. Hooke's discovery soon led to the concept of the cell as the basic building block of life. In fact, that's what cells are, the basic building blocks of life.

These are drawings Robert Hooke made of his microscope (left) and the cells he saw with it (right).

Try This!

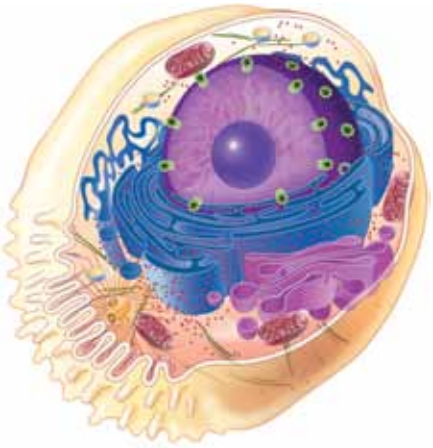
JESUS

You may already have experience using a magnifying glass, but let's do an experiment with water to show how a magnifying glass works. You will need a piece of clear plastic. You will also need a medicine dropper. Put your piece of plastic over the word inside the white box to your left. Now put a single drop of water on the plastic, right above the word. Can you read the word through the water drop? You probably can, because the water drop bends light so as to magnify the things underneath it. Experiment with different sizes of water droplets. Which ones make the word the biggest?

Explain to someone all that you've learned today before moving on to the next section.

Cells

Because scientists like van Leeuwenhoek, Hooke, and many who came after them could not see the tiny, inner parts of a cell, most scientists thought that cells were very simple things. They thought each cell was just a block with a little dot inside, which they called the **nucleus** (new' klee us). The word nucleus means core or center. Today, with more advanced microscopes as well as other advanced laboratory equipment, we are beginning to learn just how complex cells really are. Rather than being an uncomplicated block, each one is like a miniature city! These "cities" are so well run and so highly structured that what we once believed was something very simple and easy to understand, we now know is still beyond our complete understanding!



Believe it or not, this drawing represents a simplified view of the kind of cells that are in your body.

Cell Anatomy

Let's study the anatomy of a cell. I would like for you to get a piece of paper and illustrate each part of the cell that we discuss. Your illustration will not be as fancy as the one given above, but it will still be better than anything Robert Hooke or Anton van Leeuwenhoek had! After you illustrate something, draw a line out to the side and label it. If you like to write, you can also write about what it does. Later on, you will learn about the notebook you are supposed to be keeping throughout this entire course. You can use the *Anatomy Notebooking Journal* that was made for this course, or you can get a blank notebook that you will write and draw in. If you are using the *Anatomy Notebooking Journal*, make your drawing on the page that says "Cell Anatomy." If not, make your drawing on one of the first pages in your blank notebook.

Cell Membrane

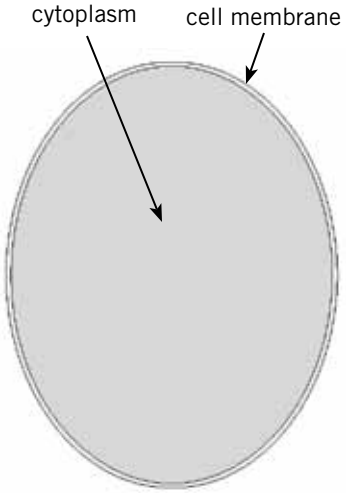
In the body, cells come in all different shapes and sizes. We'll draw a cell that is oval, because it's a bit easier to draw. So, draw an oval with a boundary around it, like you see in the drawing on the next page. That boundary is the cell membrane.

Do you remember the story of Jericho found in the Bible (Joshua 6)? If so, you'll remember that the city of Jericho had a wall around it. This wall protected Jericho from foreigners and danger. It allowed certain people and things in, like friendly neighbors and food. It also kept certain things out, like unfriendly neighbors and their weapons. Well, back in those days, almost every city had a wall around it. At the wall were gatekeepers.

These were men whose job was to open and close the gate, depending on who wanted in and who wanted out.

