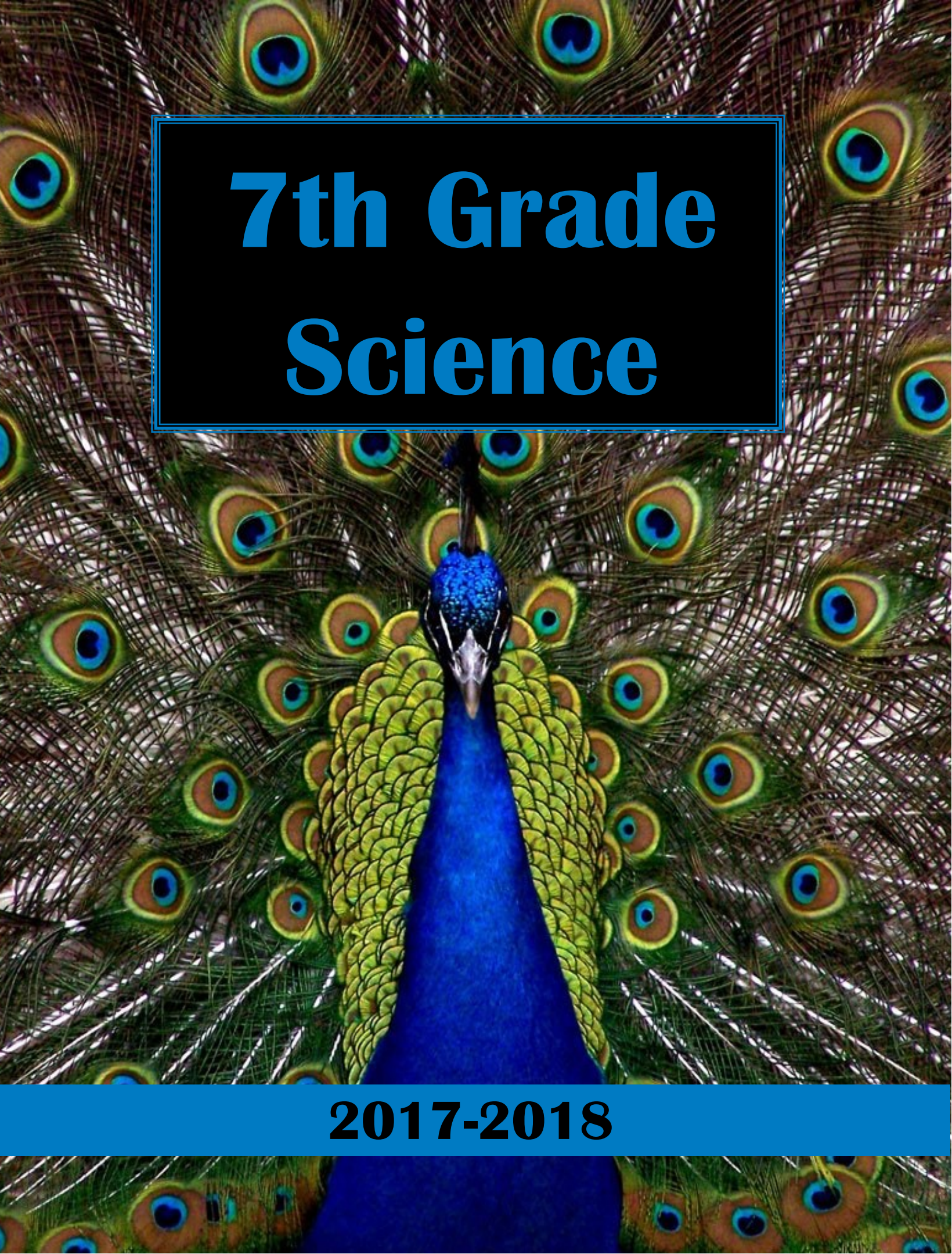
7th Grade Science



2017-2018

7th Grade Science
for Utah SEEd Standards

Utah State Board of Education OER
2017-2018

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AUTHOR

Utah State Board of Education OER

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Using this Book

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1.1 Credits and Copyright

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We especially wish to thank the amazing Utah science teachers whose collaborative efforts made the book possible. Thank you for your commitment to science education and Utah students!

1.2 Students as Scientists

Making Science

What does science look and feel like?

If you're reading this book, either as a student or a teacher, you're going to be digging into the "practice" of science. Probably, someone, somewhere, has made you think about this before, and so you've probably already had a chance to imagine the possibilities. Who do you picture doing science? What do they look like? What are they doing?

Often when we ask people to imagine this, they draw or describe people with lab coats, people with crazy hair, beakers and flasks of weird looking liquids that are bubbling and frothing. Maybe there's an explosion. Let's be honest: Some scientists do look like this, or they look like other stereotypes: people readied with their pocket protectors and calculators, figuring out how to launch a rocket into orbit. Or, maybe what comes to mind is a list of steps that you might have to check off for your science fair project to be judged; or, maybe a graph or data table with lots of numbers comes to mind.

So let's start over. When you imagine graphs and tables, lab coats and calculators, is that you and what you love? If this describes you, that's great. But if it doesn't — and that's probably true for many of us — then go ahead and dump that image of science. It's useless because it isn't you. Instead, picture yourself as a maker and doer of science. The fact is, we need scientists and citizens like you, whoever you are, because we need all of the ideas, perspectives, and creative thinkers. This includes you.

Scientists wander in the woods. They dig in the dirt and chip at rocks. They peer through microscopes. They read. They play with tubes and pipes in the aisles of a hardware store to see what kinds of sounds they can make with them. They daydream and imagine. They count and measure and predict. They stare at the rock faces in the mountains and imagine how those came to be. They dance. They draw and write and write and write some more.

Scientists — and this includes all of us who do, use, apply, or think about science — don't fit a stereotype because no people fit stereotypes. If we really want to figure out what we all have in common, it turns out that our genetic structure looks a lot like that of a chimpanzee. What distinguishes us from chimpanzees, however, might be that we walk a little more upright, have a little less hair, and make better pizza. (For what it's worth, chimpanzees do really well at many things we think of as "human" skills, such as communicating, fighting, taking care of one another, establishing communities, and using tools.) What really sets us apart as humans is not just that we know and do things, but that we wonder and make sense of our world. We do this in many ways, including through painting, religion, music, culture, poetry, and, maybe most especially, science. Science isn't just a method or a collection of things we know. It's a uniquely human practice of wondering about and creating explanations for the natural world around us. This ranges from the most fundamental building blocks of all matter to the widest expanse of space that contains it all. If you've ever wondered, "When did time start?" or "What is the smallest thing?" or even just "What is color?" or so many other, endless questions, you're already thinking with a scientific mind. Of course you are; you're human, after all. 3 1.2. Students as Scientists www.ck12.org

But here is where we really have to be clear. Science isn't just these questions and their explanations. Science is about a sense of wondering and the sense-making itself. We have to wonder and then really dig into the details of our surroundings. We have to get our hands dirty. Here's a good example: two young scientists under the presence of the Courthouse Towers in Arches National Park. We can be sure that they spent some amount of time in awe of the giant sandstone walls, but here in this photo they're enthralled with the sand that's just been re-washed by recent rain. There's this giant formation of sandstone looming above these kids in the desert, and they're happily playing in the sand. This is ridiculous. Or is it?

How did that sand get there? Where did it come from? Did the sand come from the rock or does the rock come from sand? And how would you know? How do you tell this story?

Look. There's a puddle. How often is there a puddle in the desert? The sand is wet and fine; and it makes swirling, layered patterns on the solid stone. There are pits and pockets in the rock, like the one that these two scientists are sitting in, and the gritty sand and the cold water accumulate there. And then you might start to wonder: Does the sand fill in the hole to form more rock, or is the hole worn away because it became sand? And then you might wonder more about the giant formation in the background: It has the same colors as the sand, so has this been built up or is it being worn down? And if it's being built up by sand, how does it all get put together; and if it's being worn away then why does it make the patterns that we see in the rock? Why? How long? What next?

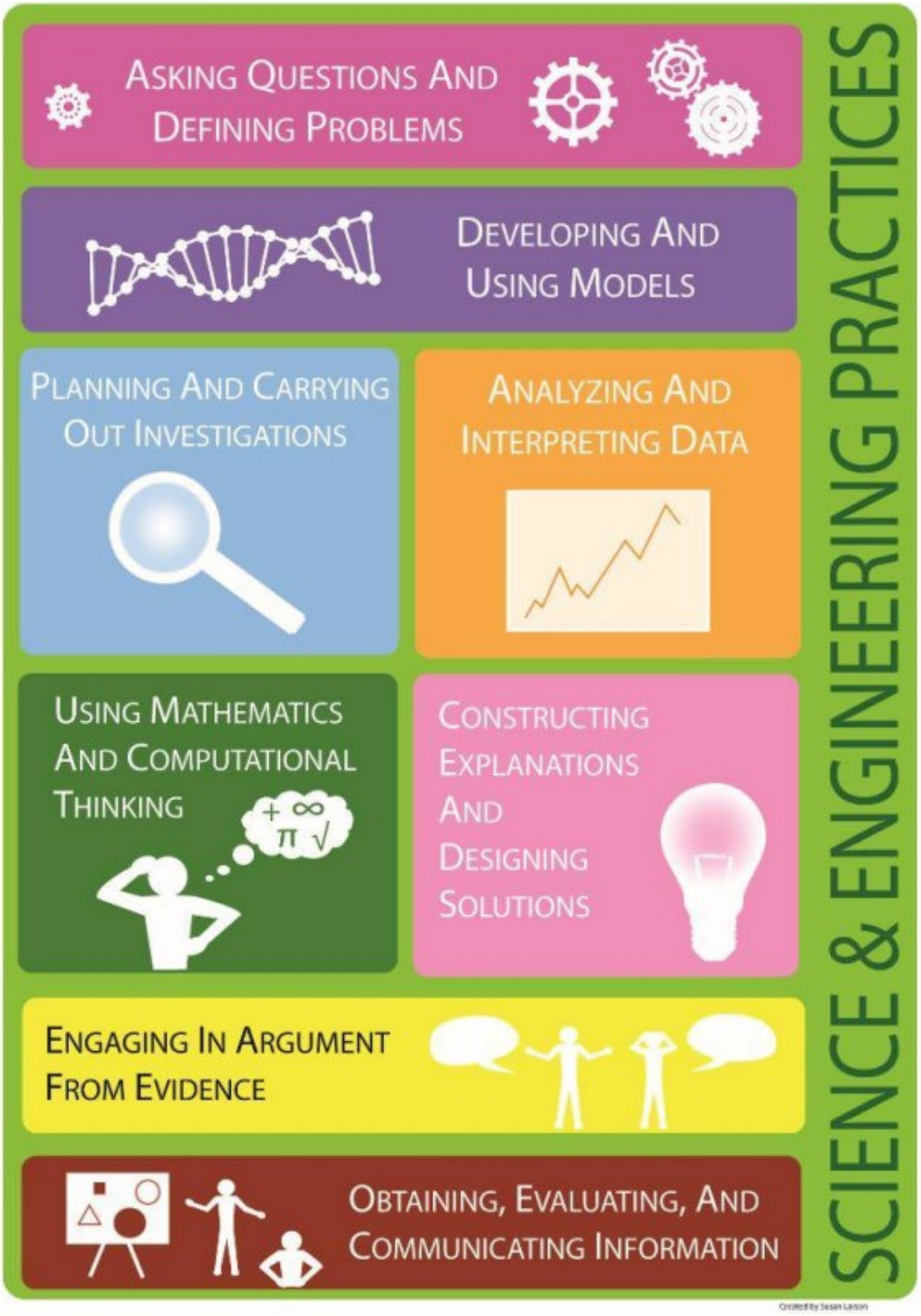
Just as there is science to be found in a puddle or a pit or a simple rock formation, there's science in a soap bubble, in a worm, in the spin of a dancer and in the structure of a bridge. But this thing we call "science" is only there if you're paying attention, asking questions, and imagining possibilities. You have to make the science by being the person who gathers information and evidence, who organizes and reasons with this, and who communicates it to others. Most of all, you get to wonder. Throughout all of the rest of this book and all of the rest of the science that you will ever do, wonder should be at the heart of it all. Whether you're a student or a teacher, this wonder is what will bring the sense-making of science to life and make it your own.

Adam Johnston

Weber State University

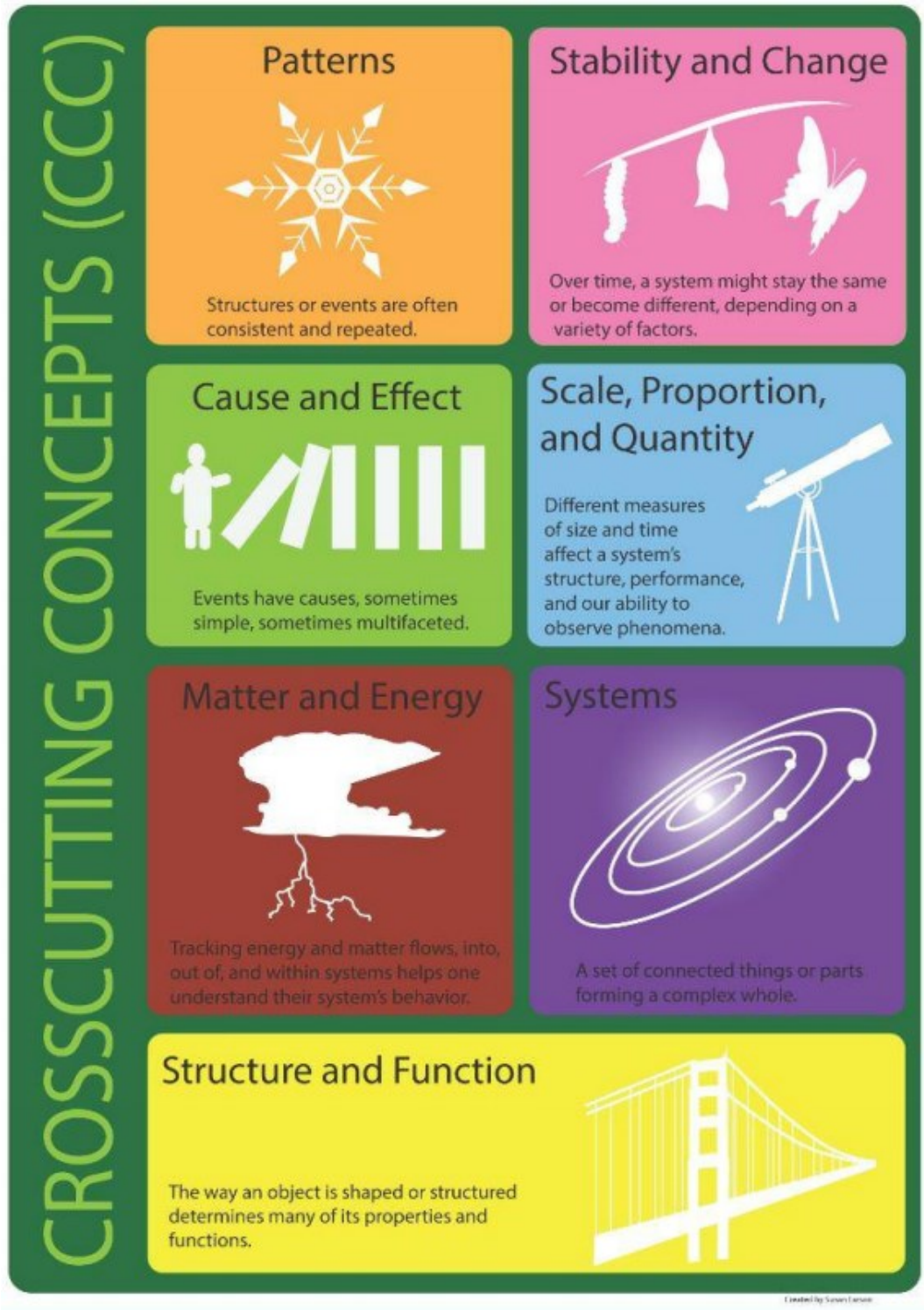
Science and Engineering Practices

Science and Engineering Practices are what scientists do to investigate and explore natural phenomena.



