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LESSON 1

Chemistry and Physics Matter

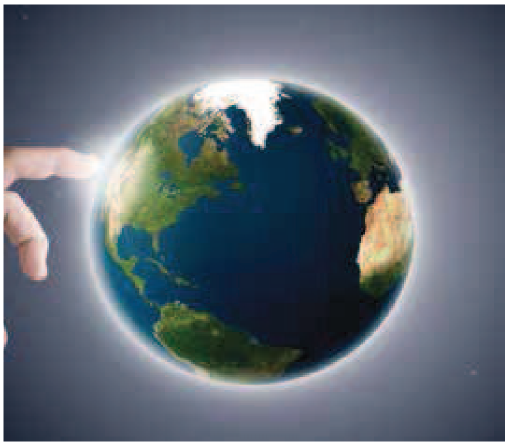
You are embarking on an adventure—an adventure filled with fascinating facts, exciting experiments, dynamic demonstrations, and power-packed projects. On this journey you'll learn about two of the most interesting fields of science: physics and chemistry. They're the sciences God created to make everything around you operate as it does. You're about to learn how God made the world work. Are you excited? Well, you might be wondering, "What on earth is physics?" and "What exactly is chemistry?" Those are great questions—important questions. In fact, even if you haven't asked these questions, I'm going to answer them for you!

Chemistry and **physics** are the studies of matter and energy. But what *are* these things called matter and energy? Simply put, matter is anything that takes up space. Regardless of how small that space is, if it takes up *any* amount of space, it's matter. Is a dust particle flying through your house matter? Yes, it is! Is a microscopic germ on the back of a flea matter? Indeed, it is! *Anything* that takes up space is matter. In this book, we'll study matter and all the things God used to make everything you see around you.

Energy is what makes everything in the world work, move, and do things. When your oven heats your food, it's using energy. When the sun warms the earth, that's energy. When you sing, the air passing by your vocal cords vibrates. That's energy too. When the earth spins on its axis or revolves around the sun, it's energy that keeps it moving. How about the ocean waves and the wind in the trees? All these things are moved by energy. You'll learn all about it in this book.

In the grand scheme of things, physics and chemistry are really the studies of how God put the world together and made it work.

In the Beginning



Do you remember what the Bible says after "In the beginning"? Let's say it together: "In the beginning, God created the heavens and the earth" (Genesis 1:1, ESV). Think about it! That means God created *matter* in the very beginning. The Bible tells us God created everything in six days and then rested. He started by creating light. Then He separated the sea from the sky. After that, God made the land appear and plants grow on it. He then made all the animals. Finally, God made human beings in His image. All that matter uses energy in some way, so matter and energy were created in the beginning. Now you know why chemistry and physics are important sciences to study. Every other science depends on them!

Let's read an important passage in the Bible that you should probably memorize. It speaks about our Lord Jesus. It's one of my favorites because it shows us who our Creator really is. "He is the image of the invisible God, the firstborn of all creation. For by him all things were created, in heaven and on earth, visible and invisible, whether thrones or dominions or rulers or authorities—all things were created through him and for him. And he is before all things, and in him all things hold together" (Colossians 1:15–17, ESV).

How many things were created by Jesus? Look at the second sentence. It says *all* things. Look at the last sentence again. Who holds it all together? The Lord Jesus does! And guess what? He used energy to create it, and we'll soon discover in this book that He uses energy to hold it all together.

Although scientists aren't exactly sure what energy is, they know that energy is what makes these flowers and these girls grow.

We'll be studying a whole lot about energy in this book. As you learn, I want you to remember this one thing: Scientists don't know exactly what energy is or where it comes from; they only know how it works. When you study energy, remember that God created it. The Bible tells us God holds all things together. Scientists have learned that energy holds all things together. Since God created everything, including energy, we know that He's the author of chemistry and physics! Chemistry and physics all boil down to one single thing—God!

Take time right now to read Genesis 1:1–2:4. After you're done, continue reading this lesson.

Forming the World

Before God created the dry ground and all you see around you, the earth was without form and empty.

Fill in this sentence: In the beginning, the earth was __________. Some Bible versions say "formless." Some say "without form." Both mean the same thing. What things can you think of that have no special form or shape? There are some things in the world of chemistry that have no special form. One of those things is liquid. A liquid takes on the form of the container it's in. When you pour a glass of milk, the milk takes on the form of the glass. When you spill milk, it forms itself to the table or floor. It really has no form of its own. Gas also has no form. So in the beginning, the earth was probably one of these two things. Which do you think it was? The next verse tells us: "The Spirit of God moved upon the face of the waters." Aha! In the first chapter of Genesis, we're introduced to a special and important liquid called water. Remember that I said chemistry and physics are the study of matter and energy. Water is matter. It's a particular kind of matter formed when two different substances bond together. Those two substances are hydrogen and oxygen. Have you ever heard water called **H_2O**? H is for hydrogen, and O is for oxygen. The 2 after the H just means there are two hydrogen atoms. H_2O is called a molecule, which is a collection of bonded atoms. We're going to learn all about atoms and molecules in the next few lessons, but first let's take some time to learn all about matter.