Like a city wall, the cell membrane is the first level of protection for the cell. It works like a gatekeeper, allowing certain substances to pass in and out. Usually, only those substances that are needed (like oxygen, water, and nutrients) are allowed in. Sometimes other stuff sneaks in, but we'll discuss that in the lessons on the lymphatic (lim fat' ik) and immune systems. In addition to letting certain things in, the cell membrane also lets certain things out. The things it allows to leave the cell might be waste products or chemicals made by the cell to help your body. As you can see, the cell membrane is very important.

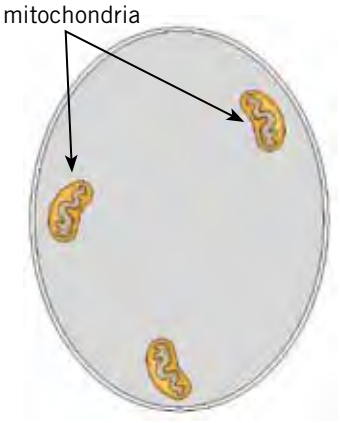
Inside the cell membrane are a variety of smaller structures called **organelles** (or' guh nelz). Organelle means little organ, and like an organ, each organelle has a special job. As you learn about each organelle, you will add it to your cell drawing. The organelles all float in a substance called **cytoplasm** (sye' toh plaz' uhm). Cytoplasm feels like runny jelly, but it's mostly water. However, cytoplasm also has nutrients in it. Together the organelles and the cytoplasm fill the cell.



The cell membrane determines what can enter and leave the cell. Inside, there is a jelly-like substance called cytoplasm.

Mighty Mitochondria

What if you wake up one morning and turn on the light switch, only to find it doesn't work? You walk around and realize that nothing works: your computer, your oven, your toaster. Nothing turns on! Later you realize the problem is not just with your house, but with every house on the street; soon you realize it's every house in the city. What happened? It seems that somehow the city's power supply was cut off. The power plants that supply power to your city are not working.



Mitochondria power the cell by burning fuel that they get from the food you eat.

Just as your city gets its power from power plants, each cell has power plants. Actually, it usually has many. These power plants are called **mitochondria** (my' tuh kon' dree uh). They are mighty mitochondria because they give each cell its might and power. Mitochondria are shaped like beans that have a squiggly line through the center. Take a minute to draw a few mitochondria anywhere inside your cell illustration.

How do mitochondria actually work? Well, your body digests the food you eat, turning it into smaller nutrients that go to the cell. The cell breaks some of those nutrients down into fuel (kind of like gasoline, the fuel that makes your car go). The fuel is then sent to the mitochondria, where it is actually burned (a bit like the way a car burns its gasoline). Burning the fuel makes energy – the very energy you use when you walk, run, and even think! That's pretty mighty, isn't it? Now don't think there are little fires going on in all the cells of your body. Your cells burn their fuel very gently, but they do, indeed, burn it. So, what exactly is the fuel that your cells burn? Well, mostly it's a kind of sugar called **glucose** (gloo' kohs). We'll learn all about that in the lesson on nutrition.

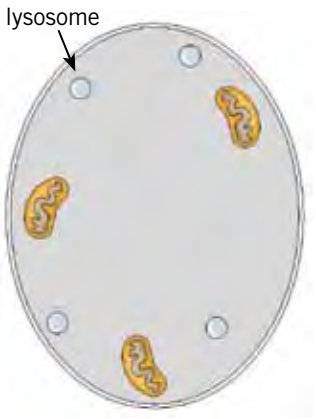
Your body is made up of cells – many different kinds of cells. Some cells are muscle cells, some are brain cells, some are skin cells. There are cells everywhere in your body, and all of them need energy. However, certain cells need more energy than others. Many of your muscles are always working, even when you sleep. So, your muscle cells need lots of energy. Amazingly, God created muscle cells with more mitochondria than other cells (like your skin cells) that don't use a lot of energy.

Lysosome Patrols

Do you remember how we compared a cell to a city? We said that the cell membrane is like the city wall, and the mitochondria are like power plants for the city. Let's stick to the city analogy as we learn about **lysosomes** (lye' suh sohmz'). What are the lysosomes in the city? Well, they are the policemen. They protect the cells by destroying invaders, like bacteria. They also break apart tired, worn out old organelles and send them out of the city through the city wall.

Like police in a city, lysosomes keep the cell safe.