Crosscutting Concepts

Crosscutting Concepts are the tools that scientists use to make sense of natural phenomena.



1.3 A Note to Teachers

This Open Educational Resource (OER) textbook has been written specifically for students as a reputable source for them to obtain information aligned to the Utah Science with Engineering Education (SEEd) Standards. This book is to be used to support the curriculum created by teachers and not to supplant classroom instruction. It is not intended to describe what content should be taught or even suggest in what order instruction should occur.

This OER textbook has been organized in the same order as the strands and standards of the Utah SEEd Standards. Most standards have their own section starting and ending with a phenomenon that students can use to gather information, reason through their understanding, and communicate their findings using the science and engineering practices. Standards that pair well together may be joined into a single section.

This book is a first iteration for the Utah SEEd Standards and was written and organized by Utah science teachers in a relatively short period of time. The short time available to create this book may mean that there are some grammatical errors or weaknesses in the content. The hope is that as teachers use this resource with their students they keep a record of their suggestions on how to improve the book. Every year, the book will be revised using teacher feedback and with new objectives to improve the book.

If there is feedback you would like to provide to support future writing teams please use the following online survey: https://www.surveymonkey.com/r/SEEdOERFeedback .

CHAPTER 2

Strand 1: Forces Interact with Matter

Chapter Outline

Forces are push or pull interactions between two objects. Changes in motion, balance and stability, and transfers of energy are all facilitated by forces on matter. Forces, including electric, magnetic, and gravitational forces, can act on objects that are not in contact with each other. Scientists use data from many sources to examine the cause and effect relationships determined by different forces.

2.1 Forces and Motion (7.1.1)

Explore this Phenomenon

This image shows someone performing a trick where a tablecloth is pulled out from under the objects on the table without anything on the table being disturbed. Have you ever tried this trick? What makes this trick possible?

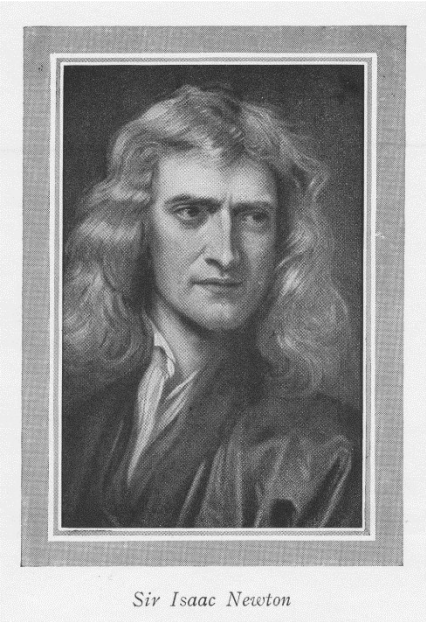
7.1.1 Forces and Motion

Carry out an investigation which provides evidence that a change in an object's motion is dependent on the mass of the object and the sum of the forces acting on it. *Various experimental designs should be evaluated to determine how well the investigation measures an object's motion.* Emphasize conceptual understanding of Newton's First and Second Laws. Calculations will focus on one dimension; the use of vectors will be introduced in high school.

It is important as you read this chapter to understand that the stability or change of an object is directly related to the mass of the object and what forces are acting on it. Unbalanced forces cause a change in motion, while balanced forces create stability.

Force and Motion

The English scientist Isaac Newton, who lived around 1700, was curious about how forces affect the motion of objects. After a lot of study and observation he was able to explain the relationship between forces and motion.



Newton observed a pattern in the relationship between force (a push or pull) and motion. He noticed a force is needed to make a stationary object start moving. A moving object will only slow down, speed up, or change direction if an outside force pushes or pulls it. In other words, objects tend to stay in whatever state they are in (motion or rest) unless another force acts on them. This property is called inertia and is known as Newton's First Law. Consider what happens when you roll a ball across a floor. According to Newton's first law the ball should keep rolling until a force acts on it to make it stop rolling. What force makes the ball stop rolling?

In the picture above you can see the two children exerting a force on the ball to move it across the grass. If they do not push on it, it will not move.

Along with forces, Newton observed another property that affects how an object's motion changes: the mass of the object. The relationship between the force on an object, its mass, and how its motion changes is called Newton's Second Law. How would the force needed to push a full shopping cart be different from the force needed to push an empty shopping cart? How is the amount of force needed to move an object related to the object's mass?

The motion of an object is determined by the sum of the forces acting on it. The greater the mass of the object, the greater the force needed to achieve the same change in motion.

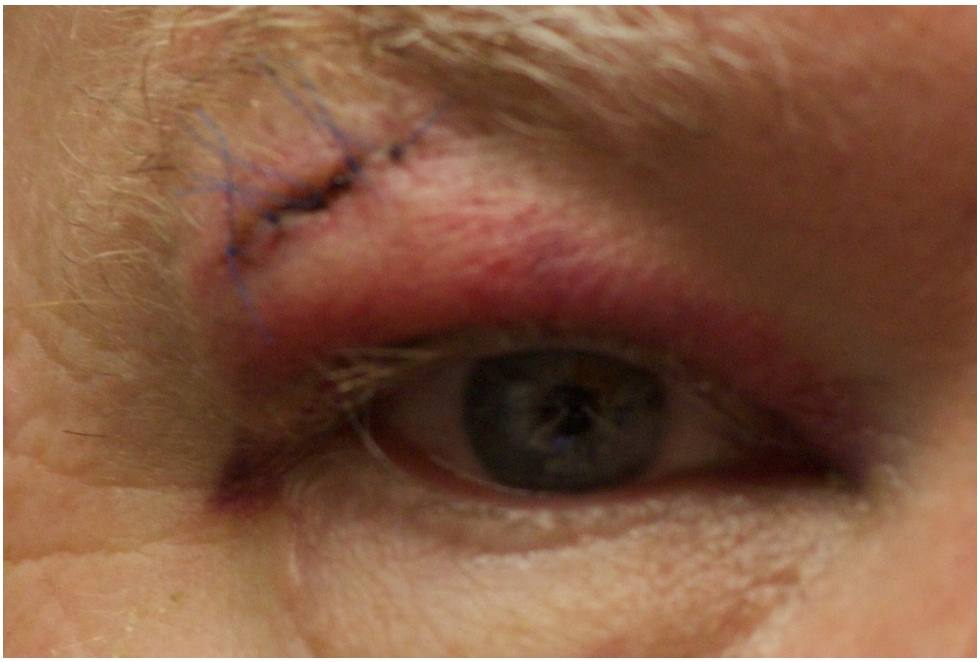
Putting It Together

- Can you use what you know about mass, force and motion to explain why you can pull a tablecloth from under the dishes on the table?

- Explain why it would be easier to do this trick if there was a full platter of food on the table than if there was an empty platter on the table.

2.2 Action and Reaction (7.1.2)

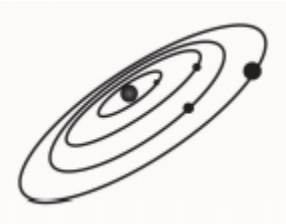
Explore this Phenomenon



Sometimes when people go rifle shooting and use a scope on their gun, they end up with the type of injury shown in the picture above. First, they put the rifle butt to their shoulder, aim through the scope and shoot. Then….OUCH! What would cause this injury?

7.1.2 Action and Reaction

Apply Newton's Third Law to **design a solution** to a problem involving the motion of two colliding objects in a system. Examples could include collisions between two moving objects or between a moving object and a stationary object



As you read, try to imagine two colliding objects as a system. Think about what forces or energy are going into the system and out of the system. What impact do those forces have on the system as a whole? Scientists and engineers are always looking for ways to reduce the damage that might be caused when two objects collide.

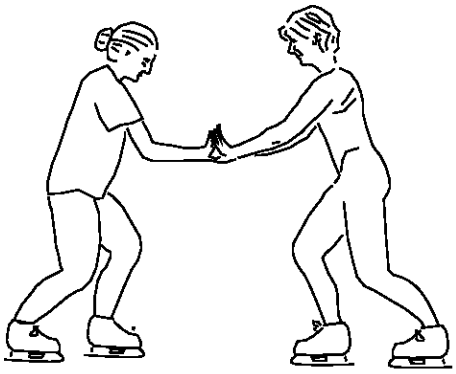
Action and Reaction

Whenever you apply a force to an object, it applies the same force back on you. These forces are equal and act in opposite directions. This is Newton's Third Law, which states that every action has an equal and opposite reaction.

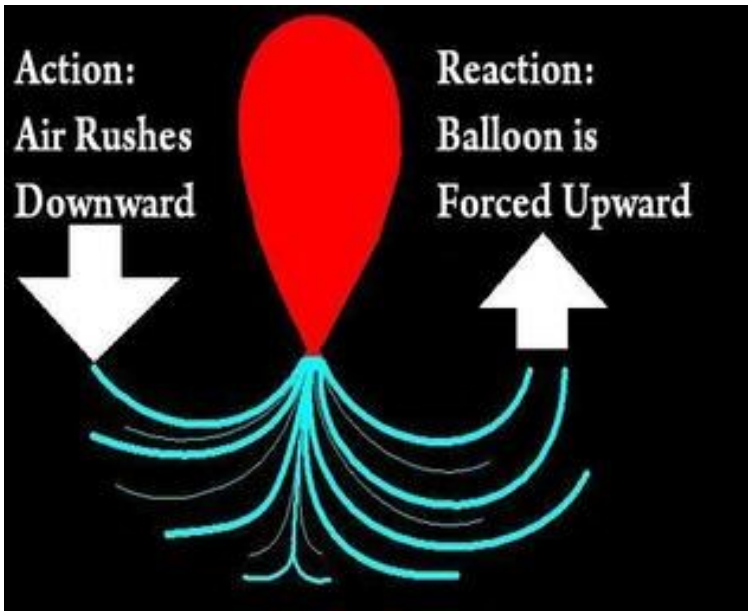
Just because the forces are equal and opposite does not mean that they have the same effect. When you kick a soccer ball, you apply a force to the ball, and it pushes back on you with the same force. If the forces are equal, why does the soccer ball move but you don't?

You have a lot more mass than the soccer ball. Remember that the more mass an object has, the more force is needed to move it. The force acting on the soccer ball is big enough to make the ball move, but the opposite force acting on you is not big enough to make you move because you have more mass.

If two skaters were to push on each other's palms, the skaters would move backward, away from each other. What would happen if the skaters just used one finger to push off each other?

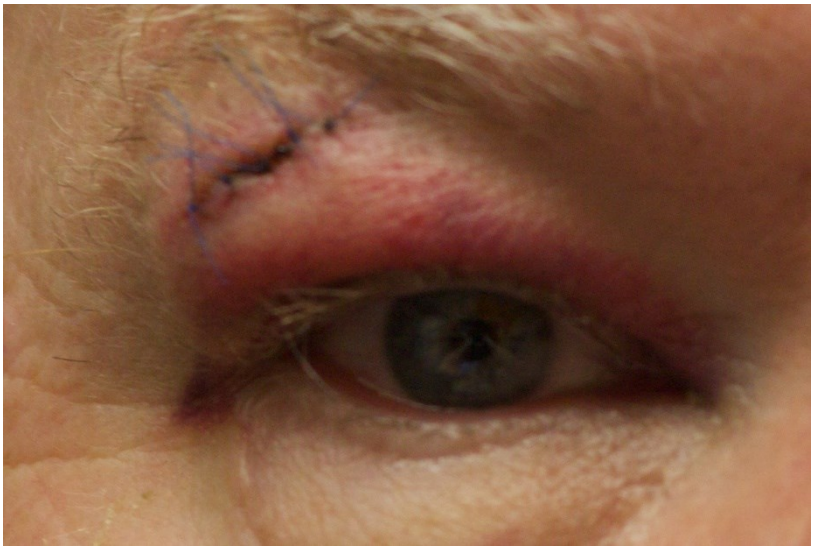


One other example is when you release the air out of a balloon. If you let go of a balloon without tying it closed, the air rushes out of the balloon and the balloon goes flying in the other direction.



If a car hits a tree, the tree pushes back on the car. Damage to the car and/or the tree depends on what factors?

Putting It Together



Create a model that shows the forces involved when a person shoots a gun. Then design a solution that shooters might use to help protect them from injury.

2.3 Electric and Magnetic Forces (7.1.3)

Explore this Phenomenon #1

- Have you ever rubbed your head with a balloon?
- What happens?
- What do you think causes your hair to stand up and be attracted to the balloon?