Everything Matters

Have you ever played the game 20 Questions? While I was growing up, my family spent hours playing this game. One person would think of an object—any object in the world. Then the rest of us would ask yes-or-no questions to discover what that object was. The first thing we'd ask was, "Is it an animal, vegetable, or mineral?" "Vegetable" refers to anything that grows from plants. "Animal" refers to any living, moving creature. "Mineral" refers to something that has never been living. Then we'd ask, "Is it bigger than a bread box?" A bread box holds a loaf of bread. We could ask only 20 questions to discover all the properties and uses of the object. So we really had to think of specific questions that gave us a great deal of information. This is what scientists do all the time. They're full of questions about everything they see around them, and they figure out ways to find the answers. They're always interested in the different **properties**—those special features, traits, or attributes of materials found in the universe. Knowing the properties of something helps scientists identify what it is.

How would you describe each item in this picture? How are the items similar? How are they different? What properties does each have? Scientist are always seeking to describe matter according to its properties.

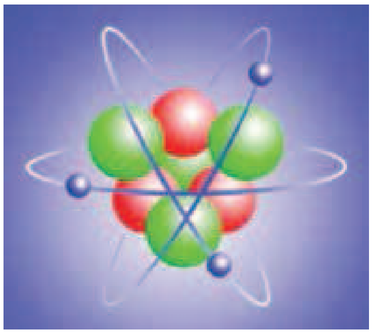
Being able to describe the properties of matter is an important skill. What are the properties of a tree? What are the properties of a cat? Can you describe the properties of a street sign? What about lake water? Is ocean water different from lake water? Everything has different properties. Some things have similar properties. Knowing how to find the properties that separate one thing from another is important.

Try This!

Find a companion and try playing another version of the 20 Questions game called "I Spy." Look around and choose an object in the room. Then say, "I spy with my little eye something that is ____." (Name the color of the object or another property.) Your companion will ask you yes-or-no questions about the object. Remember, only 20 questions are allowed. With each question and answer, you'll be describing the properties of the object. Take turns doing this with one another and have fun spying!

As you can see, the properties of matter are important. Scientists always look for certain properties when they explore matter. Let's study these special properties of matter.

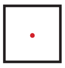
Matter Matters



Although atoms are too small to see, artists draw them to look something like the image here.

I told you earlier that matter is anything that takes up space. Scientists say that **matter** is anything that has volume and mass. Do you know what volume and mass are? You're about to find out. But before we talk about volume, mass, and their cousin, density, I want to tell you a little bit about atoms. Do you know what an atom is? Atoms are the particles that make up everything around you. In the next lesson, we're going to get to know atoms quite well. But for now, you just need to know they exist and that everything you see around you is made up of them. Everything—whether it's hard, soft, wet, sticky, or microscopic—is made up of tiny particles called atoms.

Did I mention that they're teeny tiny? Take a look at the dot below:



That little dot is made up of atoms. How many atoms do you think could fit into that dot? Believe it or not, it would take 7.5 trillion atoms to fill up the dot, so you can imagine how small they are. They'll be mentioned a lot throughout this book. For now, just remember these little particles called atoms make up every single thing in the world.

Let's explore properties now!

Turn Up the Volume

When I bake bread, sometimes the bread rises beautifully. It's big, light, and fluffy. It fills my bread box to the top. It has a lot of volume. But sometimes the bread doesn't rise at all. It's thick and compressed. It has the same amount of bread in it because I used the same recipe, but it doesn't have much volume. It doesn't take up as much space in my bread box.

The amount of space something takes up is called its **volume**. Anything that's matter takes up space, so all matter has volume. That's really important to remember. A fly takes up space, so a fly has volume. Even a germ takes up space, so it has volume. A fly has a much greater volume than a germ. People have a much greater volume than a fly. Do you take up much space? Some people have a lot of volume. Some have only a little bit of volume. Who has the greatest volume in your family?

The larger fly has more volume than the smaller fly.

When this family gets out of the hot tub, the water level will go down.

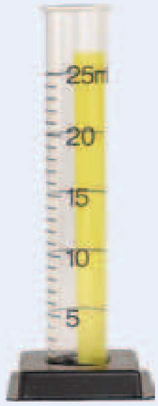
In our backyard we have a hot tub. It's filled with water almost to the top. I can tell who has the most volume in our family by how much the water level rises when people get into the hot tub. When I get in, the water is displaced, rising a little. Then, when all four of my children pile in, the water level rises a lot more. Together, they take up a bunch of space. They're displacing the water even more. You can probably guess what **displace** means. It means to replace matter with another kind of matter—or to move matter. When things are moved by something, they're being displaced. In this case, a liquid (water) is being displaced by solid objects (my children). Eventually, Daddy sees the fun and decides to join us. Guess what happens next? He gets in, and the water flows out of the hot tub onto the deck. He has a huge amount of volume, taking up even more space. So he displaces the water right out of the hot tub!