The lysosomes have another extremely important job: they break down chemicals that the cell membrane takes inside. This is what happens: you eat a big meal of meat and potatoes. The meat has **proteins** (proh' teenz) in it, and the potatoes have **carbohydrates** (kar' boh hye' draytz). Proteins and carbohydrates are similar to beaded necklaces in that they are made up of small units linked together. In your intestines, the "necklaces" are taken apart into much smaller units – often into individual beads.



Lysosomes protect the cell by destroying invaders and getting rid of broken-down organelles. They also break down nutrients into smaller, usable units.

These smaller units are taken into your cells. But, in order for your cells to use them, they often need to be broken down even further so that the cell can then rebuild them to meet a specific need. This process is very much like taking apart a Lego creation so that you can make something new. When you are taking the Lego creation apart – breaking it down into smaller Lego units – you are acting like a lysosome. So, whether they are dealing with invaders that are trying to harm the cell, worn out organelles and chemicals that should no longer be in the cell, or nutrients that the cell needs, the lysosomes break down things. This allows the cell to get rid of things it doesn't need and build the things it does need.

Place the lysosomes into your cell illustration. Draw the lysosomes as small round balls. Each cell has hundreds of them, but you only need to draw a few.

Grocer Golgi

What would a city be without grocery stores? Well, the cell is equipped with grocery stores called the **Golgi** (gohl' jee) **bodies**. Each Golgi body looks like a stack of differently-sized, curved pancakes. It keeps a supply of chemicals like proteins and fats that the cell makes. One thing that's unique about the Golgi body is that it sends its products for delivery, whereas most grocery stores do not. Whenever protein or fat is needed in another part of the cell city, the Golgi body wraps it up and sends it to where it is needed. That's pretty handy.

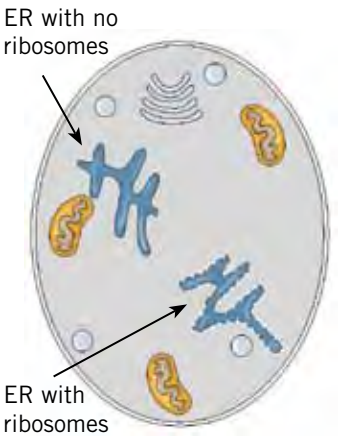
Draw your Golgi body as curved pancakes stacked on top of each other. There are usually several in each cell, but you can just draw one if you wish.

The Golgi body stores chemicals and sends them to where they are needed.

You've learned a lot about cell anatomy.
Try to tell someone in your own words what the cell membrane, the mitochondria, the lysosomes, and the Golgi bodies do.

ER Delivery and Pick Up

My children can't wait for the mail to arrive each day. Sometimes a big truck will bring a box with interesting new items from Grandma or Aunt June. Other times, a different truck will deliver boxes containing things we ordered. These delivery trucks are a lot like the **endoplasmic** (en' doh plaz' mik) **reticulum** (rih tik' yuh luhm). Can you say endoplasmic reticulum three times fast? Well, since no one really wants to have to say endoplasmic reticulum too many times, everyone calls the endoplasmic reticulum the ER.



The ER delivers chemicals to where they are needed and sends waste out of the cell.

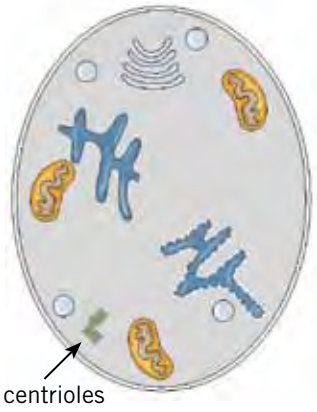
The ER transports things around the cell city. It also has another job: garbage man. What would happen to your city if there was no trash pick up, or no city dump in which to discard the trash? Just imagine that. There's a great poem by Shel Silverstein about a girl who would not take out the trash, and it eventually polluted the entire city. Well, just as a city needs mailmen and garbage men, every cell needs a delivery and clean-up service. So, the ER takes chemicals that were packaged by the Golgi bodies (as well as chemicals from other parts of the cell) and delivers them to where they are needed. It also sends waste to where it needs to go so it can leave the cell. The ER is the mailman or the garbage man, depending on what needs to be done.