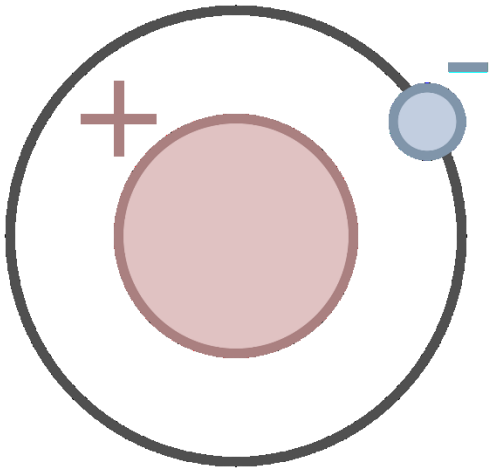
7.1.3 Electric and Magnetic Forces

Construct a model using observational evidence that describes the nature of fields exist between objects that exert forces on each other even though the objects are not in contact. Emphasize the cause and effect relationship between properties of objects (such as magnets or electrically-charged objects) and the forces they exert.

In this chapter, see if you can identify the causes and effects of electric and magnetic forces. As you observe forces try to identify the cause of each force. We can use cause and effect to help us predict what might happen in similar situations.

Introducing Electric Charge

Electric charge is a physical property. It occurs between particles or objects. It causes them to attract or repel each other. They do not even have to touch. This is unlike the typical push or pull you may be familiar with. All electric charge is based on the protons and electrons in atoms. A proton has a positive electric charge. An electron has a negative electric charge (see figure below).



Electric Force

When it comes to electric charges, opposites attract. In other words, positive and negative particles are attracted to each other. Like charges repel each other. If two positive charges

are brought close to each other, they will repel or push away from each other. The same is true with two negative charges. They too will repel each other. What if a negative and a positive charge are brought near each other? They will attract each other and the force of attraction will try to pull them closer together. Can you think of an example of invisible forces that attract or repel each other?

The force of attraction or repulsion between charged particles is called electric force. The strength of the electric force depends on several factors. It depends on how many electrons or protons there are. It also depends on the distance between the charged particles. How do you think the force will change if you increase or decrease the distance?

Static Electricity

Static electricity is a buildup of electric charges on objects. Charges build up when negative electrons are transferred from one object to another. This happens when you rub a balloon on your hair. Negative charges from your hair are transferred to the balloon and it becomes negatively charged. Your hair gives up electrons and becomes positively charged. Pictured below is another example of static electricity. How would going down a slide cause this child's hair to stand up?

Putting It Together

- How could you use the electric force to explain why your hair stands on end if you rub a balloon on your head?

- Try combing your hair vigorously for a minute then place the comb near a small stream of water from the faucet.

- What happened?

- Using your knowledge of electric forces what caused what you observed to happen?

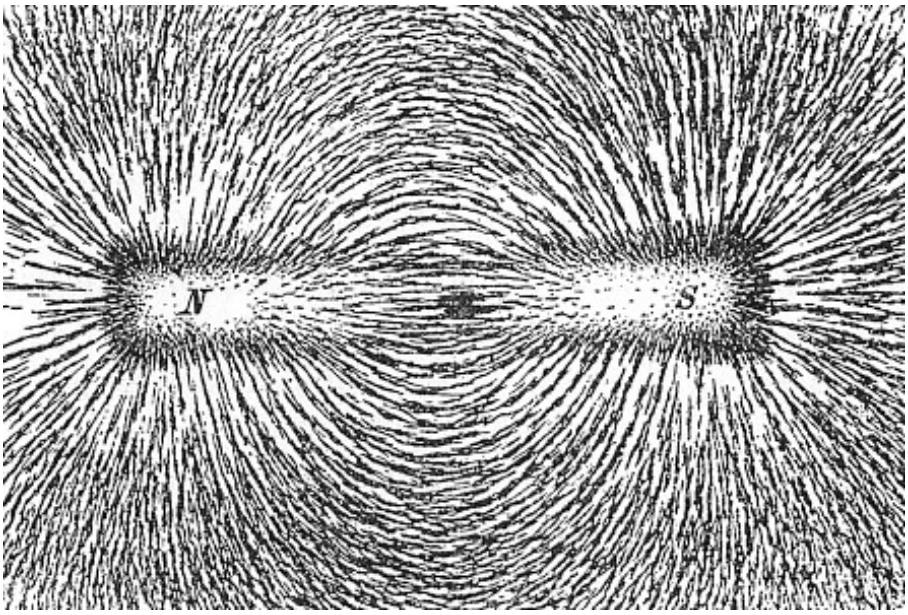
Explore this Phenomenon #2

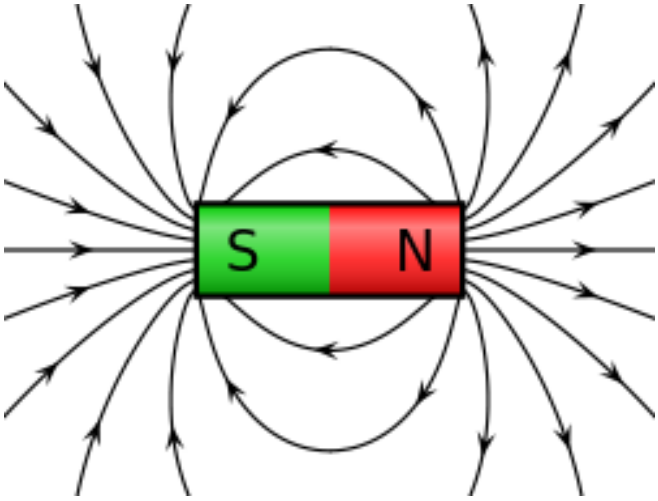
This roller coaster at Lagoon Amusement Park is not powered the way that most roller coasters are. Most roller coasters have a chain that pulls the car out of the station and up the first hill.

This coaster depends on magnets to travel out of the station and up the first hill. Look at the picture above and see if you can see the magnets going up the side of the rails. How do you think magnets propel the train forward and cause it to move so fast?

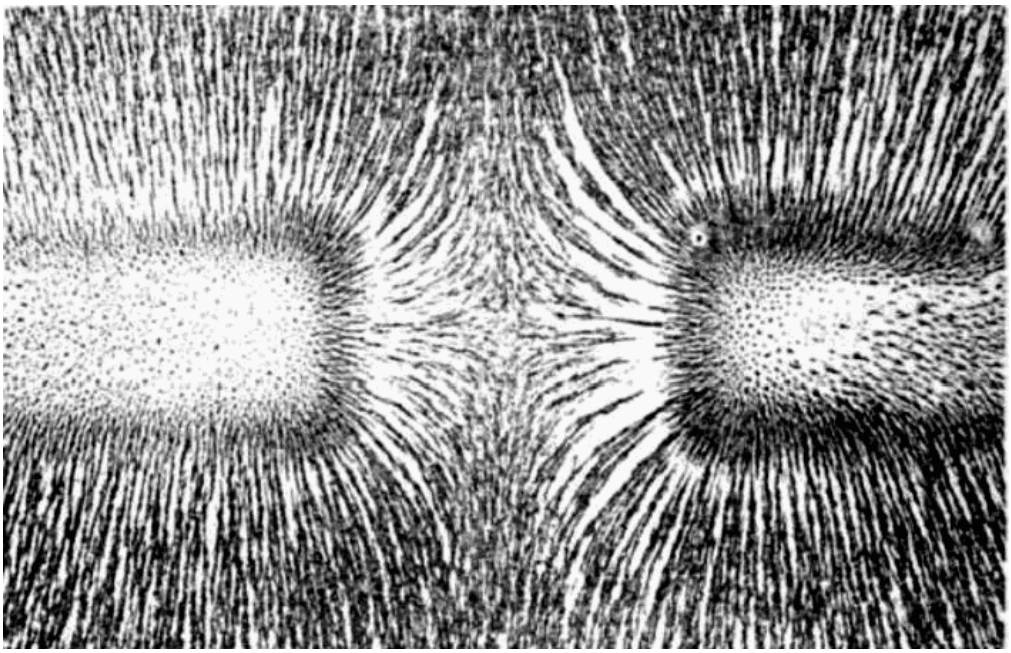
Magnetic Force and Magnetic Field

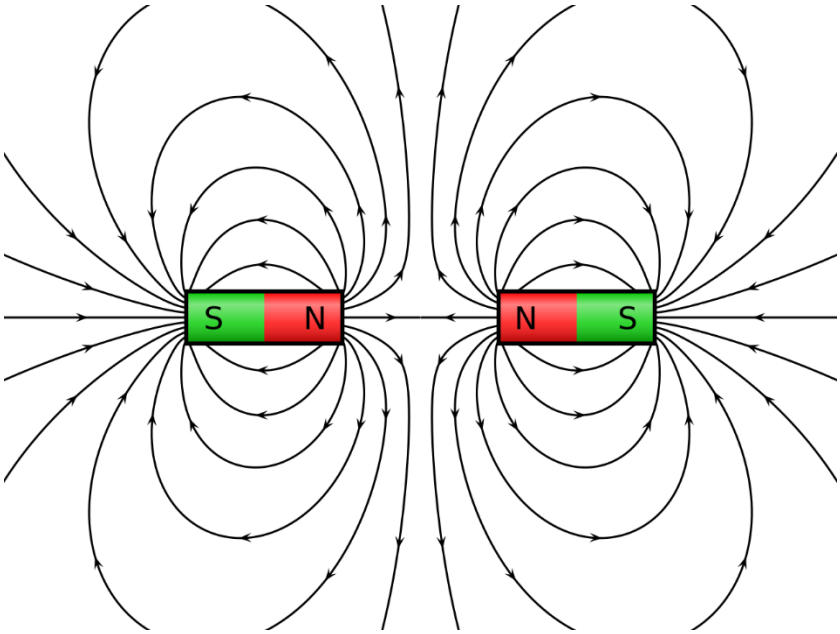
The force that a magnet exerts on certain materials, including other magnets, is called magnetic force. This force is similar to the electric force because the particles do not have to touch. A magnet can exert force over a distance because it is surrounded by a magnetic field. In the figure below, you can see the magnetic field surrounding a bar magnet. Tiny bits of iron, called iron filings, were placed on a sheet of paper. When a magnet was placed under the paper, it attracted the iron filings. The pattern of the iron filings shows the lines of force that make up the magnetic field of the magnet. The concentration of iron filings near the poles (the ends) indicates that these areas exert the strongest force.





Magnetics can either attract matter or repel matter. If you put two magnets with the same poles facing each other, they will repel each other. The following two pictures show magnets repelling each other, as evidence by the iron fillings.



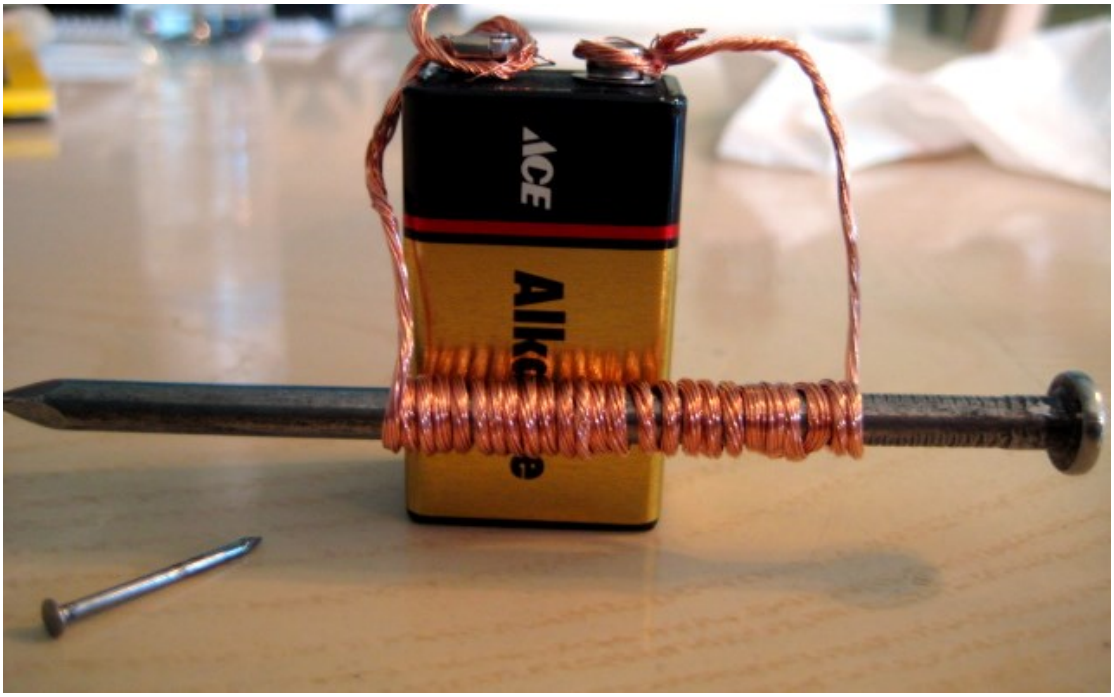


Putting It Together

Magnets are used on the track and on the cars to make the cars on the roller coaster *Wicked* move. Create a diagram showing how magnets can propel the cars forward.

2.4 Strength of Electric and Magnetic Forces (7.1.4)

Explore this Phenomenon



You can turn a nail into a magnet by wrapping a wire around it and connecting the wire to a battery. What factors do you think affect the strength of this magnet?

7.1.4 Factors that Affect the Strength of Electric and Magnetic Forces

Collect and analyze data to determine the factors that affect the strength of electric and magnetic forces. Examples could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or of increasing the number or strength of magnets on the speed of an electric motor.

Magnets and electrical forces can exert different amounts of strength. In this section pay special attention to how making changes to the magnets and electrical forces can cause a change in the strength or effect of these forces.

Electromagnets

One of the most famous electric car companies is Tesla, named after Nikola Tesla. These electric cars, and all others, require an electromagnet to run the engine.

Our knowledge of electromagnets developed from a series of observations. In 1820, Hans Oersted discovered that a current-carrying wire produces a magnetic field. Later in the same year, André-Marie Ampere discovered that a coil of wire acted like a permanent magnet and François Arago found that an iron bar could be magnetized by putting it inside of a coil of current-carrying wire. Finally, William Sturgeon found that leaving the iron bar inside the coil greatly increased the magnetic field.