We can sometimes measure how much volume something has by using water. An ancient Greek mathematician named Archimedes discovered this. The story goes like this: Archimedes' king gave a large volume of gold to a crown maker. He asked him to make him a crown using all that gold. When the king received his crown, he didn't believe that *all* the gold was used to make the crown. He wondered if perhaps the crown maker had taken some of the gold for himself. The king knew the volume of the gold he had sent but was unsure of the weight. How could he tell that the gold in his crown was the same amount of gold that was given to the goldsmith? To find out, he sent for Archimedes, the greatest scientific thinker in his country. Archimedes arrived but was unsure how to find the truth. He couldn't eat or sleep or even bathe for days as he pondered the problem at hand. He was getting really smelly. Finally, he gave in to the pressure of those around him and took a bath. When he got into the bathtub, he was astonished to see the water rise. He realized the amount of water that was displaced was a way to measure volume. It was said that Archimedes jumped out of his tub and ran immediately to the king without getting dressed. He cried, "*Eureka!*" which means "I have found it!" Archimedes was then able to accurately measure the volume of the king's crown. Sadly for the crown maker, the story does not have a happy ending.

Let's try a similar experiment with water so you can see what I mean about volume.

Try This!

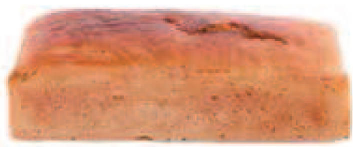
You will need: An adult's supervision, a graduated cylinder, water, and a small, solid object that doesn't absorb water (such as a rock).



To begin, fill the cylinder about halfway with water and take note of where the water level is. Now drop your object into the cylinder. Observe where the water level is now on the cylinder and take note of its measurement. Subtract the first volume measurement from the second volume measurement to find the volume of the object. You now know the exact measurement of how much space that object takes up.

Note: The volume of a liquid is measured in a unit called a liter, while solids are measured using cubic centimeters. You'll convert liters to cubic centimeters to get the correct unit for solids. 1 mL = 1cm^3 (1 cc).





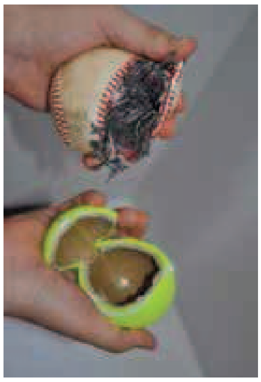

Look at the images above. For each pair, identify which has more volume.

I want you to remember two important things about volume before we study mass: Matter has volume, and volume is how much space something takes up.

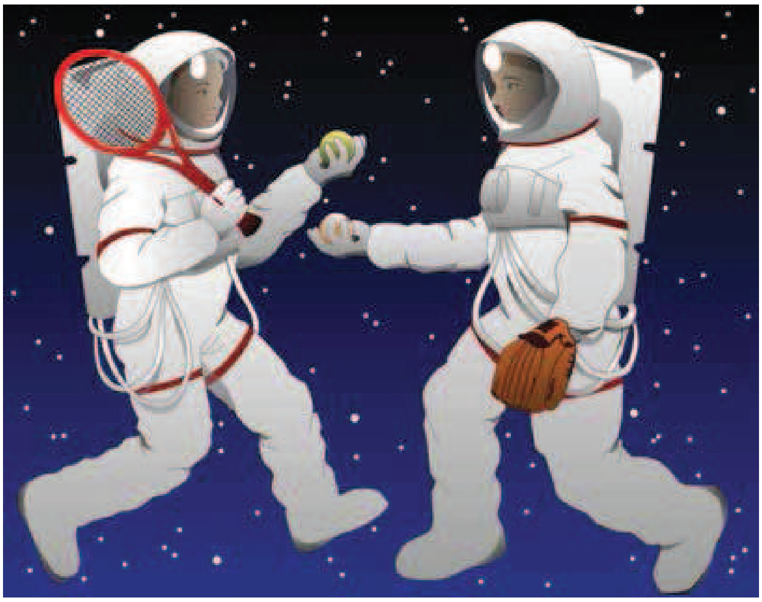
Now that you know what volume is, let's study mass!

Mass Matters

Have you ever held a baseball and tennis ball at the same time? They're about the same size, aren't they? The balls have about the same volume. They take up about the same amount of space. However, one ball is heavier. What about a golf ball and a ping-pong ball? They have about the same volume, but again, one is heavier. Why do you think it's heavier? The baseball and golf ball are heavier because they both have more matter packed inside. A tennis ball and a ping-pong ball are empty on the inside. If something has more matter inside it, we say it has more mass. **Mass** is a very important property of matter that tells us how much matter is inside something.



Since I mentioned weight with the baseball and golf ball, you may be tempted to think of mass in terms of how much things weigh. That's true here on earth. But imagine if you were traveling around in outer space and decided to get out of your spaceship to play some tennis. You get out, taking your tennis ball with you. Your fellow astronaut brings his baseball because he doesn't want to play tennis. There they are—the two balls—in space. Do they weigh anything? No. They weigh nothing in space. However, the baseball still has more mass. Mass doesn't change, but weight does.



Now you know what mass is, but you should also know that we can find mass on earth by weighing things. It's not scientifically accurate to say that mass is how much things weigh. However, we know that on earth, things with more mass weigh more.