Just like real cities, most cells have a lot more mailmen and garbage men than grocery stores. Each cell will also have more ER than Golgi bodies. The ER resemble ribbons, some of them intermittently studded with beads. These beads are called **ribosomes** (rye' buh sohmz'), and they are very important. You'll learn about them in a moment. Draw your ER as ribbons that are connected to other ribbons. Put small beads on some of them to represent the ribosomes.

Centrioles: Mothers of the City

Cells reproduce, or copy themselves. That's one of the reasons you can grow up and become an adult. An adult has more cells than a child. As you grow up, your body makes more cells so you can get bigger and stronger. Also, sometimes you hurt yourself. For example, you might have an accident where a bone is broken. When that happens, cells die. Your body must repair the damage, and part of the repair job involves replacing the cells that died with new cells.

Centrioles (sen' tree ohlz) are special organelles that help cells reproduce. They look like two pieces of pasta that form an "L" shape. These centrioles would be the mothers of the cell city, since they help the cell make more of itself.



Centrioles help cells make more cells.

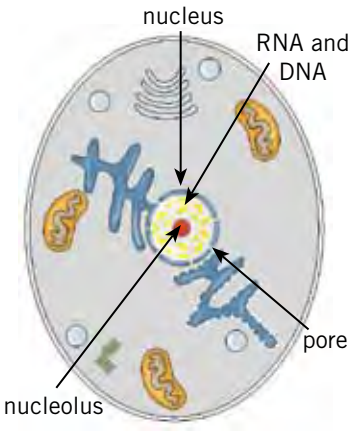
The Nucleus Government

How do your parents know how fast to drive or how much tax to pay? Who decides when to pave the city streets or who will take the garbage to the landfill? Who helps those who do not have enough of what they need? All these things are decided by your city's government. Well, you may wonder, "How does each cell know what to do and when to do it?" Just like a city has a government, the cell has a control center. It is called the nucleus, and it functions like the government of the city.

The nucleus is larger than any other organelle in the cell. It's usually a big round ball and is sometimes located in the center of the cell. On the outside of the nucleus is a thick membrane called the nuclear membrane. It gives the nucleus its form. The nuclear membrane is porous, which means it has pores (holes) in it to let substances in and out. What's inside the nucleus? DNA and RNA can be found inside, as well as a smaller

ball called the **nucleolus** (new klee' oh lus). The nucleolus is what makes the ribosomes that are sometimes found on the ER. You will learn about DNA and RNA in a moment.

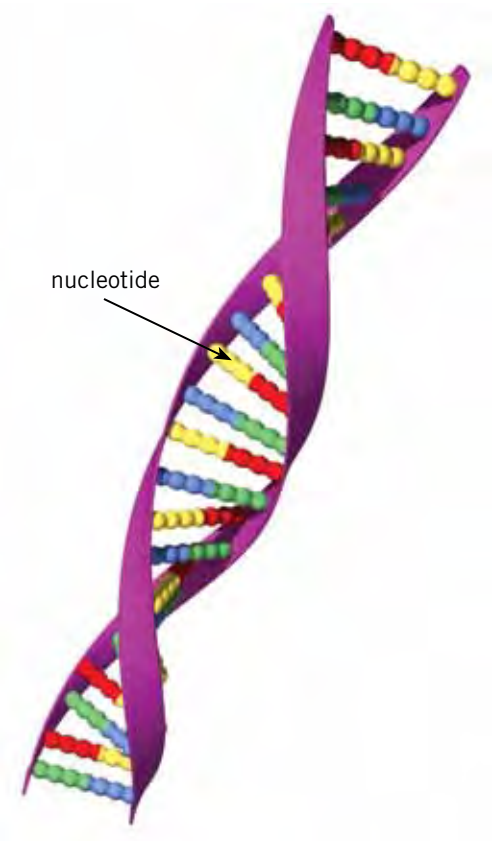
Now is a good time to draw a nucleus for your cell illustration. You can put it anywhere inside your cell. You have completed your drawing of a cell. Now please understand that there is a lot more to a cell than what you have drawn here. Remember the drawing on page 26, and then remember that it is actually a simplified drawing! However, what you have is a great first step in understanding the main features of a cell.



The nucleus is the control center of the cell. It is surrounded by a porous membrane and contains DNA, RNA and the nucleolus.