Two major advantages of electromagnets are that they are extremely strong magnetic fields, and that the magnetic field can be turned on and off. When the current flows through the coil, it is a powerful magnet, but when the current is turned off, the magnetic field essentially disappears.

Electromagnets find use in many practical applications. Electromagnets are used to lift large masses of magnetic materials such as scrap iron, rolls of steel, and auto parts.

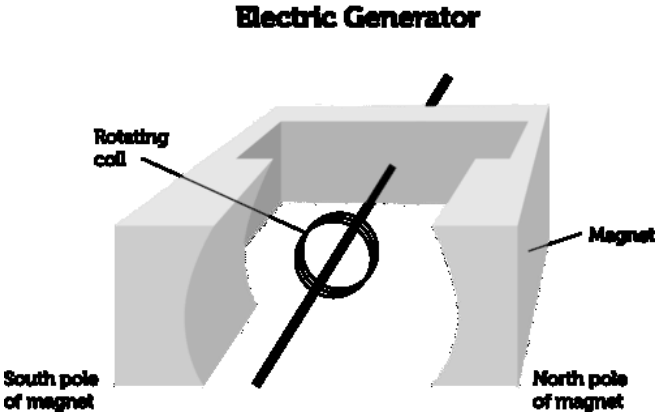
The overhead portion of this machine (painted yellow) is a lifting electromagnet. It is lowered to the deck where steel pipe is stored and it picks up a length of pipe and moves it to another machine where it is set upright and lowered into an oil well drill hole.

Electromagnets are essential to the design of the electric generator and electric motor and are also employed in doorbells, circuit breakers, television receivers, loudspeakers, electric deadbolts, car starters, clothes washers, atomic particle accelerators, and electromagnetic brakes and clutches. Electromagnets are commonly used as switches in electrical machines. A recent use for industrial electromagnets is to create magnetic levitation systems for bullet trains.

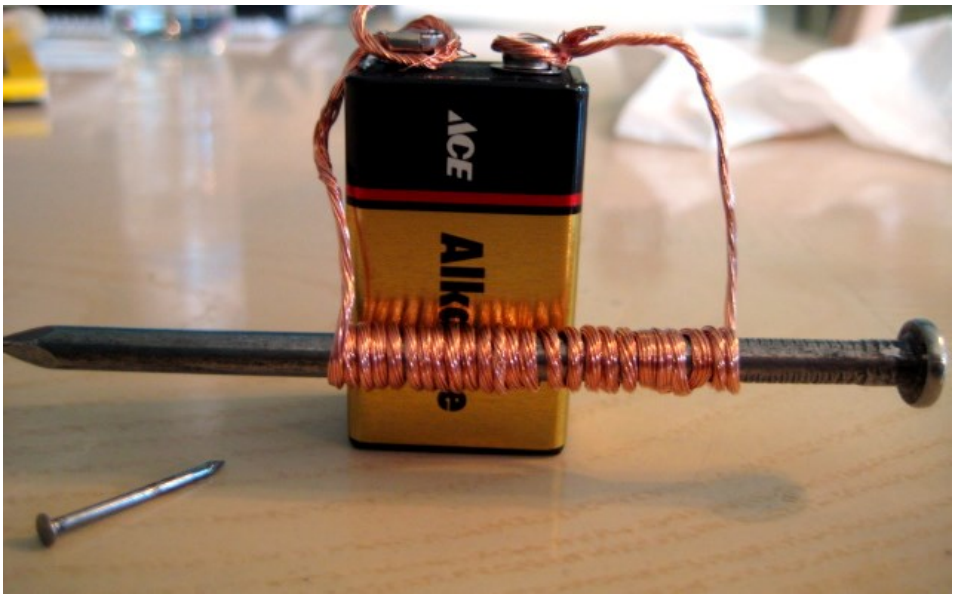
Electric Generators

An electric generator is a device that generates an electric current using a magnetic field. Electricity can be generated when a magnetic field and an electric conductor, such as a coil of wire, move relative to one another.

A simple diagram of an electric generator is shown in the figure below. In any electric generator, some form of energy is applied to turn a shaft. The turning shaft causes a coil of wire to rotate between the opposite poles of a magnet. Because the coil is rotating in a magnetic field, electric current is generated in the wire.



Putting It Together



You can build a simple electromagnet using a battery, wire, and nail. How does each factor below affect how strong the electromagnet is?

- The diameter of the wire.
- The voltage of the battery.
- The size of the nail.
- The number of times you wrap the wire around the nail.

2.5 Gravity (7.1.5)

Explore this Phenomenon

According to NASA, it takes 1,607,185 pounds of fuel to launch a space shuttle. Do you think it would take more, less, or the same amount of fuel to launch a space shuttle from the moon? Why?

7.1.5 Gravity

Engage in argument from evidence to support the claim that gravitational interactions within a system are attractive and dependent upon the masses of interacting objects. Examples of evidence for arguments could include **mathematical** data generated from simulations or digital tools.

Systems can be big or small. A system model can be used to show the energy that goes in and out of a system. A system consists of all the parts (matter) that are in the system and everything that is affecting the system.

What is Gravity?

Gravity has traditionally been defined as a force of attraction between things that have mass. According to this concept of gravity, anything that has mass, no matter how small, exerts gravity on other matter. Gravity can act between objects that are not even touching. In fact, gravity can act over very long distances, but the farther apart the objects are, the weaker the force of gravity between them is.

Mass Influences the Strength of Gravity

The strength of gravity between any two objects depends on two factors: the masses of the objects and the distance between them. An object with more mass will have a stronger gravitational pull. For example, because Earth is so massive, it attracts your desk, holding it to the ground, more strongly than you can attract your desk. There is a force of gravity between Earth and you and also between you and all the objects around you. When you drop a paper clip, why doesn't it fall toward you instead of toward Earth?

If we look at the solar system, the sun's mass is about 98% of the total mass of the system. Our eight plants are exerting a force on the sun, but the sun is exerting a greater force on the planets which cause them to be attracted to the earth. This attraction and the sideways motion of the plants keep them rotating around the sun.

We can measure the force of gravity on earth with a spring scale. The more mass an object has the harder it is to pick up, because of the pull of gravity on that object. A bowling ball has more mass therefore it takes more force to pick it up than the force needed to pick up a beach ball.

Putting It Together

• Create a model to show why less fuel would be needed to launch the space shuttle from the moon than it would take to launch the space shuttle from earth.

• Could you launch the space shuttle from Jupiter, the largest planet in our solar system, with the same amount of fuel that is needed to launch the shuttle from earth? Explain your answer.

• Much of the research for space travel is used to develop materials for the space shuttle that have the smallest mass possible. Make an argument with evidence for why this research is important?

2.6 References

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7. Susan Larson

8. https://flic.kr/p/7Sseik

9. By Geek3 (Own work) [GFDL (http://www.gnu.org/copyleft/fdl.html) or CC BY-SA 3.0 (http://creativecommons.org/licenses/bysa/3.0)], via Wikimedia Commons

10. Gina Clifford. Electromagnet.

11. Susan Larson

12.http://www.nasa.gov/sites/default/files/styles/full_width_feature/public/1981_april_sts_001_0.jpg?itok=9Yqsa 9Xg

CHAPTER 3

Strand 2: Earth's Processes

Chapter Outline

Earth's processes are dynamic and interactive and are the result of energy flowing and matter cycling within and among Earth's systems. Energy from the sun and Earth's internal heat are the main sources driving these processes. Plate tectonics is a unifying theory that explains crustal movements of the Earth's surface, how and where different rocks form, the occurrence of earthquakes and volcanoes, and the distribution of fossil plants and animals.

3.1 The Rock Cycle (7.2.1)

Explore this Phenomenon

• What do you notice about this rock? Write your observations.

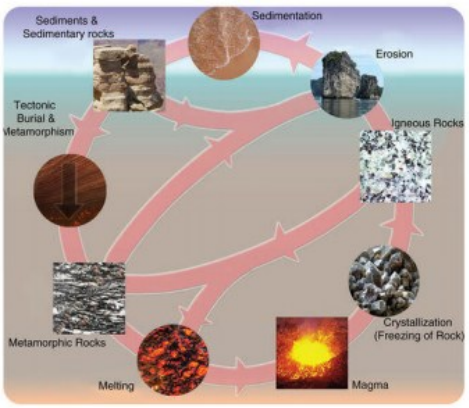
• How do you think it got those these wavy lines?

7.2.1 The Rock Cycle

Develop and use a model of the rock cycle to describe the relationship between energy flow and matter cycling that create igneous, sedimentary, and metamorphic rocks. Emphasize the processes of melting, crystallization, weathering, deposition, sedimentation, and deformation, which act together to form minerals and rocks.

As you read about the rock cycle, try to imagine the amount and type of energy that is needed in order to get matter (rock) to change.

The Rock Cycle



The rock cycle pictured above, shows the three major rock types: igneous, sedimentary, and metamorphic. The picture also shows how one rock can change into another rock.

Rocks change as a result of natural processes that are taking place all the time. Most changes happen very slowly. Right now, rocks deep within the Earth are becoming other types of rocks. Even on the earth's surface, rocks are changing in ways we might not notice.

The Three Rock Types

Rocks are grouped into three major groups according to how they are formed.

Igneous

Igneous rocks form from the cooling and hardening of melted rock. Melted rock is called magma. Igneous rocks can cool slowly beneath the surface of the earth or quickly on the surface. As the magma cools, crystallization can occur. Different crystals form at different temperatures from different minerals within the rock. For example, the mineral olivine crystallizes out of magma at much higher temperatures than quartz. The rate of cooling

determines how much time the crystals will have to form. Slow cooling produces larger crystals, found in granite, while fast cooling results in smaller crystals, found in basalt and pumice.

Sedimentary

Sedimentary rocks are formed when sediments, broken pieces of gravel, sand, silt, or clay, are compacted and cemented together. Sediments can be formed from the weathering and erosion of existing rocks Wind, heat, and running water all work to weather Earth's surface down into smaller pieces. Also, water that finds its way into the cracks of rocks and then freezes can break even large rocks into small sediments. These tiny sediments are then carried from one place to another by wind, running water, ice, and gravity.

Arches National Park

During sedimentation, the sediments are laid down or deposited. Sediments are deposited on beaches and deserts, at the bottom of oceans, and in lakes, ponds, rivers, marshes, and swamps. Landslides drop large piles of sediment. Glaciers leave large piles of sediments, too. Wind can only transport sand and smaller particles. The type of sediment that is deposited will determine the type of sedimentary rock that can form. In order to form a sedimentary rock, the accumulated sediment must become compacted and cemented together in a process called cementation.

Metamorphic

Metamorphic rocks form when rocks are exposed to extreme heat and pressure within the Earth but do not completely melt. The tremendous amount of heat and pressure can actually change the minerals that are in the rock, change its shape and texture, making a new type of rock. In the example below, the mudstone has been exposed to heat from Earth's interior and metamorphosed into a new rock called Schist.

Parent Rock: Mudstone

Daughter Rock: Schist

Putting It Together

• How was this rock created?

• Create a model of the rock cycle that shows how this particular rock was formed. Make sure to include what type of rock this is.

3.2 Earth's Surface Changes over Time (7.2.2)

Explore This Phenomenon

In 1983, a giant landslide occurred near the town of Thistle, UT. The landslide plugged the Spanish Fork River which then formed a lake within a matter of days. What can this landslide tell us about the changes to the Earth's landscape over time?

7.2.2 Earth's Surface Changes over Time

Construct an explanation based on evidence for how processes have changed Earth's surface at varying time and spatial scales. Examples of processes that occur at varying time scales could include slow plate motions or rapid landslides. Examples of processes that occur at varying spatial scales could include uplift of a mountain range or deposition of fine sediments.

As you look at and read about the structure of the earth, keep in mind that most features took a very long time to form. Some features happen very quickly. It is important to remember that no matter how fast or slow, big or small, different processes contribute to how earth looks today and how it will change in the future. Studying these changes within a small system can help us make predictions about Earth as a whole.

Kaboom!

Amazing but true: The 1980 eruption of Mt. St. Helens (pictured above) released a cloud of ash 8 to 10 miles into the sky. Sadly, 57 people died and over $1 billion in property was destroyed. But as volcanic eruptions go, that eruption was pretty small.

A volcano is a vent from which the material from a magma chamber deep in the earth escapes. Volcanic eruptions can come from volcanic cones, fractured domes, a vent in the ground, or many other types of structures.

When a volcano erupts Earth's surface can be changed in a matter of seconds.

Landslides

There are other events that can drastically change Earth's landscape very quickly. A landslide happens when a large amount of soil and rock suddenly falls down a slope because of gravity. You can see an example in the picture below. A landslide can be very destructive. It can bury or carry away entire villages in a matter of minutes.

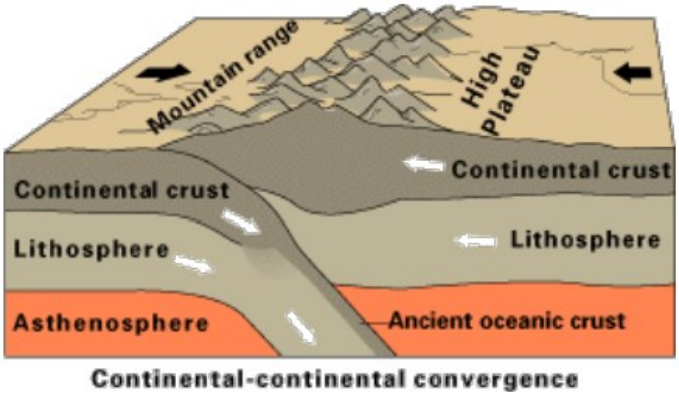
This 2001 landslide in El Salvador (Central America) was started by an earthquake. Soil and rocks flowed down a hillside and swallowed up houses in the city below.

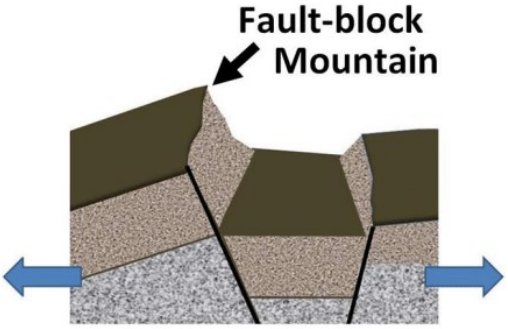
Erosion by Streams

Other landforms take years and years to form. As streams travel, they break down or erode sediment from the rocks on their banks. The running water picks up and transports the sediments further downstream. Pictured above is the San Juan River. The twist and turns have been created over millions of years as water, wind, frost, and gravity have cut 1,000 feet into Earth's crust.