Here's the important thing to remember: Matter has mass and volume. That's the actual scientific definition for matter. Anything with mass and volume is matter. Volume refers to the space it takes up, and mass refers to how much stuff is inside it.

Wow! You've learned a lot and are well on your way to becoming a physicist! Before we move on to density, let's review what we've learned.

Tell someone in your own words what matter, volume, and mass are.

The gold bars have more mass than the soap bars.

Density Matters

Density is another important property of matter. In order to understand density, let's try an experiment.

> **Try This!**
>
> **You will need:** An adult's supervision, safety goggles, 2 glasses, 2 eggs, ½ cup of salt, and hot water.
>
> First, run the sink water until it becomes hot. Next, fill both glasses about halfway. Add ½ cup of salt to one of the glasses and stir it well. Now, make a hypothesis (a guess) about what will happen if you drop the eggs in the glasses. What will the eggs do? Go ahead and drop an egg in each glass to see what actually happens.

Were you surprised by the results of the experiment? What happened? Really and truly, density happened! Density is related to mass and volume. In fact, **density** is how much mass is in a certain volume of matter. Does that make sense? I'll try to explain so that you understand.

Let's go back to my bread. The mass of my bread was the same whether it had a lot of volume or not. I used the same amounts of flour, water, and everything else to make both loaves. But one loaf rose and produced fluffy bread with a lot of volume. The other loaf fell and did not have as much volume. But they had the same amount of mass.

The same amounts of flour and other ingredients were added to both of these loaves of bread. However, the one on the left has more volume than the one on the right. That's because it rose during baking, while the other did not.

Now let's add density to this equation. Which bread was denser? Which bread had more mass per volume? Well, the bread that fell had the same mass packed inside that smaller volume. It was dense. The fluffy bread had more volume, but the mass was spread out more, so it was not as dense.

Here's how it works: If something is really dense, there are a lot of particles inside the particular volume of that object. For example, in my bread, the particles are tightly packed together. In the experiment you just did, there was a lot of matter—a lot of extra particles inside the glass with salt in it. There were not as many particles inside the glass with only water.

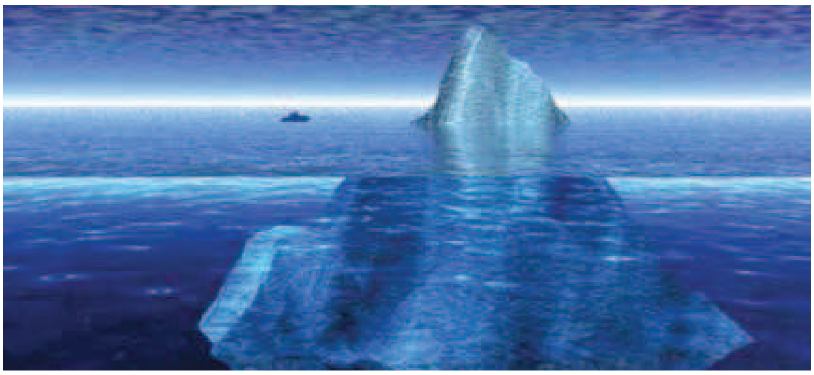
Think of when you pack a lunch for yourself. If you put a couple of things in your lunch box (like a sandwich and a juice box) and close it, you'll have a lot of space between the items in your lunch box. Not a very dense lunch, if you ask me. There's a lot of room in that lunch box. It's a light lunch box. Now if you decide you'd rather have a dense lunch box (and who wouldn't?), you could add a banana, a box of raisins, yogurt, a spoon, a cheese stick, some crackers, an extra bottle of water in case you get thirsty after you finish your juice box, and, of course, a package of cookies. Make that *two* packages of cookies. Now that's a lunch with density! When you close your lunch box, you'll find that all the things inside are closely packed together. Since it's denser, it's also heavier.

Which lunch box is denser—the one on the left or the one on the right?

Let's get back to the eggs. Eggs have more particles packed inside them than water. The egg was denser than plain water, so it sank. But after adding salt to the water, the egg floated. The salt made the egg less dense than the water.

When you get into water, you're usually more dense than the water—so you sink. That's why you had to learn to swim. One time, my family and I went to a part of the ocean that was extremely salty. It was dense water. When we swam out into the ocean from the beach, we just floated in the water without swimming!

Let's try a few more experiments to find out more about density.



Ice is less dense than water. That's why icebergs float in the water. However, 90% of the iceberg is found below the surface of the water.

This man is able to float in the Dead Sea because he's less dense than the very salty water.

Try This!

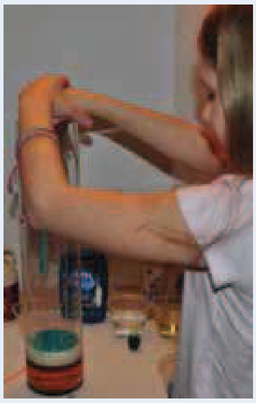
You will need: An adult's supervision, safety goggles, a clear plastic straw, very warm water, food coloring (red, blue, green, and yellow), 4 plastic cups, measuring spoons, and 10 tablespoons of salt.