Inside the Nucleus

Now that you have learned about the basics of cell anatomy, let's look inside the cell's government building, the nucleus. Learning about what's in the nucleus will help us understand more about how cells work.



DNA contains genes, which are made of nucleotides.

DNA

DNA, which is short for **deoxyribonucleic** (dee ahk' see rye boh noo klay' ik) acid, is a molecule inside every person (and every living thing, for that matter). It contains all the information about that person. Your DNA is like a huge book all about you. Of course, it's longer than any book ever written! If you took the DNA out of a cell and unfolded it, it would be about 2 meters (about 6 feet) long. If you extracted all the DNA from every cell in your body and laid it out end to end, it would reach to the sun and back more than seventy times! God sure is a genius to get all that DNA packed inside your body!

The words in your DNA "book" are called **genes** (jeenz). Have you ever heard that word? You may have thought it referred to a pair of pants. Those jeans are for the outside of your body; the ones we're talking about now are on the inside. You get your genes from your parents – one set from your mother and one set from your father.

These gene "words" are made up of letters. Scientists call these letters nucleotides (noo' klee uh tides). Letters strung together make words, and words strung together make a book. Similarly, nucleotides strung together make genes, and genes strung together make DNA. Just like the information in an encyclopedia is packaged into different books, DNA is packaged into units called chromosomes (kroh' muh sohmz). Each of your cells has 46 of these packages of DNA.

What is so important about DNA? Well, the genes in DNA produce the code for a person's life. They help to determine what color hair the person will have, the color of the person's eyes, whether the person is a he or a she, when the person will lose his or her first tooth, how tall the person will be, and so on. So, a person's DNA is a *big part* of what makes the person who he or she is. The DNA is literally the recipe, or set of instructions, that helps to make the person.

Nearly every cell in your body has DNA. So, you could take a cell from almost any place in a person's body and get DNA from it. If you understood the code, you could determine a lot of information about

Scientists can use DNA to help solve crimes.

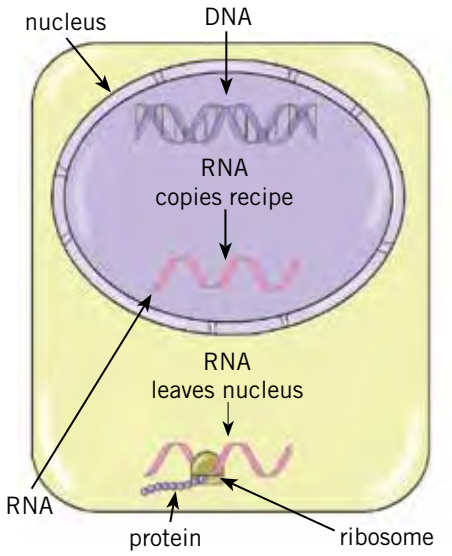
that person. No two people in the whole world have the same DNA, except identical twins or triplets. Even though identical twins have the same DNA, they are still different people, because DNA doesn't determine *everything* about a person. A person's life experiences help to determine things as well. For example, even though they have the same DNA, identical twins have different fingerprints, because they have different experiences, even as they develop before birth.

Because a person's DNA is unique (unless the person has an identical twin), detectives can solve crimes by collecting DNA at crime scenes. Everyone's skin, hair, and blood have DNA. Scientists can collect samples of skin, hair, or blood and study them to find out who was present during a crime. Determining a person's identity from DNA found at a crime scene is a rather newly-developed technique, but it is helping to solve old crimes. People are studying DNA from old crime scenes and are learning that some people accused of crimes were actually not even present when the crime was committed. This has led to people who have been wrongly accused being released from prison.

RNA

How does DNA help determine things like your eye color and your hair color? Well, DNA's main job is to tell your cells what proteins to make and how to make them. You see, nearly everything that happens in your body is under the control of proteins. By telling your cells what proteins to make and how to make them, DNA is basically telling your cells what to do.

How does DNA instruct the cell when it comes to making proteins? After all, the DNA is in the nucleus. How does it instruct the cell from in there? Well, it does this via a messenger, and that messenger is RNA. RNA copies part of the information that is in DNA and then leaves the nucleus through one of the pores in its membrane. Remember the ribosomes? That's where the RNA goes after it leaves the nucleus. The information carried by the RNA is a recipe for a protein. The ribosome reads that recipe and makes that protein. So the information the cell needs about what proteins to make and how to make them is in the DNA, which is in the nucleus. When DNA wants to instruct the cell, it sends its messenger, RNA, out of the nucleus with a recipe. The ribosome reads that recipe and "cooks up" the protein that the cell needs.