Gooseneck State Park in Utah photo by Tracie Maughan

Mountain Building





Ever wonder how mountains are formed? The earth's crust is broken into different plates that move and bump into each other, and slide over and under each other. The first picture shows how when two plates bump into one another one can be pushed up creating mountain ranges. An example of this is the Himalayan Mountain Range, which is still growing today. Changes to the mountain can occur when the plates move away from each other like in the second picture. The Sierra Nevada mountain range was changed this way.

Deposition of Sediments

What happens to the little of pieces of rock or sediment that get eroded away by wind, water, and ice? At times, some sediment will become sedimentary rock. Some sediments can be turned into rich soil that is perfect for growing crops and supporting life. However, soil development takes a very long time. It may take hundreds or even thousands of years to form the fertile upper layer of soil. Soil scientists estimate that in the very best soil forming conditions, soil forms at a rate of about 1mm/year. In poor conditions, it may take thousands of years!

Wind is one of the best movers of sediment. Like water, as wind slows down it drops the sediment it's carrying. This often happens when the wind has to move over or around an obstacle. A rock or tree may cause wind to slow down. As the wind slows, it deposits the largest particles first. Different types of deposits form depending on the size of the particles deposited. When the wind deposits sand, it forms small hills. These hills are called sand dunes. For sand dunes to form, there must be plenty of sand and wind. Sand dunes are found mainly in deserts and on beaches.

Putting It Together

Construct an explanation based on evidence for how processes, such as this landslide, have changed the earth's surface at varying time and spatial scales.

3.3 Engineering and Geologic Hazards (7.2.3)

Explore This Phenomena

This California Memorial Stadium is sometimes called a "tectonic time bomb".

The Hayward Earthquake Fault passes directly beneath both end zones at California Memorial Stadium, the home of football at the University of California, Berkeley. The site probably looked flat and easy to build on in 1922 before knowledge of earthquake faults was very advanced. To make the stadium safe for workers, players, and fans, the stadium is being renovated in a $321 million project involving 10 miles of steel cables, silicone fluid-filled shock absorbers, concrete piers, 3 feet of sand, plastic sheeting, and stone columns.

Where in Utah do we have to worry about geologic hazards? What geologic hazards might affect Utah? How do we know what buildings are at risk for damage in the event of a geologic hazard? What kinds of precautions can engineers take to protect out buildings from these geologic hazards?

7.2.3 Engineering and Geologic Hazards

Ask questions to *identify constraints* of specific geologic hazards and *evaluate competing design solutions* for maintaining the stability of human engineered structures such as homes, roads and bridges. Examples of geologic hazards could include earthquakes, landslides, or floods.

Sometimes unexpected things might happen that affect the stability of manmade structures. As you read, think like an engineer and see if you can identify the hazards we should watch out for as we build structures. You can predict and then evaluate the best design solution.

Geologic Hazards Affect Humans

The devastating earthquake that occurred on April 25, 2015 between the cities of Pokhara and Kathmandu in Nepal killed thousands of people, destroyed communities, and left millions in need of food and shelter. Events like these can be terrifying and assistance efforts require the coordinated involvement of the entire world.

Earthquakes

The Earth's crust is made of continental and oceanic plates that fit together much like a puzzle. Earthquakes can occur along these plate boundaries. Sometimes one plate moves past another plate and their jagged edges get stuck. When they finally break away

from each other, all of the energy that was stored is released and an earthquake occurs. Sometimes one plate slips underneath another plate causing an earthquake. Regardless of how earthquakes occur, the energy they release can cause problems for people on earth.

Landslides

Landslides are the most dramatic, sudden, and dangerous examples of Earth materials moved by gravity. Landslides are sudden falls of rock much like avalanches are sudden falls of snow. When large amounts of rock suddenly break loose from a cliff or mountainside, they move quickly and with tremendous force. Air trapped under the falling rocks acts as a cushion that prevents the rock from slowing down. Landslides can move as fast as 200 to 300 km/hour.

This landslide in California in 2008 blocked Highway 140.

Landslides are exceptionally destructive. Homes may be destroyed as hillsides collapse. Landslides can even bury entire villages. Landslides may create lakes when the rocky material dams a stream. If a landslide flows into a lake or bay, they can trigger a tsunami.

Floods

A flood occurs when so much water enters a stream or river that it overflows its banks. Flood waters from a river are shown in the following picture.

Floods are a natural part of the water cycle, but they can cause a lot of damage. Farms and homes may be lost, and people may die. In 1939, millions of people died in a flood in China.

Floods may occur when deep snow melts quickly in the spring. More often, floods are due to heavy rainfall. Floods happen when rain falls more quickly than water can be absorbed into the ground or carried away by rivers or streams.

How can humans engineer structures to withstand the above mentioned geologic hazards?

New construction can be made safer in many ways:

- Skyscrapers and other large structures built on soft ground must be anchored to bedrock, even if it lies hundreds of meters below the ground surface.
- The correct building materials must be used. Houses should bend and sway. Wood and steel are better than brick, stone, and adobe, which are brittle and will break.
- Larger buildings must sway, but not so much that they touch nearby buildings. Counterweights and diagonal steel beams are used to hold down sway.
- Large buildings can be placed on rollers so that they move with the ground.
- Buildings may be placed on layers of steel and rubber to absorb the shock of the earthquake waves.
- In a multi-story building, the first story must be well supported.
- In Louisiana, where flooding is common, houses are often raised on stilts.

The first floor of this San Francisco building is collapsing after the 1989 Loma Prieta earthquake

Retrofitting

To make older buildings more earthquake safe, retrofitting with steel or wood can reinforce a building's structure and its connections. Elevated freeways and bridges can also be retrofitted so that they do not collapse.

Preventing Fire Damage

During earthquakes, fires often cause more damage than the earthquake. Fires start because seismic waves rupture gas and electrical lines, and breaks in water mains make it difficult to fight the fires. Builders zigzag pipes so that they bend and flex when the ground shakes. In San Francisco, water and gas pipelines are separated by valves so that areas can be isolated if one segment breaks.

Steel trusses were built diagonally and horizontally across windows to retrofit a building at Stanford

In the 1906 San Francisco earthquake, fire was much more destructive than the ground shaking.

Cost Considerations

Why aren't all structures in earthquakes zones constructed for maximum safety? Cost, of course. More sturdy structures are much more expensive to build. So communities must weigh how great the hazard is, what different building strategies cost, and make an informed decision.

A Better Bridge

In September 2013, the eastern span of the San Francisco-Oakland Bay Bridge was replaced by a new earthquake resistant bridge. This photo shows the bridge a few days after the new span was put into service and the old span was abandoned.

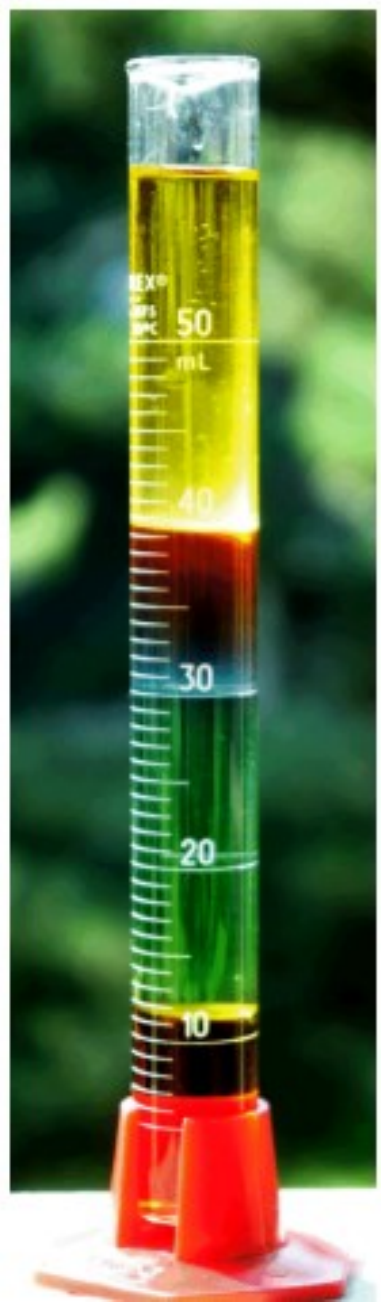
Putting It Together

• In Utah what are some criteria we should be aware of when building in areas prone to geologic hazards?

• What are some constraints we should be aware of when building in areas prone to geologic hazards?

3.4 Earth's Interior (7.2.4)

Explore This Phenomena



This cylinder contains 6 different liquids. Notice how they are separated into different layers. What causes them separate this way?

Can you think of anything else that has layers?

7.2.4 Earth's Interior

Develop and use a scale model of the matter in the Earth's interior to demonstrate how differences in density and chemical composition (silicon, oxygen, iron, and magnesium) cause the formation of the crust, mantle and core.

The earth formed billions of years ago. As you read, watch for the different causes that affected how the earth to formed layers.

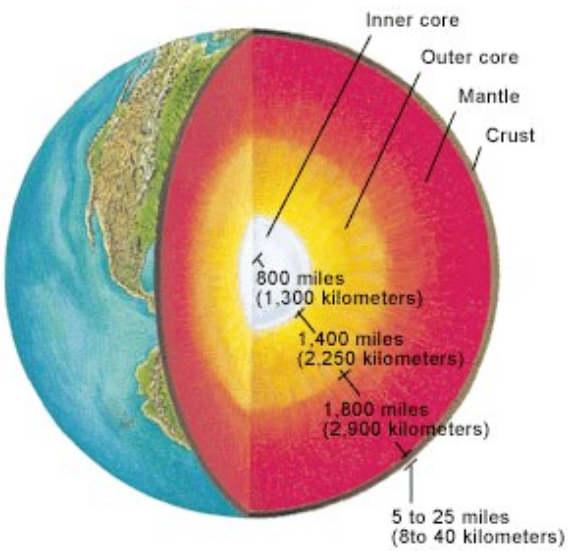
"You're My Density"

A golf ball and a table tennis ball are about the same size. However, the golf ball is much heavier than the table tennis ball. Now imagine a similar size ball made out of lead. That would be very heavy indeed! What are we comparing? By comparing the mass of an object relative to its size, we are studying a property called density. Density is the amount of material (mass) contained within a certain amount of space (volume). More dense materials will always form a layer underneath less dense materials. Less dense items float, and more dense items sink.

The materials that make up the Earth follow all of the principles of density that were discussed above. The densest materials in the Earth tend to be located closest to the center, or core, of the Earth. The least dense materials are on top of the Earth. The air, which is the least dense earth material, is located above the Earth.

The Core

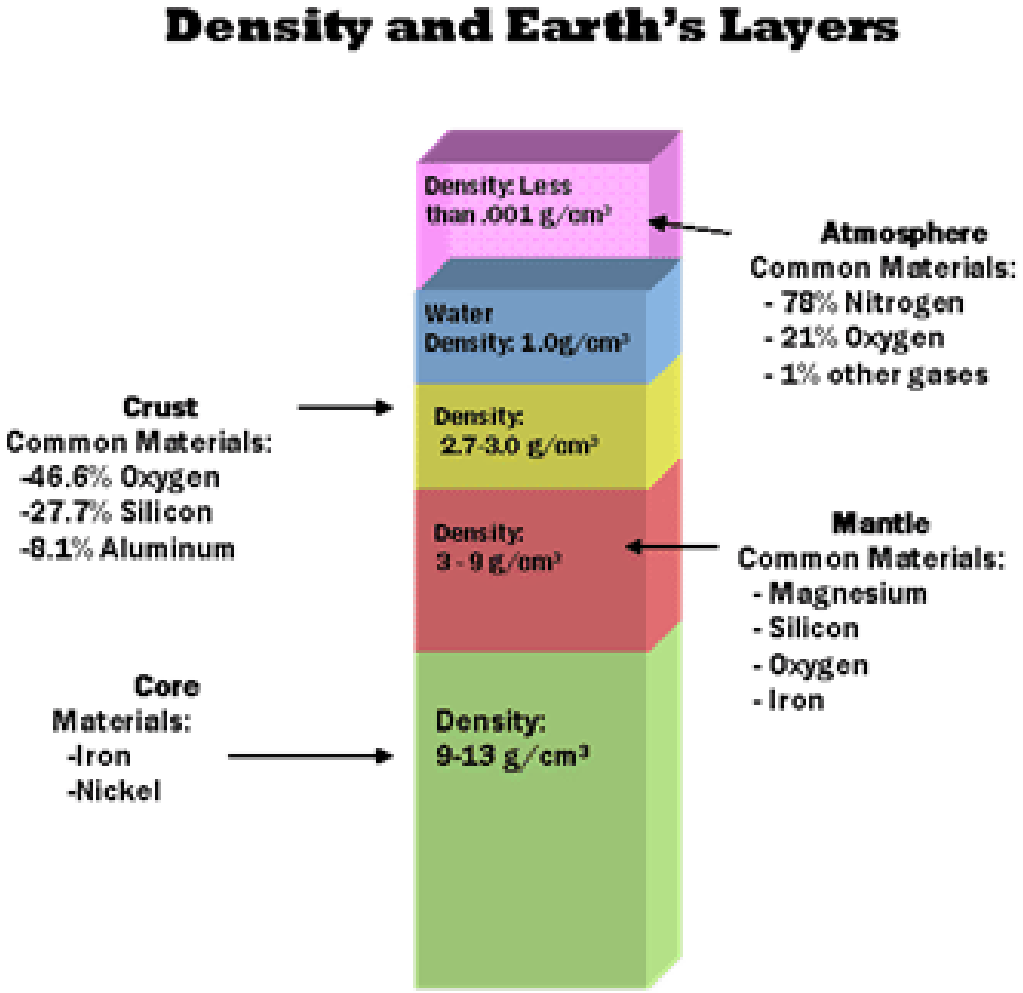
The very center part of the Earth is called the core. Earth's core is divided into the inner core and the outer core



The inner core of the Earth is a solid ball and its chemical composition is made up mostly of iron and nickel. These are very dense materials. Scientists study Earth's magnetic field as well as other properties of the Earth as evidence that the core is made of iron and nickel.

