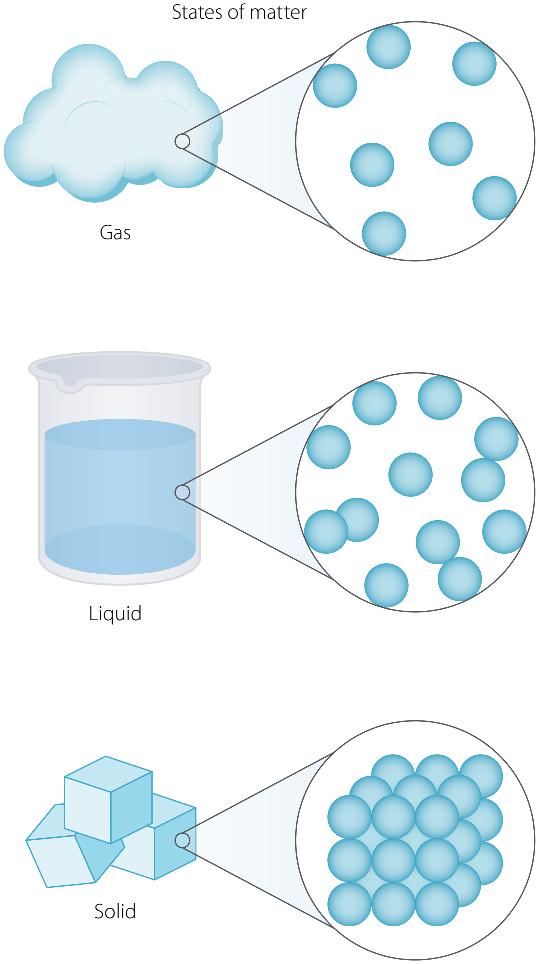
Core Knowledge® SCIENCE

Investigating Matter

Reader

States of matter



Chemical change

Properties of matter

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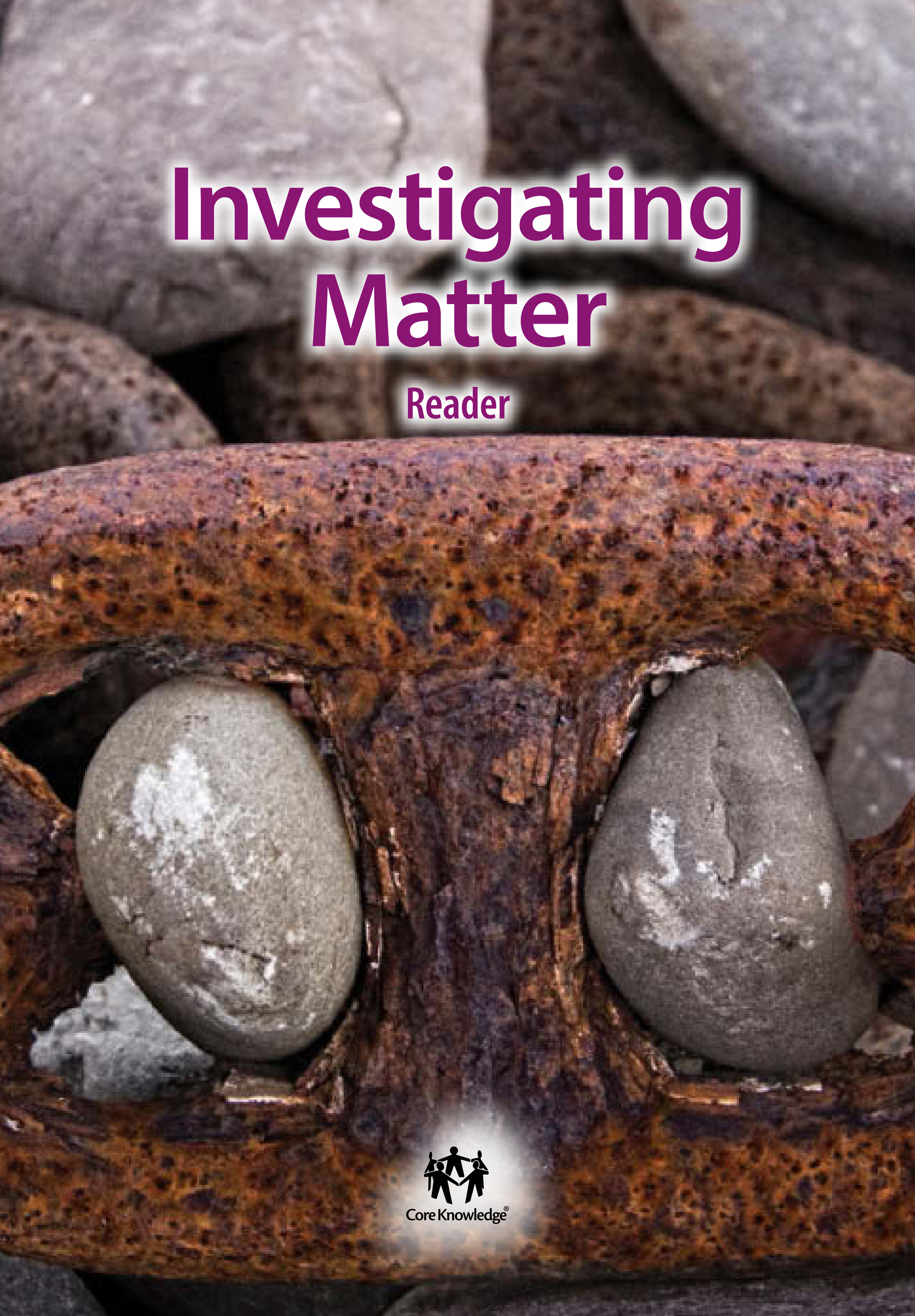

Core Knowledge®

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Investigating Matter

Table of Contents

Properties of Matter

Chapter 1

Everywhere you look there are objects to describe. What do all these have in common? They are made of **matter**. Everything in the universe is made up of matter. This includes all solids, liquids, and gases. Matter is anything that has mass and takes up space.

Big Question

What properties can I use to describe matter?

Vocabulary

matter, n. anything that has mass and takes up space

It is easy to name many different kinds of matter. Just think of what you can see and touch. You can see and touch a rope, a fish, a boat, or water. But there is also matter that you cannot see and matter that isn't easy to touch. Air is matter—it has mass and takes up space. You cannot see air or grab it, though you can feel it as wind. Blow up a balloon with air, and you can see that the air takes up space inside. Air is matter because the gases in it have mass and take up space.