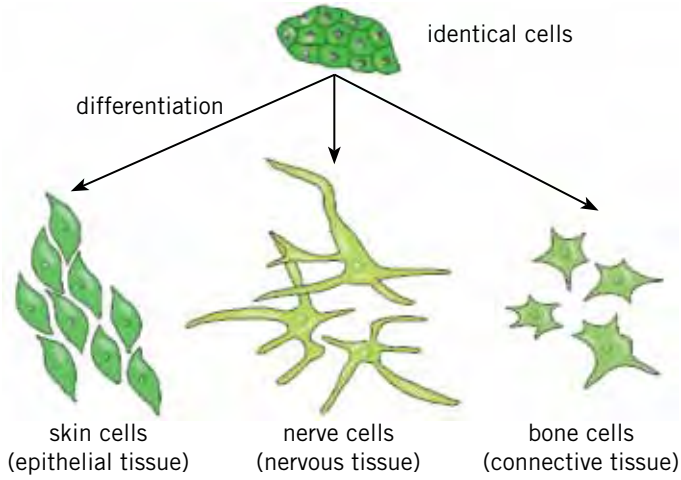
RNA copies recipes from DNA and leaves the nucleus so the ribosomes can make proteins according to the recipes.

Wow. That was a lot of information about cell anatomy. You are becoming quite an expert. Tell someone all that you remember from the last part you read.

Cell Creation

Your body contains billions and billions of cells. Where did all those cells come from? Well, they were copied from the first cell that made you. Every single cell in your body came from one original cell, which was formed at the moment of your creation.

Have you ever tried to copy something? Maybe you do copywork exercises in school. If so, you understand that it's hard not to make a mistake. Well, can you imagine copying something 100 times without making a lot of mistakes? Think of it! As each of us grows from one cell to the many billions of cells that make up a person, the nucleus (with the help of the centrioles) directs the cell to copy itself billions of times! For most



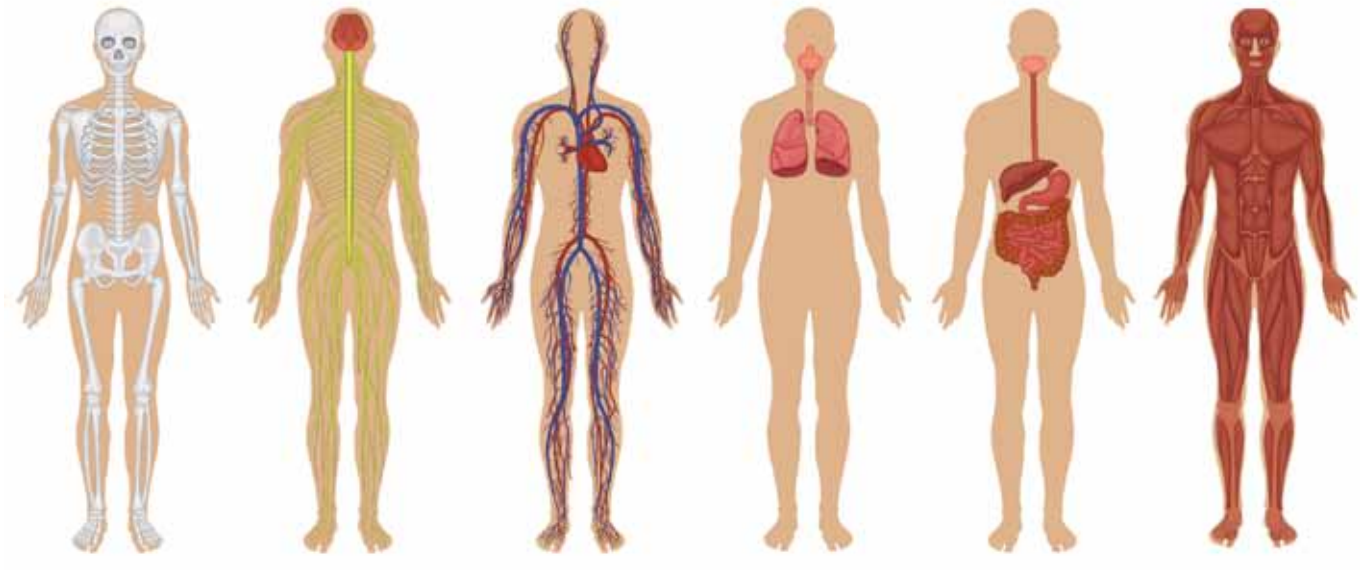
When cells differentiate, they become specific cells that can make specific tissues.

people, all this happens without mistakes.