Begin by filling all the cups ¾ full of very warm water. Make sure the water level is equal in all the cups. Now place several drops of a different color of food coloring in each cup. Next, add 1 tablespoon of salt to the blue water and stir it until the salt has dissolved. Put 2 tablespoons of salt into the red water and stir. Next, add 3 tablespoons of salt to the green water and stir. Finally, put 4 tablespoons of salt into the yellow water and stir.

Place one end of the straw about 1 inch into the blue water, and place your index finger over the other end of the straw. Pull the straw out of the water, keeping your finger at the top so the water stays in the straw. Without releasing your finger, lower the straw into the red cup about an inch lower than the blue cup (about 2 inches). Now carefully release your finger from the top of the straw. The red liquid will push the blue layer up to the level of the water in the cup. Press your finger firmly on top of the straw and remove the straw. Next place the straw 3 inches into the green cup and carefully release the straw so that it fills with green liquid just a bit. Put your finger back over the top and remove the straw. Next, do the same with the yellow liquid. Put it inside the cup an inch lower than all the others, and allow some liquid in. You now have four layers of colored water in your straw!

Try This!

You will need: An adult's supervision; safety goggles; a tall, thin glass or vase, honey, corn syrup, 100% pure maple syrup; whole milk; dish soap; water; vegetable oil; rubbing alcohol; 8 plastic cups; a turkey baster; food coloring; a popcorn kernel; a die from a game; a cherry tomato; bead; a piece of a plastic straw; and a ping-pong ball or marshmallow.



Pour 8 ounces of each liquid listed above into a separate cup. Place a drop of a different color of food coloring into each cup except the cups with the oil and honey. Write down the color for each liquid. (Example: maple syrup: red, water: green, etc.) Next, pour the following cups of liquid very, very *slowly and carefully* into the center of the glass container one at a time in the following order (*make sure the liquids do not touch the sides of the container while you are pouring*): honey, corn syrup, and maple syrup. For the next two liquids, use the turkey baster to *slowly and carefully* drip the liquids into the middle of the glass container: milk and dish soap. For the rest of the liquids, use the turkey baster to *slowly and carefully* pour the liquids down the side of the container: water, vegetable oil, and rubbing alcohol. Now make a hypothesis (an educated guess) about which items (popcorn kernel, die, cherry tomato, etc.) will land in which layer of liquid based on density. Write down your hypothesis. Finally, drop the items one by one into the glass container and watch which layers they rest in.

How did the colors separate in the first experiment? It was density! You added more and more salt to the water, making it more and more dense. The solution with the highest density (yellow) stayed at the bottom of the straw while the solution with the least amount of salt (and the lowest density) remained at the top. Because you increased the amount of salt in each cup (and kept the volume of water in each cup the same), each liquid had a different density. Therefore, the liquids separated into different layers.

Were you surprised by what you saw in the second experiment? Each object sank until it found a level that had more density than it did. Obviously, the die was the densest object and sank to the bottom.

Spend some time telling someone all you've learned about mass, volume, and density.

Try This!

You will need: An adult's supervision; a bowl of water; and several items from around the house, like a piece of wood, a cork, a piece of ice, some coins, and a few different plastic toys.

Predict whether or not each item you collected will sink or float. Now place the items one by one in the bowl of water. What happens? Are you surprised by the results?

Buoyancy Basics

When something floats in water, we say it's buoyant. **Buoyancy** is the ability of something to float. It's buoyant because of the upward push of the water. If you put a raft in a pool, the upward push of the water on the raft is strong enough to keep the raft afloat. But if you drop a nail in the pool, the upward push of the water is not strong enough to keep the nail floating. This goes back to density. If the density of an object is less than the density of the liquid, it floats in the liquid! Some objects may seem like they would be denser than water—metal, for example. But their shape changes their density. Boats are an example of this. They're shaped in a way that increases their volume, which decreases their density, allowing more air to fill them.

Shipbuilders design and build ships in a way that increases the surface area. The ship's metal is flat and spread out, with high sides. This enables the ship to go down into the water with a lot of air in the submerged part of the ship.

Try This!

You will need: An adult's supervision, safety goggles, a large pan of warm water, a few drops of blue food coloring, pennies, ¼ cup of salt, and aluminum foil.

Imagine that a pirate ship was captured and you've been asked to bring all the treasures from the ship back to shore. You need to design a boat out of foil that can hold all that treasure. Your pennies will be the treasure! First, fill a large pan with warm water. Add the salt and food coloring. Next, design and construct a boat out of the aluminum foil. How many pennies do you think your boat can hold? Make a guess. Now float the boat in the water. Then place as many pennies in the boat as it will hold before it sinks. If you're doing this with others, have a contest to see whose boat can hold the most pirate treasure!

Spend some time explaining to someone what you've learned so far. If you're finished reading for the day, write down in your notebooking journal a few of the things you've learned. Be sure to include illustrations!