The outer core, like the inner core's chemical composition, is mostly iron and nickel, but the outer core is a liquid. Seismic waves help scientists to determine which part of the core is solid and which part is liquid.

Temperature increases as you get closer to the center of the Earth. If both the inner and outer core are made of similar materials then why would the inner core be solid and the outer core liquid even though the inner core was hotter? In order for a solid to become a liquid it must be able to expand. The weight of all of the upper materials on the inner core is so intense that it cannot overcome the pressure and expand to become liquid, much like getting squished on the bottom of a dogpile. Therefore, it must remain solid. If the pressure were to ease up, the inner core would expand and liquefy. The core of the Earth is tightly compacted. The density of the core ranges between 9 and 13 g/cm3. The core contains about 33% of Earth's total mass.

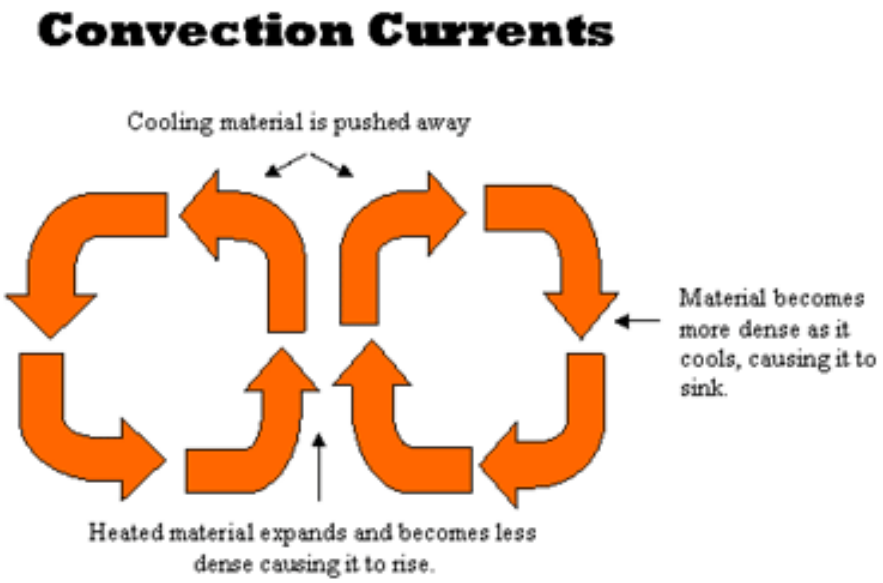


The Mantle

The part of the Earth that lies between the core and the surface is the mantle. It is the thickest layer of the earth. About 67% of Earth's mass is located in the mantle.

The mantle is located far enough below the crust that no one has been able to go there and study it. Scientists must rely on interpreting data that they have in order to study the mantle. Volcanoes offer some help in studying the mantle. Since magma from volcanoes come from the mantle scientists can use lava flows and magma domes to see what materials are present in the mantle. From these sources we know that magnesium, silicon and oxygen are the most common materials found in the mantle making up the majority of its chemical composition.

The mantle is divided into the upper and lower mantle. The lower mantle is about 2,550 km thick and is made up of solid rock. Most of Earth's mass is located here. The upper mantle is about 250 km thick and is made of rock that flows very slowly. This rock can best be explained as a semi-solid. It is "plasticky", having a consistency like peanut butter. Heat in the lower mantle circulates in convection currents. Convection currents are where heated magma rises up from the bottom of the upper mantle to near the surface, and then cools down and falls, only to heat up and rise again. Scientists believe that, since the Earth's tectonic plates sit on top of the lower mantle, they ride these currents. It is these currents that are partly responsible for the plate movement in plate tectonics.



In a convection current, heat rises because it is less dense than the cooler material around it. As it rises it cools and is pushed out by the hotter material rising below it. Eventually, it cools and sinks. As it sinks it is heated again and is pulled to the center to fill the space left by the rising heated material.

The mantle is a fairly dense region of Earth's interior but nowhere near as dense as the core. The density of the mantle ranges between 3 and 9 g/cm3.

The Crust

The upper part of the Earth where life exists is called the crust. The crust ranges in thickness from about 5 to 100 km. The thickest spots are on land and are called continental crust. The thinner parts of the crust are under the ocean, called oceanic crust.

The most abundant elements making up the chemical composition of the crust are oxygen, silicon, and aluminum. Many other elements are present as well, but in lower quantities.

The density of Earth's crust is between 2.7 and 3.0 g/cm3. Since water has a density of 1.0g/cm3, it is less dense than the crust and it sits on top of the crust and fills in any seams, cracks, and empty areas that may be present.

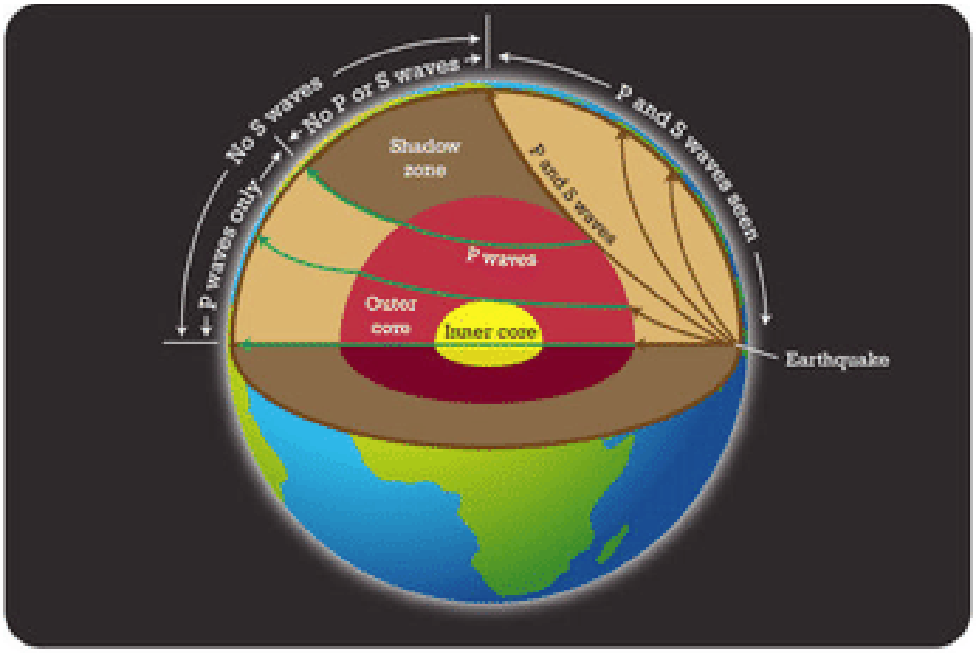
The Atmosphere

The least dense layer of the Earth is the atmosphere. The atmosphere is the layer of the Earth that contains all of the oxygen and other gases in the air around us. It extends several miles above Earth's surface. The reason our atmosphere is above the Earth is because it is far less dense than each of the other layers. The atmosphere has a density of less than .0013g/cm3.

Remember, the densest materials in the Earth tend to be the closest to the core. Likewise, the least dense materials tend to be located on the surface and above the surface of the Earth.

How Do Scientists Know About the Inside of the Earth?

Seismic waves are another way that scientists can study the Earth's interior without actually visiting there. Seismic waves are the energy waves that are generated by earthquakes. To understand what these waves are like, fill a sink with water and drop a rock into the water. Watch the waves that spread out from the point that the rock entered the water. When an earthquake occurs, the energy waves move out from the point of the quake in much the same way.



The properties of seismic waves allow scientists to understand the composition of Earth's interior

There are two types of seismic waves, S waves and P waves. These waves act differently in solids and liquids. When P waves pass through liquids they slow down. They pick up speed when they reach a solid on the other side of the liquid. The S waves stop completely in liquids. Waves also travel faster in materials that are denser. Scientists look at data that they collect from earthquakes and can determine the composition of Earth's interior by how the waves slow down, speed up, and disappear.

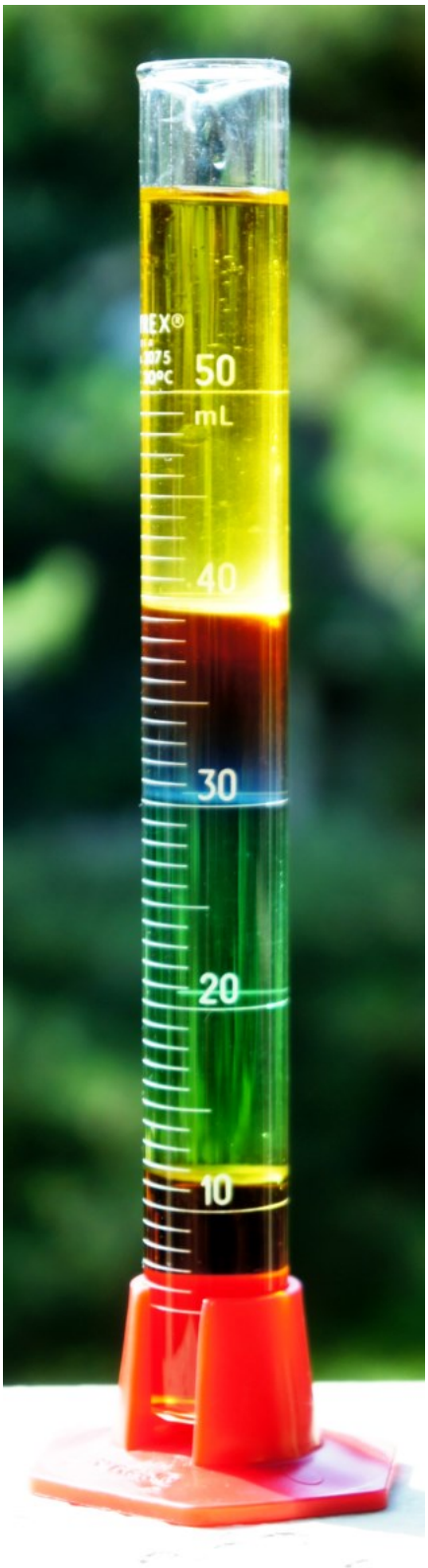
Meteorites

Scientists study meteorites to learn about Earth's interior. Meteorites formed in the early solar system. These objects represent early solar system materials. Some meteorites are made of iron and nickel. They are thought to be very similar to Earth's core. An iron meteorite is the closest thing to a sample of the core that scientists can hold in their hands!

Online Interactive Activity

- Plate Tectonics: http://tinyurl.com/UT7th2-2-b

Putting It Together



- What caused these liquids to separate into different layers?

- How does this relate to the layers of the Earth?

- Explain the factors that caused Earth's interior to separate into the layers crust, mantle, and core?

3.5 Patterns in Plate Tectonics (7.2.5)

Explore this Phenomenon

Check out the image above. Scientists hypothesize that all of the land on Earth used to be connected in one large land mass. What evidence do you see that might lead support that claim?

Draw a picture of what you think the large land mass might have looked like?

7.2.5 Patterns in Plate Tectonics

Ask questions and analyze and interpret data about the patterns between plate tectonics and:

(1) The occurrence of earthquakes and volcanoes,
(2) Continental and ocean floor features
(3) The distribution of rocks and fossils.

Examples could include identifying patterns on maps of earthquakes and volcanoes relative to plate boundaries, the shapes of the continents, the locations of ocean structures (including mountains, volcanoes, faults, and trenches), and similarities of rock and fossil types on different continents.

Patterns exist everywhere in the natural world. In this section you can see how analyzing the patterns that we see on Earth today can help us explain what has happened in the past and make prediction about the future.

Plates

The crust of the Earth is split into several large chunks called plates. These plates sit on top of the mantle and are able to move. Where two plates meet is called a plate boundary. There are three ways that plates can meet so there are three types of plate boundaries. Plates can move away from each other. They can move toward each other. Finally, they can slide past each other.

Most geological activity takes place at plate boundaries. This activity includes volcanoes, earthquakes, and mountain building. The activity occurs as plates interact. Giant slabs of crust and upper portion of the mantle moving around can create a lot of activity! The features seen at a plate boundary are determined by the direction of plate motion and by the type of crust found at the boundary.

Volcanoes and the Pacific Rim

Volcanoes at plate boundaries are found all along the Pacific Ocean basin, primarily at the edges of the Pacific, Cocos, and Nazca plates.

The Cascade Mountains, along the west coast of the North American continent, are a chain of volcanoes at a boundary where some oceanic plates are moving beneath the continental plate.

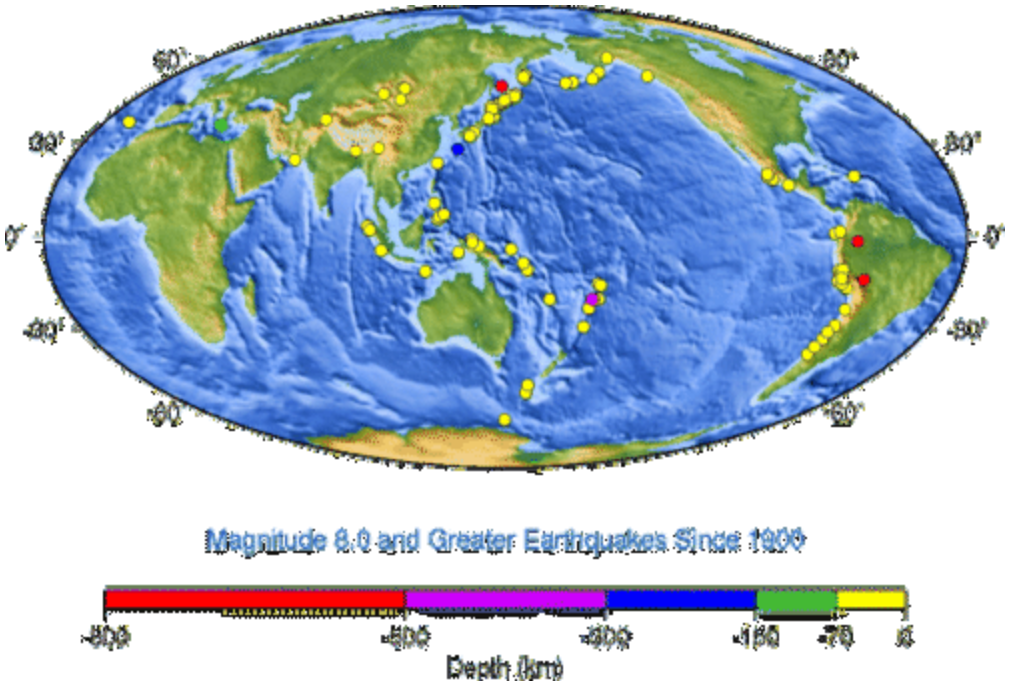
The Cascade Range is formed by volcanoes created from the oceanic crust moving beneath the North American continent.