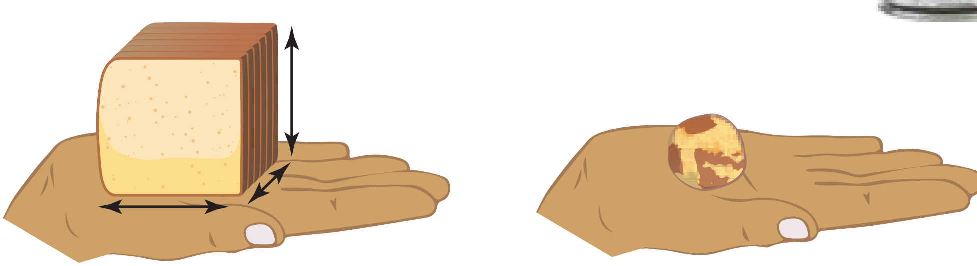
How many different kinds of matter can you identify in this picture?

Weight and Volume Help Describe Amounts of Matter

Mass and Weight: Some objects are made up of more matter than others. Mass refers to the amount of matter an object is made of. A cotton ball has a small mass. A rock that is the same size as the cotton ball has a greater mass. The rock contains more matter than the cotton ball, even though the two objects are the same size.

You can tell which of two objects has more matter by weighing each one. Earth's gravity pulls on all matter near the planet. You can measure the force of gravity on an object by placing it on a scale. Scales determine an object's weight. The more matter an object contains, the greater the pull of gravity on it, and the more it weighs.

Volume: All matter takes up space. When you breathe in, air takes up space in your lungs. You can measure how much space an object takes up using tools such as graduated cylinders and rulers to determine dimensions. These tools help you to measure the volume of an object.



A piece of bread can be described using weight and volume. If it is squeezed into a tight lump, it will take up less space. The weight will be the same, but the volume will be reduced.

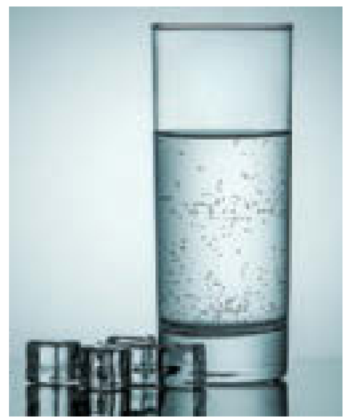
Properties Describe and Help to Identify Types of Matter

Measurements such as weight and volume help us describe the amount of matter in objects. We use other means to describe matter. When we describe how a material looks, feels, or behaves, we are describing the material's **properties**.

Vocabulary

property, n. a quality, trait, or detail used to describe something

What is the solid matter in this picture? You might have identified the glass, but you could also identify the ice cubes. If asked to identify the transparent matter, the material you can see through, you could have named the glass, the ice, and the water.



The examples of matter in this picture have different properties. How would you describe these types of matter?

What is the difference between the glass and the ice, though they are both solids that look a lot alike? You might explain that the ice cubes will melt at room temperature but the glass will not. We can use a combination of properties to describe different examples of matter and tell them apart.

Think About Melting

Ice melts at thirty-two degrees Fahrenheit. Other substances, such as steel, have different properties and do not melt until the temperature is much hotter. Steel is made of a combination of metals that does not melt until the temperature reaches around 2,500 degrees Fahrenheit! The temperature at which an object melts, its melting point, is a property of matter.

Matter Has Physical Properties

Solubility: If you crush a sugar cube, you know that the powder that results is still sugar. You still have the same amount of sugar. You could even measure the weight to be sure.

But what if you mix the sugar into a cup of tea and stir it? The sugar seems to disappear. When you taste the tea, how can you tell the sugar is still there?

The sugar has dissolved in the tea. Tea is mostly water. The property of how matter dissolves is called solubility. Sugar is a type of matter that dissolves in water very easily. It has a high solubility. Sand does not dissolve in water and has low solubility.

How might you describe the differences between table salt, sugar, and white sand that you find on a beach? One way might be to test the solubility of each. Table salt looks a lot like sugar, but the salt takes longer to dissolve in water than sugar. White beach sand looks a lot like both sugar and salt, but it won't dissolve in a glass of water at all. Like other properties, solubility allows you to describe and identify the matter you see around you.

Sugar dissolves in tea, making the tea taste sweeter.

Knowing the properties of matter can help us identify materials and use them to solve engineering problems. Look at the physical properties of a rock called pumice and the metal copper.

Color: Though it can be darker, pumice is usually light tan or gray. What color is the copper? Well, it's "copper"! Copper is so recognizable by the property called color that the name of the color and the name of the mineral are the same.

Hardness: Some rocks and minerals are harder than others. Hardness is tested by scratching the materials with each other to determine which is harder. This is called a scratch test, which you can use to show that copper is harder than pumice.

Reflectivity: When you look in a mirror, you see your image in the shiny, reflective surface. Many rocks and minerals have shiny surfaces that reflect light. Metals such as copper have high reflectivity. Dull materials, such as pumice, have low reflectivity.

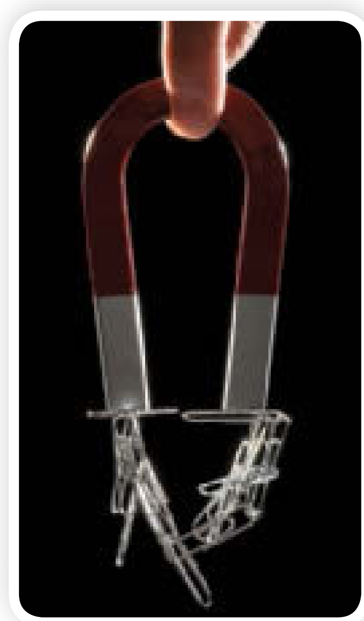
Buoyancy: Pumice is an unusual rock because it floats in water. Pumice floats because the matter in the rock is more spread out than the matter in water. Buoyancy describes an object's ability to float. The more buoyant an object is, the more likely it will float. Copper is not considered buoyant because it sinks.

Metals Have Certain Properties

People use the properties of matter to describe different metals as well. Copper, iron, aluminum, and stainless steel are all metals, but they have different properties. Let's look at three properties that these metals share to varying degrees.

Electrical Conductivity: Copper is used for wires because it is a metal that conducts electricity. An electric current passes through it easily. But an electric current is not conducted at all through the plastic coating on wire. Metals vary in their ability to conduct an electric current.

Heat Conductivity: Pots and pans are made of materials that conduct heat to help cook food. They allow heat to pass through them easily from the stove to the food. Most metals conduct heat well. Many kinds of pots and pans are made from cast iron or copper because these metals conduct heat better than stainless steel and aluminum. You might also notice that most pots and pans have handles made of different materials from the part that sits on the stove burner to make it safer to hold.