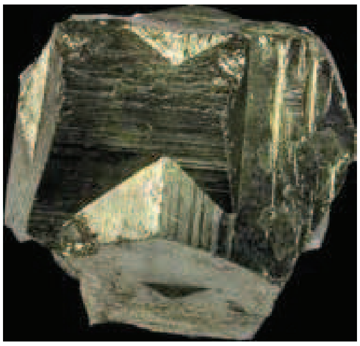
More on Matter

Now you know that matter has mass, volume, density, and buoyancy. But that's not all you need to know to identify matter around you. Consider the pillow on your couch or bed. How would you describe it? Consider the knife in your kitchen. What about the vinegar in your pantry? Each of these items has other properties that are unique. Some of the other important properties we should consider include color, shape, hardness, odor, and taste (although you shouldn't taste things that are not food because they might be poisonous). These features can help determine what it is we see around us.

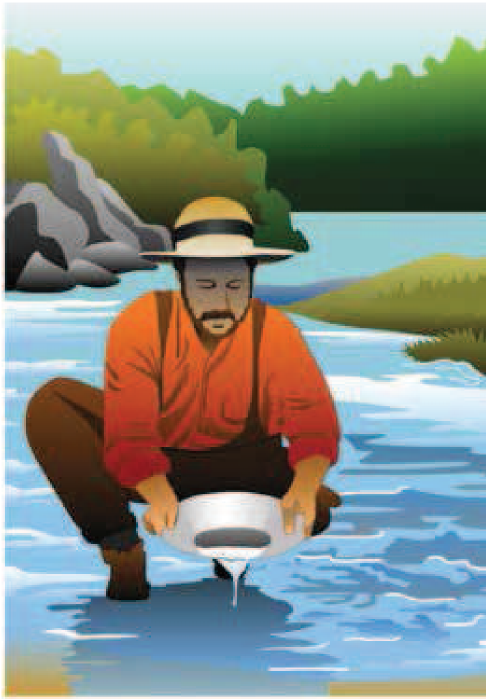
Let's take a quick look at these other properties of matter before we close this lesson. Then we'll do a fun project.

The Golden Rule

Years ago, when gold was discovered in California, thousands of people poured into the hills and panned for gold in the rivers and streams. Sometimes they would see shiny gold in their pans and believe they had hit the jackpot. Hooray! They would never have to work again! They were rich! But many times what they thought was gold was really a gold copycat called iron pyrite—later known as fool's gold. Iron pyrite looks like gold, but it's not. How could you discover whether you had real gold or iron pyrite? Well, you would need to explore the physical properties of the golden material you found. We'll be looking at luster, color, shape, hardness, and odor to discover the properties of gold versus iron pyrite.



Many times gold miners would mistake iron pyrite (left) for genuine gold (right). They had to know the special properties of each not to be fooled.

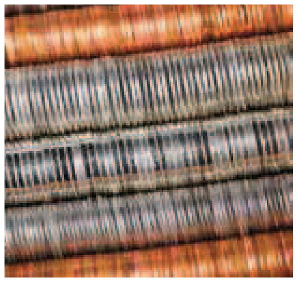


Prospectors poured into California to pan the rivers for gold. Many times they would find substances that only looked like gold.

Luster Matters

Have you ever noticed that some things shine while other things don't? Look around the room you're in. What would you say is the shiniest thing in the room? Do you have a brass lamp or light hanging from the ceiling? Is someone wearing a shiny ring? The amount of shine something has is called **luster**. It's really hard to tell fool's gold from real gold based on luster. That's because fool's gold is really shiny—maybe even shinier than real gold.

Most metals are quite lustrous. Both gold and fool's gold—as well as silver, aluminum, copper, brass, and other metals—are shiny or lustrous. So although luster is an important property of matter, it's not going to tell you whether your piece of golden matter is valuable or not. But you can look at the color and find some clues to identify the material.



Although these coins are made out of different metals, they're all quite lustrous.

Color May Matter

Silver

Aluminum

All matter has its own special color. Pure gold has one color, and pure silver has another. Aluminum is similar to silver in color, but not exactly the same. Look at the images of silver and aluminum on this page. Their colors closely match, but they're not identical.

However, some materials are exactly the same color. Therefore, you'll have to look at other properties besides color to determine which material is which. Suppose you have a piece of silver and a piece of aluminum and aren't sure which is which. How do you tell? Well, the best way to tell the difference is to find the density of each and compare. Silver is almost four times denser than aluminum.

Gold

Iron pyrite

Gold and iron pyrite don't match as closely as silver and aluminum. Look at the pictures on this page of gold and iron pyrite. Do you notice that gold looks more yellow than iron pyrite? We might say iron pyrite has a silvery gold or brass tone. If you had a piece of real gold, you could compare the color. But what if you don't have a piece of real gold? Density is an excellent test here as well; gold is almost four times denser than iron pyrite. Iron pyrite might look like real gold if you don't have any gold with which to compare it. But there are other properties you can explore if you still aren't sure which material you have found.

Let's look now at the property of shape.