The Cascades have been active for 27 million years, although the current peaks are no more than 2 million years old. The volcanoes are far enough north and are in a region where storms are common, so many are covered by glaciers.

Earthquake Zones

Nearly 95% of all earthquakes take place along one of the three types of plate boundaries.

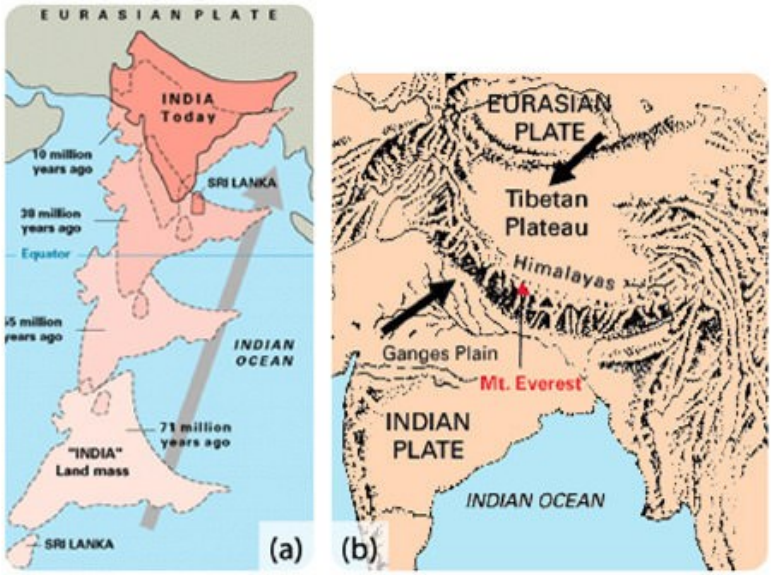
- About 80% of all earthquakes strike around the Pacific Ocean basin because it is lined with plates moving toward and sliding past boundaries (Figure below).
- About 15% take place in the Mediterranean-Asiatic Belt, where the Indian Plate runs into the Eurasian Plate.
- The remaining 5% are scattered around other plate boundaries or are intraplate (not at plate boundaries) earthquakes.



Earthquake epicenters for magnitude 8.0 and greater events since 1900. The earthquake depth shows that most large quakes are shallow focus, but some sub ducted plates because deep focus quakes.

Continental Plates Moving Toward Each Other

Two continental plates collide and smash upwards to create gigantic mountain ranges. There is currently no mountain range of this type in the western U.S., but we can find one where India is pushing into Eurasia.

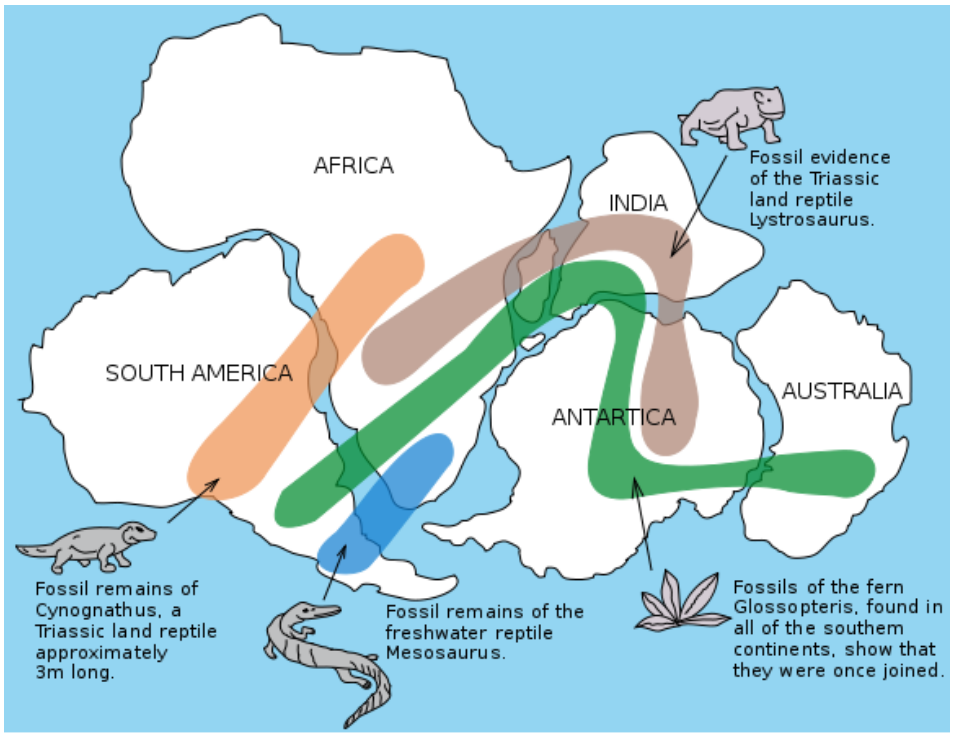


(a) The world's highest mountain range, the Himalayas, is growing from the collision between the Indian and the Eurasian plates. (b) The crumpling of the Indian and Eurasian plates of continental crust creates the Himalayas.

Oceanic Plates Moving Away From Each Other

At plate boundaries where they are moving away from each other, hot mantle rock rises into the space where the plates are moving apart. As the hot mantle rock convects upward it rises higher in the mantle. Lava erupts through long cracks in the ground, or fissures. Ocean floor maps show that the youngest seafloor rock is found where these splits happen and oldest sea floor rock is found near the continents.

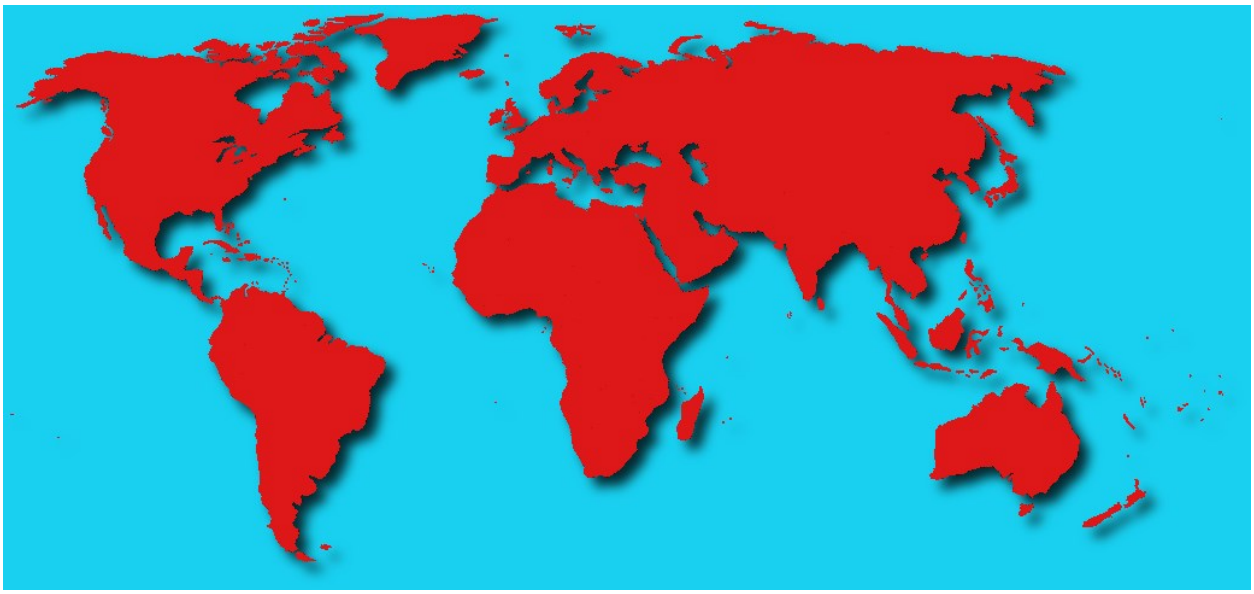
Fossil Evidence for Plate Movement



Fossil evidence for plate movement includes the presence of similar and identical species on continents that are now great distances apart. For example, fossils of the therapsid *Lystrosaurus* have been found in South Africa, India and Antarctica, alongside members of the *Glossopteris* flora, whose distribution would have ranged from the polar circle to the equator if the continents had been in their present position; similarly, the freshwater reptile *Mesosaurus* has been found in only localized regions of the coasts of Brazil and West Africa.

Additional evidence for plate movement is found in the similar geology of adjacent continents, such as the eastern coast of South America and the western coast of Africa. The polar ice cap of the Carboniferous Period covered the southern end of Pangaea (when all the contents were one large land mass). Glacial deposits of the same age and structure are found on many separate continents which would have been together in the continent of Pangaea.

Putting It Together



Using data found in this chapter, give an explanation as to why we believe the coasts of South America and Africa where once connected.

What other patterns, besides the shape of the continents, can we use as evidence to prove that the continents are moving?

3.6 How Old is the Earth (7.2.6)

Explore this Phenomenon

Have you ever been on a hike or floating on a river in a large canyon? Did you notice the layers of different colors or materials in the canyon walls? How did those different layers get there? Are some layers older than other layers? Write an explanation as to why the canyon walls look like they do?

7.2.6 The Earth is How Old?

Make an argument from evidence for how the geologic time scale shows the age and history of Earth. Emphasize scientific evidence from rock strata, the fossil record, and the principles of relative dating, such as superposition, uniformitarianism and recognizing unconformities.

Scientists use evidence to show the age and history of the Earth. As you read, think about the time scale and what evidence you could use to make an argument for the age of the earth.

Clues from Fossils

Fossils are our best form of evidence about Earth's history of life. Fossils give us clues about past climates, the motions of plates, and other major geological events. Scientists use what we know about the present to understand the past. What we know about a type of organism that lives today can be applied to past environments. We call this principle uniformitarianism. Scientist assume that natural laws and processes that operate on earth today, operated the same way back millions of years ago.

History of Life on Earth

The fossil record illustrates how life on Earth has changed over time. Fossils in relatively young rocks resemble the types of animals and plants that are living today. In general, fossils in older rocks are less similar to modern organisms.

We would know very little about the organisms that came before us if there were no fossils. Modern technology has allowed scientists to reconstruct images and learn about the biology of extinct animals like dinosaurs!

Environment of Deposition

Geologists can determine whether a region was terrestrial (on land) or marine (underwater) or even if the water was shallow or deep by what type of organism created the fossil.

Geologists can further find clues about the original environment by studying the type and structure of the rock in which the fossil was found. The type of rock may give clues to whether the rate of sedimentation was slow or rapid which would be an indication of the rate of erosion and available materials.

The amount of wear and breakage of a fossil allows scientists to learn about what happened to the region after the organism died; for example, whether it was exposed to wave action.

Geologic History

The presence of marine organisms in a rock indicates that the area where the rock was deposited was once on the bottom of the ocean. Sometimes fossils of marine organisms are found on tall mountains indicating that rocks that formed on the seabed were pushed up, becoming uplifted.

The photo below is as sand dune in Coral Pink Sand Dunes State Park, Utah. We see that wind can cause cross-bedding in sand. Cross-bedding is due to changes in wind direction. There are also ripples caused by the wind waving over the surface of the dune.

Sand dune in Coral Pink Sand Dunes State Park, Utah.

This doesn't look exactly like the outcrop of Navajo sandstone found in Zion National Park, but if you could cut a cross-section into the face of the dune it would look very similar.

Since we can observe wind forming sand dunes with these patterns now, we have a good explanation for how the Navajo sandstone formed. The Navajo sandstone is a rock formed from ancient sand dunes. The rock shows that the ancient wind direction changed from time to time.

This is just one example of how geologists use observations they make today to unravel what happened in Earth's past. Rocks formed from volcanoes, oceans, rivers, and many other features are deciphered by looking at the geological work those features do today.

Sedimentary Rock Rules

Sedimentary rocks follow certain rules.

1. Superposition: Sedimentary rocks are formed with the oldest layers on the bottom and the youngest on top. The rocks that got there first will be located at the bottom of the layers.
2. Sediments are deposited horizontally, so sedimentary rock layers are originally horizontal. For example, some volcanic rocks, such as ash, fall and cover the ground horizontally.
3. Unconformities: Sedimentary rock layers that are not horizontal are deformed and indicate something unusual happened.

Since sedimentary rocks follow these rules, they are useful for seeing the effects of stress and other geologic processes on rocks. Sedimentary rocks that are not horizontal must have been deformed by these processes.

You can trace the deformation a rock has experienced by seeing how it differs from its original horizontal, oldest-on-bottom position. This deformation produces geologic structures such as folds, joints, and faults.

Unconformities

An unconformity represents time during which no sediments were preserved in a region. The local record for that time interval is missing and geologists must use other clues to discover that part of the geologic history of that area. The image below is an example of an unconformity discovered by James Hutton on the 1700's.

Hutton’s Unconformity

Hutton's Unconformity is a name given to various famous geological sites in Scotland identified by the 18th-century Scottish geologist James Hutton as places where the junction between two types of rock formations can be seen. This geological phenomenon marks the location where rock formations created at different times and by different forces adjoin.

Using a combination of superposition, uniformitarianism and recognizing unconformities, as well as specific fossils and layers of rock, geologists have constructed a well-defined timeline of Earth’s relative geologic history. With information gathered from all over the world, estimates of rock and fossil ages have become increasingly accurate.

Putting It Together

Create an argument from evidence as to how we know the relative ages of the different layers of rock. Be sure to include at least three pieces of evidence.