Some metals are drawn to magnets.

Magnetism: Matter can be described and identified by its magnetic properties as well. Iron, nickel, and cobalt are metals that are attracted to magnets. Not all metals respond to magnets, though. Try to pick up a copper penny or a piece of aluminum foil with a magnet, and nothing will happen.

Applying Properties of Matter

Chapter 2

Imagine your school has to replace the chains on the playground swings. The school asks the students to act as engineers and come up with a solution to this problem.

When trying to solve a problem, it helps to use the **design process**. The design process is a method people use to find and develop a **solution** to a problem. The solution to a problem can be a physical object, or it can be a procedure for doing things a certain way.

Big Question

How can I use properties as evidence to identify matter?

Vocabulary

design process, n. a plan that is used to find and develop solutions to a problem

solution, n. a way to solve a problem

Why would the school want to replace these chains?

To solve a problem, it helps to start by evaluating solutions that were used by others. For example, chains used in the past had some positive properties and negative properties for use on a swing. Your design can improve on the existing solution or be a completely different solution that solves the same problem.

The Design Process

Define the Problem: The first step in the design process is to define the problem. In our case, we need to replace the chain on the swing. You have to consider criteria, the standards by which something is judged. When we consider what properties the chain should have, we are establishing criteria. You also have to consider constraints, which are limits on the design process.

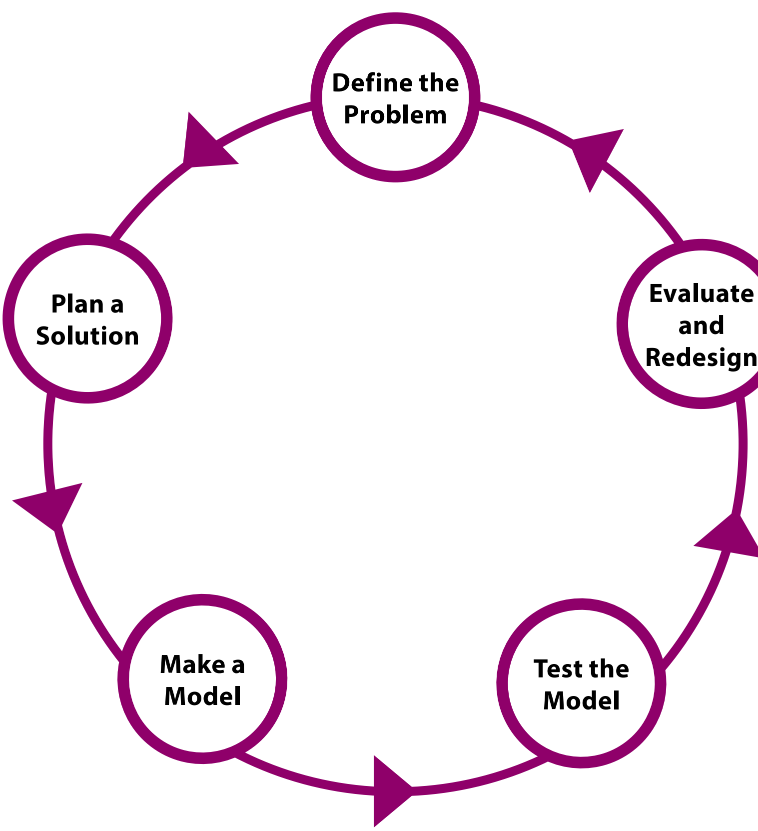
Plan a Solution: The next step is to plan a solution. Think about why the chain needed to be replaced. What part of your solution will address the problem? Be sure to consider the criteria and constraints as you plan a solution.

Make a Model: The next step is to make a model. The model should be similar to real life so you can test your solution under similar circumstances. What properties would your solution to the rusty chain have? What features should your model have to replicate the real world in order to test your solution fairly?

Test the Model: The next step of the process is to test your model. When you test your model, you should test it in similar conditions to how your solution will be used in real life. In what type of conditions would you need to test your solution for a rusty chain? What would be a good test of your solution's properties?

Evaluate and Redesign: The last step of the process is to evaluate your design. Does it meet the criteria and constraints that you set when you defined the problem? Even more important, does your solution work? Some solutions will work without meeting some or all of the criteria and constraints. You may also find that there were criteria and constraints that were missed at the start of the design process. Some great inventions have been the result of errors or mistakes in the design process.

This is also the stage to consider ways to redesign your solution based on testing and based on other criteria and constraints you have uncovered. If your testing reveals that your solution won't work, you should test again and consider ways to redesign your solution.



Selecting Materials Based on Properties

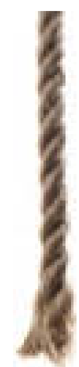
Apply what you have learned to consider good materials to replace the chain on the swing. First, think about the properties, criteria, and constraints of using the chain.

Properties of chain	**Criteria** (things the solution needs to be)	**Constraints** (limits)
• hard • flexible • shiny	• strong • flexible • easy to grip	• cost • size of someone's grip • weight

Now consider three possible solutions to replace the chain. Each possible solution has advantages and disadvantages.

Nylon rope
- strong
- gets stiff in the cold
- weathers well

Nylon strap
- strong
- hard to hold
- does not weather well



Jute rope
- strong
- easy to grip
- does not weather well

How would you test each possible solution? What properties of each solution would you test for? What if none of your solutions meet all of the criteria and constraints?

You would examine why each solution didn't work and apply that as you redesign and test again. In the design solution, you can continue to test and retest solutions until you come up with a solution that works.

Too Small to Be Seen

Chapter 3

Have you ever read a mystery? Mysteries are stories with problems to solve. How do we solve a mystery? We look for clues! Clues are pieces of information that help us solve the problem.

Big Question

How do models help to explain that matter is made of small particles?

To solve problems in science, we look for clues. We call those clues **evidence**. Evidence is information that supports our answers to scientific questions.

Vocabulary

evidence, n. information that helps answer a question, support a claim, or solve a problem

Much of the time, you can answer scientific questions using evidence from observing something. You can use the evidence you observe either directly or indirectly to support a scientific claim. For example—what if you observe that there is water on a cobweb but it hasn't rained? Where did the water come from?

By taking a close look at matter, you can probably figure out the mystery and make a claim about where this water came from.

Air Is Made of Small Particles

Sometimes in science something is too big or too small for us to be able to see. For example, we cannot see Earth all at once because it is too big. But we use **models** of Earth, such as globes and maps, to represent our enormous planet. Similarly, we cannot see air or the **particles** that we breathe in. These particles are too small for our eyes to detect. But we can find evidence that air is all around us. Scientists often use models of matter that is not visible, such as the air in our atmosphere, to help understand and explain how it behaves.