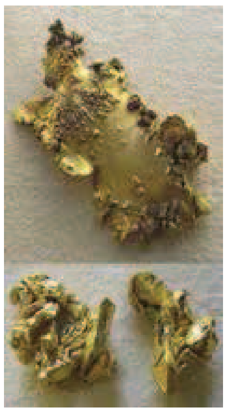
Try This! If you have a rocky yard or know of a place where a lot of rocks can be found, go out there today and explore to see if you can find rocks with geometric shapes. Try to find as many different types of shapes as you can. Draw pictures of the rocks or take photos for your notebooking journal.

The Shape of Matter

Shape can be an important clue to discover what element you've found. Look at the shapes of the different pieces of gold on this page. Do you notice that iron pyrite is shaped more symmetrically than gold? It typically forms in a particular pattern or structure, with geometrically shaped pieces stuck together. We say it's crystallized or it forms crystals. We'll talk more about crystals later and even make some! But real gold is found in nuggets. They're often odd, uneven-shaped pieces. In fact, gold can be found in sheets, in flakes, or even in grains. If the golden material is oddly shaped, you may be in the money! If it looks geometric, it's probably fool's gold.

But maybe you still aren't sure. Well, there's another property of matter you can explore to get more information that will help you get to the bottom of the mystery. Let's look at how hard or soft the materials are.

Iron pyrite has a geometric shape.



Gold has an odd, uneven shape.

Hardness Matters

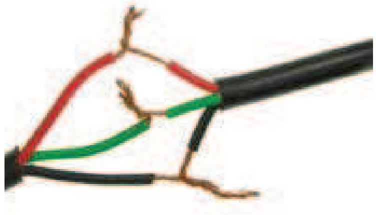
Although they're made of metal, these cans are able to be crushed rather easily. This tells us that the metal used is malleable.

Every material in nature has a different hardness to it. A wood floor is pretty hard. But would you rather fall on a wood floor or a granite floor? Granite is a lot harder than wood. The Bible tells us that the streets in heaven are paved with gold. Pure gold is really soft. That means if we fall down on the streets in heaven, it'll probably make a dent in the street but won't hurt us.

Hardness is an important property to explore when determining whether or not you need to keep searching for your pot of gold. As I said, pure gold is soft and bendable. We call bendable materials **malleable** (**mal** ee uh buhl). We sometimes call this **plasticity** (pla **sti** si tee). This means a material can be changed into a different shape without breaking. Does the word plasticity remind you of anything? You probably thought of the word plastic. Well, plastic gets its name from this property. Plastic items can be molded into almost anything. We'll learn all about plastics in lesson 4. If you pound gold with a hammer, it will bend into different shapes. It can also be pounded into extremely thin leaves. This isn't true of iron pyrite. Therefore, iron pyrite is harder than gold. If you pound iron pyrite with a hammer, it'll smash into pieces because it's brittle.

A copper piggy bank would be difficult to break open.

Scientists also talk about **ductility**, which is whether or not the object can be made into a wire. Many metals—such as gold, silver, and copper—can be formed into a wire. We say they're very ductile. But you can't form iron pyrite into a wire. Actually, you can't form it into anything.

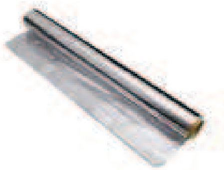


Copper is very ductile because it's easily shaped into wires. Most wires are made of copper because copper has many properties needed for wires.

Rate the materials in the picture below in the order of how hard they are. Put the hardest material first and the softest material last.

Wood

Rock



Aluminum foil

Clay

You can definitely decide whether you have gold or fool's gold depending on what happens if you hit it with a hammer.

What if you don't have a hammer? Well, you could always smell the golden chunk! Yes, indeed, you could smell it!

Try This!

You probably have a lot of metal objects in your house such as coins, hardware, tools, and more. Gather some now so you can discover the different smells of metals. Which ones smell and which ones do not? You can find out by rubbing the metal objects with your fingers and sniffing to see if an odor lingers on your hands. Wash your hands and try with other metals. It may be helpful to have a damp paper towel handy to clean your hands between objects.

Smell Matters

We often use the sense of smell to discover the identity of things. This girl is smelling basil leaves to determine what they are.

Believe it or not, you can tell whether or not you have fool's gold or gold by the odor of the golden chunk in your possession. Gold actually has no smell at all. But if you rub iron pyrite on a hard, scratchy surface, it will give off a boiled-egg-like odor. This is because both eggs and pyrite contain sulfur atoms and produce the foul-smelling gas hydrogen sulfide.

So far, you've learned a lot about the differences between gold and iron pyrite. If you were panning for gold, you could find out pretty quickly whether or not that shiny matter in your pan was fooling you. There are also some other properties of matter you could use to discover the contents of your pan. Let's look at those before we close this lesson.

More Properties Matter

Not all objects stick to magnets. Objects that stick are made of iron.

There are two other ways to help decide what material you have: check the density and check the magnetism. Gold will sink in a swirling pan of water, while iron pyrite may be washed away. This is because gold is one of the densest substances on earth—19.3 times denser than water. When panning for gold, prospectors would add more water to the pan, swirling and swirling the pan. The heavier substances would then sink to the bottom. This is how they collected their gold nuggets, or more often gold flecks.