At first, each cell makes an exact copy of that first created cell. But by the end of the first week of your little life, the cells begin to **differentiate** (dif' uh ren' she ayt). What do you think that means? That means they become different. They differentiate into cells that will go on to become muscle cells, brain cells, and so on. Then, these collections of specific cell types form **tissues**. A tissue is simply a group of cells of the same type.

There are four main kinds of tissue: **nervous tissue**, **muscular tissue**, **connective tissue**, and **epithelial** (ep' uh thee' lee uhl) **tissue**. Muscular tissue makes muscles. Nervous tissue makes up your brain, spinal cord, and nerves, which help you feel the world around you and control the parts of your body you want to control. Connective tissue is tissue that connects to other organs in your body. For example, connective tissue connects your muscles to your bones and keeps your skin where it's supposed to be. The last type of tissue is the kind you see with your eyes. In fact, your epithelial tissue is showing right now, because your skin is made of epithelial tissue! Epithelial tissue also includes the lining of your mouth and nose as well as the lining of many organs. God uses these four tissue types over and over, in different locations and combinations, to form all your many organs.

An organ is a group of tissues that work together to perform a special function. As you develop, your tissues come together to form organs. They begin doing this within three weeks of your life as your body forms inside your mother. In 21 short days, that very first cell has reproduced and has begun to create your brain, heart, and other organs. Groups of organs then begin to form entire organ systems, such as the digestive system, which includes your mouth, stomach, and intestines.



These are some of the organ systems you will learn about in this course. Remember that organ systems are made of organs, organs are made of tissues, and tissues are made of cells.

Your body has eleven organ systems, and this book will take you on a journey to learn about most of them. You'll learn about the cells, tissues, and organs that form the organ systems inside your body. Since cells are the building blocks of all systems, you'll get to learn a lot about different kinds of cells as you study anatomy. Cells may be small, but they are very interesting and important.

Even after you have finished growing, every single hour of every single day, your body produces nearly exact copies of millions and millions of cells in order to replace old and worn out cells. For example, did you know that you shed about four pounds of skin cells each year? Count up how many pounds of skin comes from all your family members each year by multiplying 4 times the number of people in your home. No wonder your house gets dusty! As each of these skin cells dies and flakes off, it is replaced by a new cell. Every time you get a cut, new skin is made to replace the damaged or lost cells resulting from your cut. Wow! Your cells are really busy aren't they?

I know you think all cells are simply too small to see with your own eyes, but there are some cells in your body that are actually pretty long. The nerve cells in your legs are thinner than the strands of a spider's web, but they can be more than 3 feet in length! Another kind of cell that you can see is a chicken egg. The entire egg actually starts out as just one single cell.

So now you are a cell expert. Hopefully, you've enjoyed learning all about cells. It's now time to answer some questions about what you've learned. Then, you can do some special activities and projects to have fun learning more about cells!

What Do You Remember?

What tells us that the Egyptians understood a lot about anatomy? How do the laws that God gave to the Hebrews show us that God cares about our health? What was wrong with the way the Greeks decided on their scientific beliefs? What did Galen use to treat gladiators' wounds? What did Hooke call the tiny rectangles he saw in the cork he examined under a microscope? Name the different cell parts about which you've learned.

An egg is a single cell. If a baby chick starts developing in the egg, however, it quickly becomes more than one cell.

Notebooking Activities

You will create a notebook of all you've learned in this study of anatomy. You can purchase a beautiful *Anatomy Notebooking Journal* that goes along with this book, or if you prefer, you can make your own notebook. Simply use a notebook and copy paper to complete the notebooking journal assignments that you will be given in each lesson. Today's notebooking assignment is to write a simple description about the history of anatomy, from the ancient Egyptians to the discovery of the microscope. You can draw or paste a photo about each scientist or discovery. Remember that your cell illustration needs to be put into your notebook as well.