Vocabulary

models, n. pictures, symbols, or physical examples that help explain something that we cannot directly observe

particles, n. tiny pieces of matter that are too small to be seen

Gathering and considering evidence is important to understanding matter, especially air. Consider this scientific claim:

> IF matter is made of particles too small to be seen, THEN we should be able to find evidence to support that idea.

Air is matter, so air has mass and takes up space. But how can we use a model to support this idea with evidence?

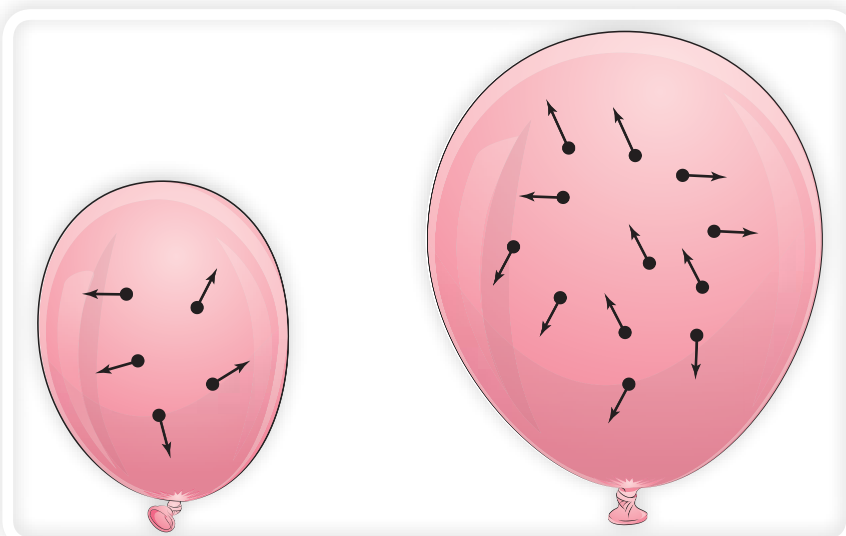
What evidence might you use to prove that the air you breathe takes up space?

Let's generate some supporting evidence using a balloon. When you blow air—a combination of gases—into a balloon, the balloon **expands**, and its shape changes. Does this evidence support the claim that matter is made of particles too small to be seen? Is this evidence that air is made of matter?

Vocabulary

expand, v. to grow bigger

If air didn't have mass or take up space, then the balloon would not have expanded. IF air is matter and made of small particles as we have claimed, THEN the fact that the balloon expands makes sense. Perhaps the idea that matter is made of small particles is correct.



What is the difference between the two balloons? What evidence supports the claim that air takes up space?

Challenge Yourself!

Can you find out what kinds of gases are in the air?

Ask someone at home to help list the matter that your lungs blow into a balloon to make it expand.

Water Is Made of Small Particles

Condensation Is Evidence

Now let's get back to how water ended up on the cobweb when it didn't rain. Consider this claim: *There are particles of water in air that settled on the cobweb*. Place your hand in front of your mouth, and breathe out. Does your breath feel dry or wet? Imagine breathing on a cold window in winter or a cold glass. What would you expect to see? Little drops of water would form on the surface of the glass. This observation can be used as evidence that supports our claim. The particles of water found in the air are known as *water vapor*. Water vapor is in the air even when we cannot see it!

Remember: we use evidence to support scientific claims. The claim is that small particles of water are part of the air we breathe. Look at the picture below. What evidence do you see that supports the explanation that there is water in the air?

You can't always see water when you breathe out. But condensation on a window is evidence that there are particles of water in the air. Even if its particles are too small to be seen, the water vapor is there.

Dissolving Matter Is Evidence

Moisture in your breath and condensation may be evidence that matter is made of small particles. Dissolving solid matter in a liquid may provide even more evidence.

Suppose you want a cold glass of lemonade. You start by adding sugar to water. When you add it, the sugar seems to disappear. Did it go away? No, it **dissolved**.

When one type of matter dissolves into another type of matter, such as sugar or lemon juice in water, the matter separates and spreads out. Three types of matter are present, but you might not be able to see two of them. How might you prove to someone that the visible liquid contains more than just water?

> **Vocabulary**
>
> **dissolve, v.** to separate and spread out particles of matter into another substance

Think about the different properties that water, lemon juice, and sugar each have. How could you use those properties as evidence to prove that the sugar and lemon juice are present in the lemonade?

Water Dissolves Other Matter

The properties of sugar in water provide evidence that supports our original claim—that matter is made of particles too small to be seen. A model could be used to help us support our explanation as well. Remember that scientific models can be pictures, symbols, or anything that helps to represent something that we may not directly observe for ourselves. A scientific model of the lemonade's ingredients can help us to explain why we can no longer see the sugar after it is dissolved in water. Imagine how you might draw this to model what is happening to the sugar—would your drawing look anything like the model on the next page?

Water is one of the best substances at dissolving other substances. Salt and sugar dissolve in water. But water isn't alone. Acetic acid, also known as vinegar, is used to dissolve vegetable oil when you make a salad dressing. And the process of dissolving can change. Depending on the situation, certain kinds of matter dissolve quickly while others dissolve much more slowly.

Temperature will affect how matter dissolves. For most matter, the warmer a liquid is, the more matter will dissolve into it. A model might show that heat causes the particles of matter to move around faster, which causes them to break apart into the liquid more easily. Cooler temperatures cause the particles to move slower and group back together into a larger particle of the same matter. Less sugar or salt will dissolve in cold water, and crystals of matter will be seen at the bottom of the glass.

Consider an Example

Matter is placed into a beaker of water. For example, this could be a sugar cube placed in water. Large crystals of sugar can be seen easily in the water. If you look at them under a magnifying glass, you can see that there are many particles inside. You can now add some heat, stir the water, or both to speed up the dissolving. Both actions will help the particles become smaller and spread out.

The matter in the beaker starts to separate into smaller particles as the crystals begin to dissolve. You might be able to see the small particles of matter, as the water won't be as clear as it was at the start.

The smaller particles in the beaker continue to break apart into even smaller pieces as they dissolve into the water. The particles get small enough that they can move between the particles of water, and eventually, the particles will become too small to see.

Matter Is Made of Small Particles

Evaporation Provides More Evidence

Now, let's think about a different kind of matter that dissolves in water—salt! How would you draw a model of salt water? What evidence could prove that an unknown sample of liquid is, in fact, salt water?

Is it possible that salt water is made of small particles of salt between small particles of water? You can't see the salt that is dissolved in the water. Consider this: IF we could separate the water from the sample, THEN salt should be left behind. This sounds like an investigation! If you place a shallow pool of salt water in the warm sun, the liquid water begins to **evaporate** and eventually turns into water vapor.