Another property of iron pyrite is magnetism. Gold will not stick to magnets. If you had a strong magnet handy, you could easily tell whether you had gold or not.

We'll study magnetism in great detail in another lesson. But let's take a few minutes now to learn a little about it in this experiment. Are you ready to find out what items in your house are magnetic?

Try This!

You will need: An adult's supervision; a strong magnet; and several items from your home, such as needles, tacks, tools, hair accessories, and more. First, take a guess which items are steel (made of iron) and which are not. Can you tell which of the items are magnetic? Test them out with a magnet to see if you're correct!

Some metals are not magnetic, as you were able to see. This tells us much about their properties.

If you still aren't sure whether or not you have gold, you could perform a chemistry experiment to see how your golden chunk reacts to certain chemicals. However, these types of experiments should not be done at home. For example, you might pour hydrochloric acid on your golden material. Iron pyrite will foam and dissolve when this extremely dangerous and caustic acid comes into contact with it. (The foaming gas is hydrogen sulfide, which is quite toxic in such amounts.) Gold won't change a bit.

There are other chemical tests people can perform to determine what substance they have in front of them. The chemicals used in these tests cause reactions that help scientists discover what the material is. For example, if I had two very light, silvery metals in front of me, how would I know whether I had potassium or aluminum?

You probably have aluminum foil in your house right now, but hopefully you don't have pure potassium. It looks just like aluminum, but potassium is so soft you can easily cut it with a knife. An easy chemical test to do is to toss both substances in water. Potassium will catch fire and then explode, but aluminum won't be affected. Now you know why I was hoping you didn't have potassium in your house! Some pans are made out of aluminum. Do you think they tried to make potassium pans first? No, I don't think so.

Final Matters

Isn't it wonderful how God created so many different things when He made the earth? You're going to be amazed as you continue your journey through chemistry and physics! God's world is filled with matter, and the more we learn about all that He made, the more we understand Him and how much He loves us.

See if you can remember some of the things you've learned by answering the questions below. After that, you'll do a fun notebooking activity followed by an entertaining project.

What Do You Remember?

Physics and chemistry are both the studies of __________ and ___________. Matter is defined as anything that has __________ and __________. What is mass? Why is mass not always measured by weight? How can we measure volume? Which is denser—a cube of wood or the same size cube of gold? Why? Name as many properties of matter as you can recall.

Notebooking Activities

Your first notebooking assignment is to write down and illustrate some of the fascinating facts you want to remember about matter. If you have the *Chemistry and Physics Notebooking Journal*, a template is provided for you to use. After you've recorded your facts, do the following notebooking activity.

Have you ever been to a play? If not, have you seen a television show or watched a movie? All the actors perform the lines that were written by a playwright or screenwriter. A playwright writes plays, and a screenwriter writes scripts for movies and TV shows. A script tells each actor what to say and when to say it. Sometimes the script even includes stage directions, which tell actors things they should do or where they should move.

For your notebooking activity you will become a playwright. You are going to create a script about Archimedes and the golden crown. Your play will reenact the events that took place when the king needed a new crown and hired Archimedes to discover whether he had been cheated or not.

The *Chemistry and Physics Notebooking Journal* includes a template that you may use to create your play. The example below shows what a play script might look like.

King: Crown maker, I'm so glad you came! I need a new crown! Use all of this gold to create my new crown. (King hands gold to crown maker.)

Crown maker: Yes, your Majesty.

King: Be sure to use every bit of the gold.

Crown maker: Of course, your Majesty. I would never cheat you, your Majesty.

King: That would be most unwise. I expect it to be ready next week.

A week passes

Crown maker: Your Majesty, here is your beautiful new crown.

Project
Lava Lamps

Let's have some fun with density by making our own lava lamps!

You will need:

- 3 tall, thin plastic bottles with caps, like a soda or water bottle (Be sure to remove any labels so you can see the lava more clearly.)
- a lot of water (or vinegar for a stronger reaction)
- food coloring (3 colors of your choice)
- a large bottle of vegetable oil
- Alka-Seltzer tablets (Get a whole box!)

1. Fill each bottle halfway with oil.
2. Now fill the bottles up to the top with water. (For a bigger reaction use vinegar.)
3. Drop 3 drops of a different color food coloring into each bottle. Shake each bottle up a bit so the color can break down through the oil seal and color the water. Give the oil and water (or vinegar) a few minutes to settle back down into distinct layers before moving on to the next step.
4. Drop 1 Alka-Seltzer tablet into each bottle and place the caps on the bottles immediately to prevent the lava from overflowing.
5. Have fun watching the lava bubble up!

What happened in this project? Alka-Seltzer tablets don't react in vegetable oil. So the tablets you dropped in the bottles fell down through the vegetable oil and into the water or vinegar. When the tablets touched the water or vinegar, the chemicals inside the Alka-Seltzer reacted with the water or vinegar. This reaction caused gases to form. These gases were less dense than the oil, so they floated up into the oil, creating a bubbly effect.

Be sure to save your lava lamps as we will be using them in lesson 5.