Personal Person Project

Throughout this course you will add pictures of the organs you've studied to a paper model. This will be your Personal Person Project, and it will be kept in your notebook. You will begin by drawing the form of a person on an 8-inch x 10-inch sheet of paper. Then, you'll personalize the form with a picture of your head on top. As you progress through the lessons, you will add the different organ systems about which you are learning to your Personal Person. If you have the *Anatomy Notebooking Journal*, all the templates for completing your entire Personal Person can be found in the appendix. You will only need to add your head to personalize it. You will

keep your "progressing" Personal Person on the first page of your *Anatomy Notebooking Journal*. If you do not have the *Anatomy Notebooking Journal*, you can simply draw your version of the organ systems (based on the pictures provided in the textbook) and add them to your Personal Person. You can also print pictures of the organ systems from the Internet. Today, you are going to create the outline of your Personal Person.

You will need:

- A sheet of 8-inch x 10-inch paper (flesh-colored construction paper is recommended)
- A pencil
- Scissors
- A photograph of your face (between 2 and 3 inches tall)
- Tape

1. Fold your paper in half along the longest side.
2. Reduce the size of your paper by cutting three inches off the top.
3. On your paper, trace half a human body from the shoulders to the feet, beginning at the top folded edge. Use the pictures on the right to guide you in your drawing. Your outline does not have to be perfect.
4. Cut out the half-figure and unfold it to reveal a whole person.
5. Place your person in your notebook. If you have the *Anatomy Notebooking Journal*, there's a page near the front entitled, "Personal Person" upon which you should glue your person.
6. Cut out your face and neck from the picture of yourself.
7. Place the picture on the shoulders of your person and tape it at the top. You want the head to lift up, because you will be placing a brain underneath it later on when you study the brain.
8. As you add organs to your Personal Person, you will want to attach them in such a way that you can lift up the organs and see what is underneath.

At the end of each lesson, you will find instructions for adding the organs you've studied to your Personal Person.

Project

Edible Cell

You learned a lot about cells. It's pretty easy to forget all that you learned. So, you are going to make an edible Jell-O cell to help you remember the different parts of a cell. You will be using various kinds of candy to represent your organelles. Options are given below for some of the organelles. Choose whichever kind of candy you would like to use.

You will need:

- A sharp steak knife and a parent to use it
- A spoon
- A plate
- A glass or ceramic cereal bowl (You'll need one for each cell you intend to make.)
- Cooking spray, like Pam
- A box of yellow colored Jell-O (This will be the cytoplasm.)
- A box of unflavored Knox Gelatin (This will be used to keep your cell together as you add organelles.)
- A jelly bean or a peanut M&M candy (This will represent a mitochondrion, which is the singular of mitochondria.)
- Several Skittles, Everlasting Gobstoppers or M&M candies (These will be the lysosomes.)
- A Starburst Gummiburst or several Smarties (These will make the Golgi body.)
- A Fruit Roll Up (This will be the endoplasmic reticulum.)
- Nerds or cake sprinkles (These will be the ribosomes.)
- Tubular cake sprinkles or Twizzler Pull and Peels (These will be the centrioles.)
- A large gumdrop, jaw breaker, or round chocolate truffle (This will be the nucleus.)

1. Mix the Jell-O according to the package directions, but add one package from the Knox gelatin box and one extra cup of cold water.
2. Spray cooking spray on the inside surface of your bowl.
3. Pour your Jell-O/Knox mixture into your bowl. If there is any left over, do whatever you want with it. Remember, you could make more cells.
4. Let the Jell-O/Knox mixture (the cytoplasm) harden for several hours (overnight is preferred).
5. Once the cytoplasm is hardened, use a sharp steak knife to cut out small segments of the Jell-O, where each organelle will be placed. Be certain not to cut all the way through. Try to make your cut match the size of the organelle you will place in the cytoplasm.
6. Once you have finished placing your organelles into the cytoplasm, carefully turn the bowl over onto a plate. You've just made an edible cell!
7. Take some photographs of your cell for your notebook. Eat and enjoy!