Vocabulary

evaporate, v. to change form from liquid to gas

If all the water becomes water vapor, what remains? All the small particles of salt that were once dissolved in the water are now visible as a crust of whitish crystals.

Sea salt that you sprinkle on your food can be collected by letting seawater evaporate from shallow pools like these.

How Matter Changes

Chapter 4

Have you ever thought about where beach sand comes from? People around the world play in sand, run in sand, and make sandcastles. But how did that sand form?

Sand is made of tiny pieces of rocks and shells. These are broken down by water, wind, and ice. It can take thousands or even millions of years until the pieces are small enough to become sand.

When objects break apart to become sand, no new matter is formed. The materials break into smaller pieces, but they are still the same materials. The rocks and shells have gone through a **physical change** to create that beautiful beach. A physical change is caused when matter changes shape but nothing new is formed.

Big Question

Does the amount of matter change during a physical change?

Vocabulary

physical change, n. a change that occurs when matter changes form (shape, size) but no new type of matter is formed

No matter how tiny grains of sand are, they still have the same properties of the material they came from before that material was broken apart.

Changing State Is One Kind of Physical Change

Just like sand on a beach, water can undergo physical changes. Water also goes through physical changes when heated or cooled. The different forms, or *phases,* of matter are called **states of matter**. Three common states of matter are solids, liquids, and gases. People use water in all three states.

Vocabulary

states of matter, n. the different physical forms of matter

On a hot day, what happens to ice in your glass of ice water? It melts. When ice melts, it changes from a solid state to a liquid state. Can water change in the opposite way—from a liquid to a solid? Yes! When you make ice, such as in a refrigerator freezer, water physically changes state from a liquid to a solid.

When water changes from one phase to another, the amount of water stays the same. But the amount of space the matter is occupying changes.

As water changes from one state to another, its density changes. Density is the measure of the amount of matter in a certain amount of space. Water is one of the few elements that has a lower density in its solid state than in its liquid state. This is why ice floats in water.

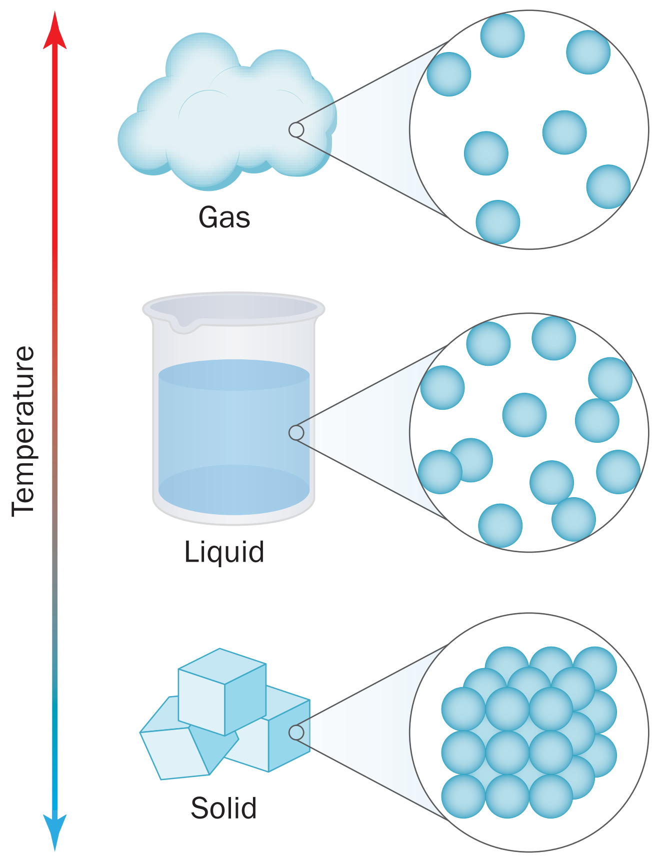
Density of Water in Different States

Liquid	**Solid** (Ice)	**Gas** (Water Vapor)
1.0000 gram per milliliter	0.9150 grams per milliliter	0.0006 grams per milliliter

A milliliter is a measurement of volume, an amount of space that matter fills up. A gram is a measurement of mass, how much matter is in a given sample.

State Changes Provide Evidence of Small Particles

When a temperature change causes matter to change state—by freezing, melting, evaporating, or condensing—this is a clue about how the matter must be made up. When matter changes physically, it gives us evidence that matter is made of particles too small to be seen. The following model helps us understand this.



Vocabulary

gas, n. matter with indefinite volume and shape, in which the particles move around freely and expand to fill any container

liquid, n. matter with definite volume but indefinite shape, in which the particles move around each other freely but do not expand to fill any container

solid, n. matter with definite shape and volume, in which the particles are rigidly arranged in place

Gases escape an open container, and their particles spread out into the air. Liquids take the shape of their containers but don't expand to fill the containers. Particles in liquids do not spread out. Solids keep their size and shape. Solids don't need to be in containers for their particles to stay together.

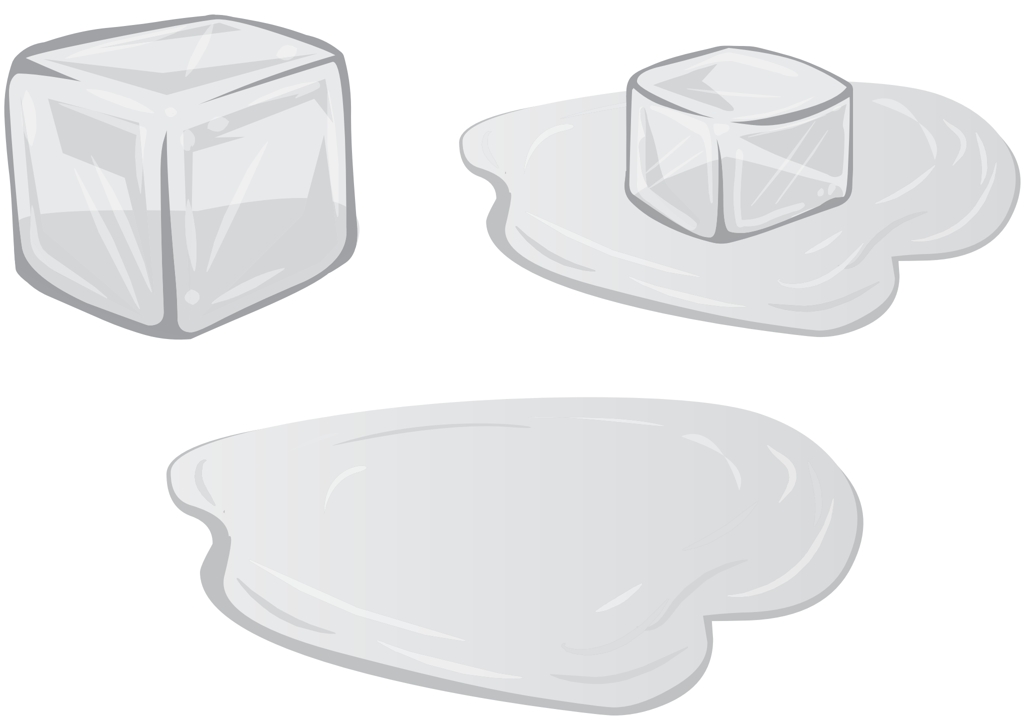
Motion Within Matter

Matter takes the form of a solid, liquid, or gas because of the way the particles are arranged. Because solids keep their own shape, we may conclude that the particles are tightly packed. Solids are rigid, and their particles do not move around each other. Ice, rock, and wood are solids.

Liquids flow and take the shape of whatever container they are in. Because liquids flow, we suspect that the particles can move around each other. Water, milk, and oil are liquids.

In gases, the particles expand to fill their container. Outside of a container, gas particles float apart and spread out in the air.

Particles of matter move more and spread apart as more heat energy is applied to the matter.



As more heat is added, solid matter such as glass or steel will melt, as ice does, and become liquid.

When a puddle on a sidewalk dries up, the water in the puddle changes from a liquid to a gas. When the surface of water changes from a liquid to a gas, the process is called **evaporation**. Can water vapor change in the opposite way too—from a gas to a liquid?

Have you ever seen little drops of dew on grass in the morning? Those drops were once water vapor in the air. When the temperature drops, some of the gas **condenses**, or turns to a liquid, which we see on leaves and grass.

Water vapor condenses to form morning dew. The amount of water stays the same as it undergoes a change of state.

Water changes phases around us every day, but it remains water. Water does not become a different type of matter when it melts in your glass or condenses on grass in your schoolyard. And when water changes physically, the total amount of water before and after the change stays the same.

Changes in state support the scientific model that says matter is made from small particles. This particle model is based on evidence we see around us every day, such as when the rain or snow falls to the ground and then when it "disappears" when heated by the sun.

Vocabulary

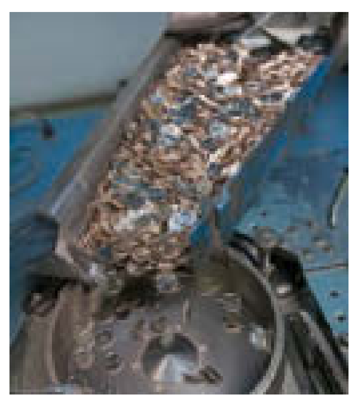
evaporation, n. the process involved when matter changes from a liquid to a gas

condense, v. to change state from gas to liquid

Matter Is Conserved During a Physical Change

Coin Making Provides Evidence

The next time you have coins jingling in your pocket, think about how they are made. Coins begin their journey to your pocket as long sheets of metal in large, heavy rolls. Little, round discs called blanks are cut from the metal. The scrap metal between the punched-out coins is saved to be recycled. The blanks are heated to make them soft. Next, a coining press stamps the design onto the blanks, which transforms them into genuine money.



A nickel weighs 5 grams. Let's suppose that 144 nickels can be made from a sheet of metal. That's a total of 720 grams of nickel coins. But the sheet itself weighs 1,309 grams. What happened to the other 589 grams? That is the scrap left over from stamping the blanks. If you weighed the coins and scrap together, the total weight would be the same as it was when the metal was an uncut sheet. This is what it means to **conserve** matter. The weight of matter you start and end with is the same. No matter is gained or lost during a physical change.

Vocabulary

conserve, v. to maintain a constant quantity

Metal Casting Provides Evidence

Are metals solids, liquids, or gases? If you answer quickly, you might say that metals are solids. And you would be right most of the time! But metals can undergo physical changes. They can exist as solids, liquids, and even gases, if the conditions are right.

Metals can be shaped through a process called *casting*. Metal is heated until it melts to a liquid state. Different types of metals must be heated to different temperatures before they become liquid. The molten metal is then poured into a hollow mold, or cast. After the cast cools, the metal has a new shape! Jewelry, tools, and sculptures are made with this process.

Molten metal is poured into a sand cast. Metal can change state, but no matter is lost or gained in the process.

In casting, two physical state changes are used to shape the metal—melting the solid to become molten liquid and then cooling the liquid back to solid forms. The total amount of metal does not change when it changes form. The amount of metal is conserved.

Can Crushing Provides Evidence

Do you recycle aluminum cans at your home? Imagine you had a problem. You have more empty cans than can fit in your recycling bin. How might you fit more cans into the space that you have? Some people use can crushers to make each can take up less space. If a can is crushed into a smaller shape, does that mean there is less aluminum inside the recycling bin?

This can crusher changes the shape of the can, a physical property, but no matter is gained or lost.

Crushing a can is a physical change. When substances undergo physical changes, no matter is gained or lost. The total weight of matter is conserved.

Matter Can Change Chemically

Chapter 5

When different types of matter mix but each type of matter remains unchanged, it is called a **mixture**. A mixture can be separated back into its original parts.

Big Question

Why do some interactions of matter result in new substances?

A salad is a mixture of things, such as vegetables or fruit. You can take the salad apart and get the same ingredients with which you started.

Vocabulary

mixture, n. a combination of different types of matter that can usually be separated back into its original parts

Sometimes when two types of matter are mixed, one form of matter will interact with the other. The result is a chemical change. This produces new chemicals with different properties. The original "ingredients" cannot easily be separated again.

Bread is a mixture of ingredients that are heated and baked. You cannot take the bread apart to get the same ingredients with which you started.

Particles Interact to Form New Matter

When certain chemicals are put together, the particles they are made of sometimes combine to make a new **chemical**. When this happens, a **chemical change** has taken place. A chemical change occurs when two or more types of matter interact to form a new substance that has new properties.

> **Vocabulary**
>
> **chemical, n.** a specific type of matter made of particles of the same type
>
> **chemical change, n.** the result when two or more types of matter interact to form a new type of matter

Newly cast iron is usually gray with a smooth surface, but over time the metal can change and become reddish-brown with a rough surface. Water and oxygen in the air interact with the iron to form a new substance, rust. The material in a rusty chain cannot be changed back to iron from rust. We know this is a chemical change because the effect of the change is a new substance with new chemical properties.

Evidence of Chemical Changes

New matter forms when the chemicals interact and recombine. This provides more evidence that matter is made up of small particles. Since the particles of matter are too small to be seen, we have to look closely for evidence of a chemical change. So, what evidence do we look for?

Formation of Gas

Cars produce exhaust when the engine is running. Exhaust is a gas that forms when an engine burns fuel such as liquid gasoline. The burning releases a set of new chemicals all mixed together as a gas. When a substance is burned, such as fuel, or when it combines with other matter to form a gas, it is often the result of a chemical change.

Change of Odor

Another example of gas formation is when a baker combines yeast and sugar. Bubbles form. The bubbles of gas make bread rise. How else can you tell if someone is baking bread? A change in odor is evidence of a chemical change. Baking bread gives off a yummy odor. Since the odor was not there to start with, we know there was a chemical change.

More Evidence of Chemical Change

Change of Color

When copper is exposed to air and water for a long time, the copper changes into other chemicals, causing a change in color. The copper changes color because a chemical change has occurred.

Shiny sterling silver metal also changes color when it reacts with the air. The chemical change causes a new substance, commonly called tarnish. The change in properties, the change of color, is evidence that a new substance has formed.

Change of Temperature

Just like color changes, a change in temperature signals a chemical change. You would never touch the head of a burning match. It is hot! The change in temperature when you light a match tells you that a chemical change has occurred.

Light

Have you ever seen tiny flashes of light in the sky at night on a summer evening? If so, you might have seen the light of a lightning bug. Lightning bugs can produce light. The light appears when a chemical change occurs in part of the insect's body. Those little flashes of light are evidence of a chemical change occurring.

Lightning bugs, also called fireflies, produce light, which is evidence of a chemical change.

Precipitate

The chemical change shown in this picture of a sink drain forms a **precipitate**. A precipitate is a solid that forms from the combination of two solutions. The solid is a new type of matter with new properties. The precipitate cannot easily be changed back to its original chemicals. Formation of a precipitate shows that a chemical change has occurred!

Vocabulary

precipitate, n. a solid formed from a chemical change

If soap and water clean things, why does a sink build up something around the drain? Certain minerals in the water combine with the soap to form a new compound.

Matter Is Conserved During a Chemical Change

During chemical changes, the types of matter change. But, just like physical changes, the total weight of matter does not change.

Fireworks contain solid chemicals that change to gases when they are burned. No matter is gained or lost.

Imagine colorful fireworks lighting up a night sky. Fireworks contain solid chemicals. When the solids burn, they quickly turn to large amounts of gas that take up more space. Since the gas is in a very small tube, pressure builds up. When the pressure releases, you hear a loud bang!

Fireworks are the result of a number of chemical changes. But if you were to measure carefully the weight of all the chemicals before and after, you would discover something interesting. You would have data that shows that the weight of all chemicals before and after a chemical change is exactly the same. No matter is lost or gained in any chemical change.

The Language of Chemistry

Chapter 6

Chemistry is the science of what matter is made of and how matter changes. But no one person thought up the idea of chemistry or of matter. People who were interested in the subject shared their ideas with one another.

Big Question

What are atoms, elements, and molecules?

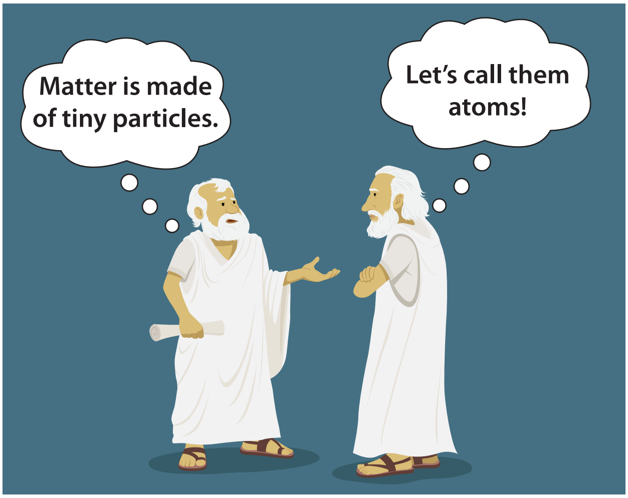
Vocabulary

chemistry, n. the science of what matter is made of and how matter changes

atom, n. a small particle of chemical matter

By 500 BCE ancient Greeks were sharing their ideas about matter. One man, Democritus, talked to his teacher, Leucippus. They agreed that all matter was made of particles too small to be seen. They could not see the particles. They could only talk about this idea.

Democritus and Leucippus needed a name for these particles. The Greek prefix *a-* means "not," and *temnein* means "to cut." If you put the words together, you get *atomos*. *Atomos* means "not to cut." **Atoms** became the new word for particles that could not be cut any smaller—the tiniest part of matter!

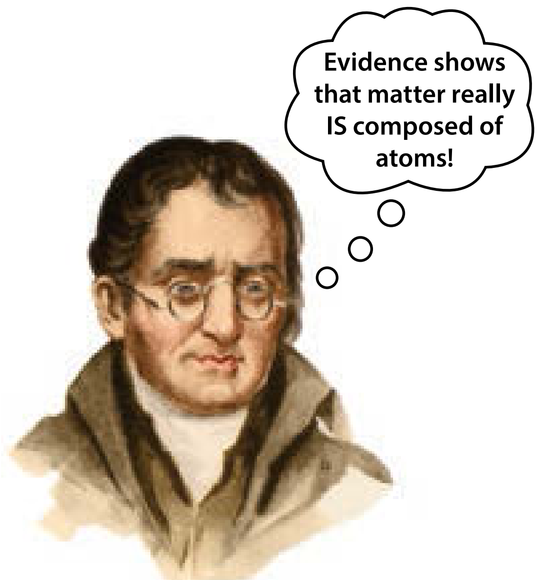


Democritus and his teacher, Leucippus, came up with the term *atom* to describe the smallest unit of matter. Sharing ideas is important to science.

John Dalton Explained the Atomic Theory

The language of chemistry began and grew in ancient Greece. The ancient Greeks had a problem, though. They did not use a scientific process for examining ideas for supporting evidence. They did not determine whether their ideas were true or false.

Democritus is known as the "Father of the Atom." However, it took about two thousand years before there was evidence to support the atomic theory of matter.



John Dalton stated that matter was made of atoms of many different kinds.

John Dalton was an English schoolteacher who studied the atom in 1808. He described matter as being made up of small particles called atoms. Unlike the ancient Greeks, he studied evidence from chemical reactions. Dalton was also very interested in weather. Studying the gases in the atmosphere helped him come up with his theory about atoms.

Dalton developed what we now call the atomic theory. This was another addition to the language of chemistry and today is used and shared by all chemists. It was built upon the ideas of Democritus: that atoms are tiny particles that cannot be further cut. But Dalton added to this idea. Dalton said that some atoms are alike and some are different. When atoms join, they make up different types of matter.

An Element Is Matter Made of a Single Type of Atom

Today, scientists have found 118 different kinds of atoms. Everything in the universe is made of the same 118 atoms. Only about 94 of the atoms are found naturally on Earth. Some atoms are made by people in special laboratories.

Matter is sometimes made of a single type of atom. When all the atoms in matter are the same, the matter is called an **element**. If we could see all the atoms in a single element, they would all be the same. The glow of a neon sign is a beautiful sight. All of the glowing gas is made of one kind of atom—neon! Likewise, all of the atoms that make up a gold nugget are atoms of the element gold.

Vocabulary

element, n. a substance made of a single type of atom

A gold nugget, such as the one shown, is made up of gold atoms.

Atoms Bond Together to Form Molecules

The element that occurs the most in the universe is hydrogen. Hydrogen gas is found in the stars and the sun. Most of the planet Jupiter is made of hydrogen gas. Hydrogen gas is two hydrogen atoms joined together.

When atoms like hydrogen atoms join, they form a bond. A chemical **bond** is a connection that holds atoms together. In hydrogen gas, two hydrogen atoms are connected by a chemical bond. In oxygen gas, two oxygen atoms are connected by a chemical bond. When one or more kinds of atoms form chemical bonds with other atoms, they form **molecules**.

Vocabulary

bond, n. a connection that holds atoms together

molecule, n. a substance made of one or more kinds of atoms joined together by chemical bonds

In hydrogen gas and oxygen gas, atoms of the same kind form chemical bonds. Atoms of different elements can bond together too. Much of the hydrogen on Earth is found in a bond with another element. Two hydrogen atoms often join with one oxygen atom. When this happens, you get a molecule of a substance you use every day. Water! Think of that the next time you take a drink or swim or brush your teeth.

Each molecule of water is made of two hydrogen atoms bonded to one oxygen atom.

Molecules Are Important for Living Things

While elements represent the different basic types of matter, molecules make up almost all the matter we see every day. The matter that makes up a sidewalk, a building, or a bedspread is all composed of molecules.

Importantly, the food we eat is composed of molecules. Eggs, nuts, beans, and meat have lots of protein in them. Proteins are large molecules. Bread, potatoes, and pasta are made of complex molecules called carbohydrates. Another kind of complex molecules are fats, such as plant oils and animal fats.

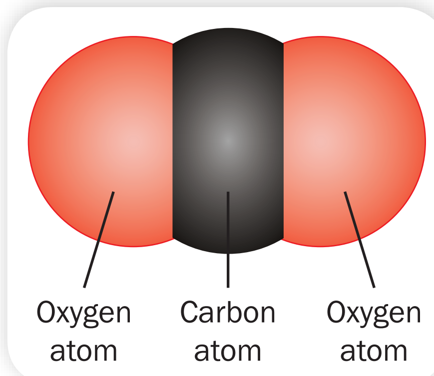
Chemical changes occur in our bodies. The molecules of the food we eat are broken apart and then combine to form new chemicals. These chemical changes give us energy and the materials our bodies need to stay alive. You can see how important molecules are to each and every one of us. Molecules are essential for living things.

These foods have protein. Proteins are large molecules made of many atoms. Our bodies use proteins to build muscles.

Models Help Us Understand Molecules

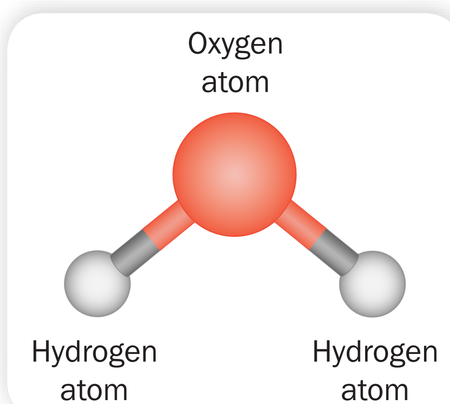
When something in science is too big or too small to see, scientists use models. In a way, a visual model is another form of language shared by chemists. Models help make things easier to understand. Models of molecules help us understand them! Scientists use models of molecules to show how the atoms are joined together.

Let's take a look at the model of one kind of molecule. Carbon dioxide is a molecule. Many of them form carbon dioxide gas. It has no color and no odor. When you breathe out, you breathe out carbon dioxide gas. Plants use it to make food. Carbon dioxide is one of the most common molecules in the world. It is found in the air and in the water. A model of a carbon dioxide molecule helps us understand how atoms combine to form that substance.



A model of carbon dioxide helps us to understand that it is made of two atoms of oxygen and one atom of carbon that are bonded together.

Look at the model of a water molecule. What types of atoms combine to form water?



Glossary

A

atom, n. a small particle of chemical matter (33)

B

bond, n. a connection that holds atoms together (36)

C

chemical, n. a specific type of matter made of particles of the same type (28)

chemical change, n. the result when two or more types of matter interact to form a new type of matter (28)

chemistry, n. the science of what matter is made of and how matter changes (33)

condense, v. to change state from gas to liquid (23)

conserve, v. to maintain a constant quantity (24)

D

design process, n. a plan that is used to find and develop solutions to a problem (7)

dissolve, v. to separate and spread out particles of matter into another substance (15)

E

element, n. a substance made of a single type of atom (35)

evaporate, v. to change form from liquid to gas (18)

evaporation, n. the process involved when matter changes from a liquid to a gas (23)

evidence, n. information that helps answer a question, support a claim, or solve a problem (11)

expand, v. to grow bigger (13)

G

gas, n. matter with indefinite volume and shape, in which the particles move around freely and expand to fill any container (21)

L

liquid, n. matter with definite volume but indefinite shape, in which the particles move around each other freely but do not expand to fill any container (21)

M

matter, n. anything that has mass and takes up space (1)

mixture, n. a combination of different types of matter that can usually be separated back into its original parts (27)

models, n. pictures, symbols, or physical examples that help explain something that we cannot directly observe (12)

molecule, n. a substance made of one or more kinds of atoms joined together by chemical bonds (36)

P

particles, n. tiny pieces of matter that are too small to be seen (12)

physical change, n. a change that occurs when matter changes form (shape, size) but no new type of matter is formed (19)

precipitate, n. a solid formed from a chemical change (31)

property, n. a quality, trait, or detail used to describe something (3)

S

solid, n. matter with definite shape and volume, in which the particles are rigidly arranged in place (21)

solution, n. a way to solve a problem (7)

states of matter, n. the different physical forms of matter (20)

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