3.7 References

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12. https://upload.wikimedia.org/wikipedia/commons/7/73/ElSalvadorslide.jpg .
13. https://upload.wikimedia.org/wikipedia/commons/8/83/Continental-continental_convergence_Fig21contcon t.gif .
14. https://upload.wikimedia.org/wikipedia/commons/d/d8/Fault_block_mountain.JPG .
15. https://upload.wikimedia.org/wikipedia/commons/4/46/Stagnogley.JPG .
16. https://pixabay.com/p-1142931/?no_redirect .
17. https://upload.wikimedia.org/wikipedia/commons/6/64/Thistlelandslideusgs.jpg .
18. Landslide blocking a highway.
19. Building collapsing after the Loma Prieta Earthquake.
20. Building retrofitted to meet earthquake safety standards.
21. In the 1906 San Francisco earthquake, fire was much more destructive than the ground shaking.
22. https://en.wikipedia.org/wiki/Density .
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CHAPTER 4

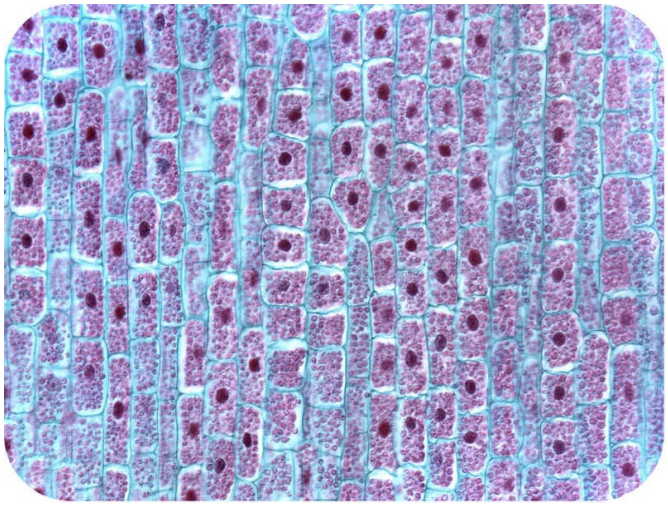
Strand 3: Structure and Function of Life

Chapter Outline

Living things are made of smaller structures, which function to meet the needs of survival. The basic structural unit of all living things is the cell. Parts of a cell work together to function as a system. Cells work together and form tissues, organs, and organ systems. Organ systems interact to meet the needs of the organism.

4.1 Cells are the Building Blocks of Life (7.3.1)

Explore this Phenomenon



Did you know that the seeds from the pine cone on the left look like the image on the right when put under a microscope?

Do all plants look like that under a microscope?

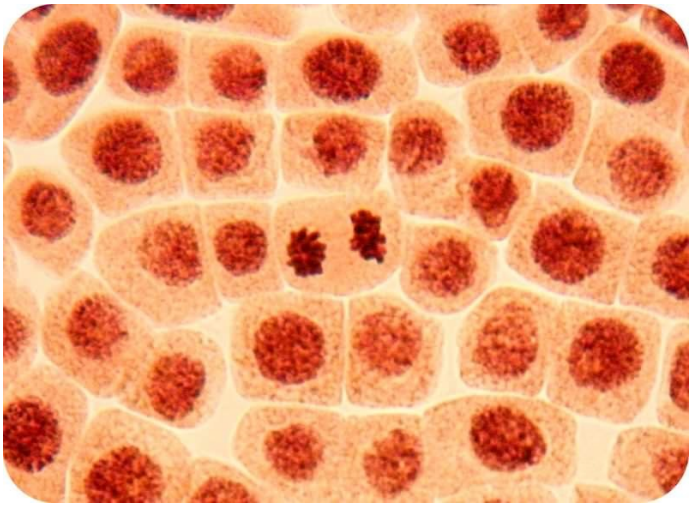
What investigation can you plan and carry out to show the basic structure of other living things?

7.3.1 Cells are the Building Blocks of Life

Plan and carry out an investigation that provides evidence that the basic structures of living things are cells. Emphasize that cells can form single-celled or multicellular organisms, and that multicellular organisms are made of different types of cells.

Cells make up all living things. Different cells have different shapes and sizes that help them perform a specific job. In this section see if you can identify how the structure and function of the tiny cells contribute to the structure and function of the whole organism.

Introduction to Cells



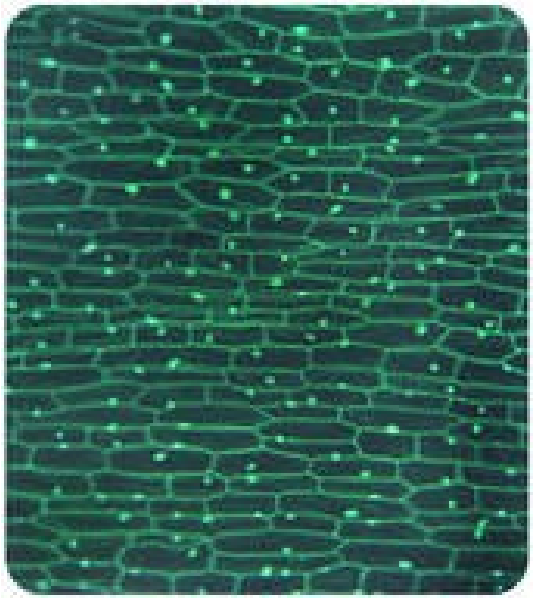
Cells make up all living things, including your own body. This picture shows a typical group of cells. But not all cells look alike. Cells can differ in shape and sizes. And the different shapes usually mean they do different things.

A cell is the smallest structural and functional unit of an organism. Some organisms, like bacteria, consist of only one cell. Big organisms, like humans, consist of trillions of cells. Compare a human to a banana. On the outside, they look very different, but if you look close enough you'll see that their cells are actually very similar.

Observing Cells

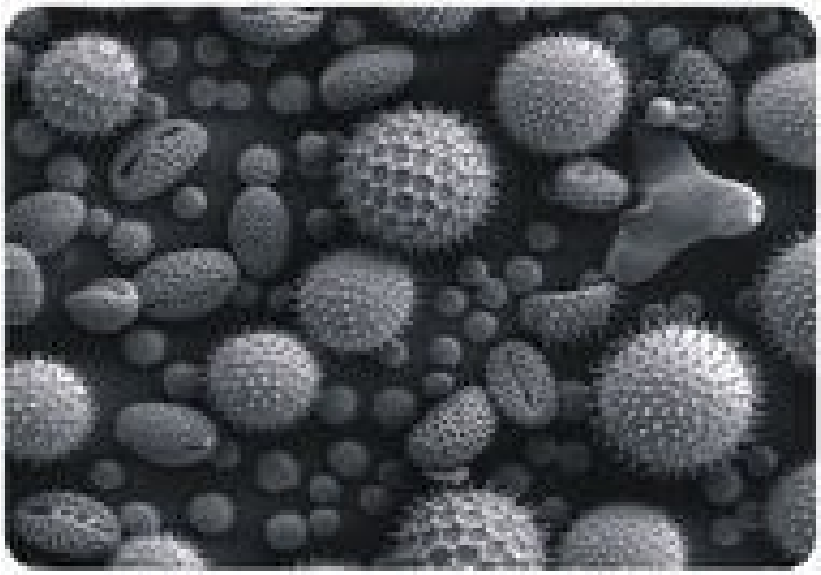
Most cells are so small that you cannot see them without the help of a microscope. It was not until 1665 that English scientist Robert Hooke invented a basic light microscope and observed cells for the first time, by looking at a piece of cork, which he got from a tree. You may use light microscopes in the classroom. You can use a light microscope to see

cells like the picture below. But many structures in the cell are too small to see with a light microscope. So, what do you do if you want to see the tiny structures inside of cells?



The outline of onion cells are visible under a light microscope.

A light microscope sends a beam of light through a specimen, or the object you are studying. In the 1950s, scientists developed more powerful electron microscope. An electron microscope, passes a beam of electrons through the specimen. Sending electrons through a cell allows us to see its smallest parts, even the parts inside the cell. Without electron microscopes, we would not know what the inside of a cell looked like.



An electron microscope allows scientists to see much more detail than a light microscope, as with this sample of pollen.

Cell Theory

In 1858, after using microscopes much better than Hooke's first microscope, Rudolf Virchow developed the hypothesis that cells only come from other cells. For example, bacteria, which are single-celled organisms, divide in half (after they grow some) to make new bacteria. In the same way, your body makes new cells by dividing the cells you already have. In all cases, cells only come from cells that have existed before. This idea led to the development of one of the most important theories in biology, the cell theory.

Cell theory states that:

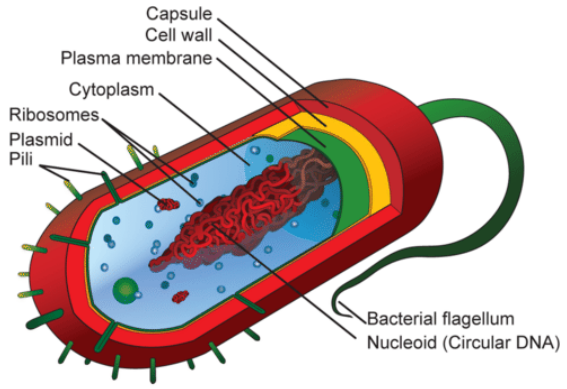
1. All organisms are composed of cells.
2. Cells are alive and the basic living units of organization in all organisms.
3. All cells come from other cells.

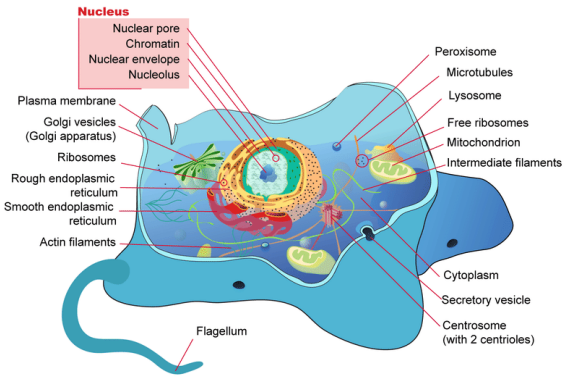
As with other scientific theories, many hundreds, if not thousands, of experiments support the cell theory. Since Virchow created the theory, no evidence has ever been identified to contradict it.

Single-celled vs Multicellular Organisms

Single-celled (unicellular) organisms like bacteria are composed of just one cell, whereas multicellular organisms can be composed of trillions of cells. Multicellular organisms include protists (though single-celled protists also exist), fungi, plants and animals. Most plant and animal cells are between 1 and 100 μm and therefore can only be observed under the microscope.

The one cell of a unicellular organism must be able to perform all the functions necessary for life. These functions include metabolism, homeostasis and reproduction. Specifically, these single cells must transport materials, obtain and use energy, dispose of wastes, and continuously respond to their environment. The cells of a multicellular organism also perform these functions, but they may do so in collaboration with other cells.





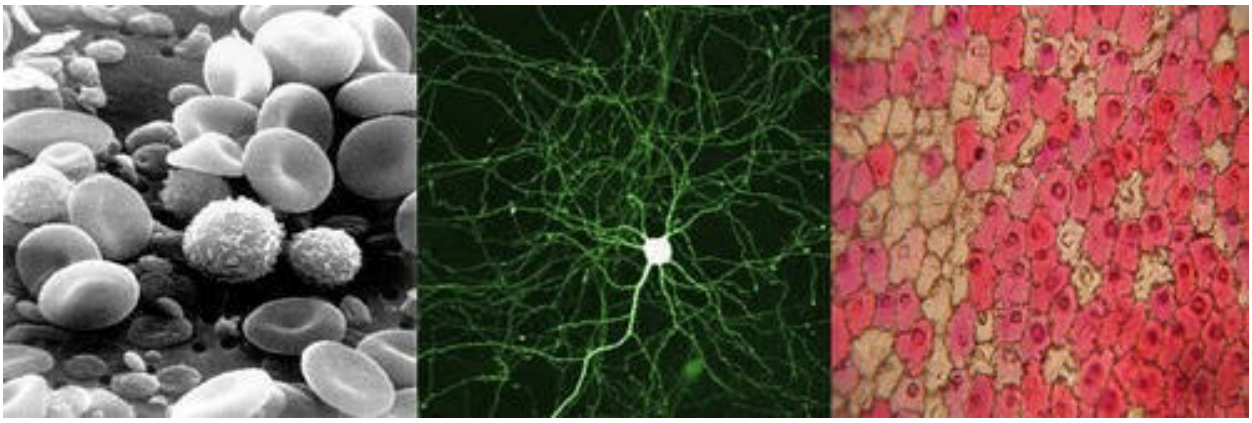
Compare and contrast the unicellular organism on the left and the cell found in a multicellular organism on the right in the drawings above. What similarities and differences do you see?

Specialized Cells for Multicellular Organisms

Although cells share many of the same features and structures, they also can be very different. Each cell in your body is designed for a specific task. In other words, the cell's function is partly based on the cell's structure. For example:

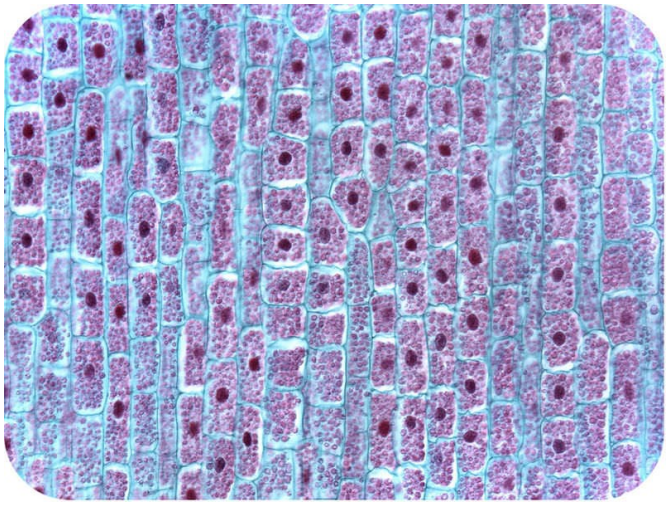
- Red blood cells are shaped with a pocket that traps oxygen and brings it to other body cells. These cells also have a large surface area that aids in oxygen transfer.
- Nerve cells are long and stringy in order to form a line of communication with other nerve cells, like a wire. Because of this shape, they can quickly send signals, such as the feeling of touching a hot stove, to your brain.
- Skin cells are flat and fit tightly together to protect your body.

As you can see in the images below, cells are shaped in ways that help them do their jobs. Multicellular (many-celled) organisms have many types of specialized cells in their bodies.



Red blood cells (*left*) are specialized to carry oxygen in the blood. Neurons (*center*) are shaped to conduct electrical impulses to many other nerve cells. These epidermal cells (*right*) make up the “skin” of plants. Note how the cells fit tightly together.

Putting It Together



Look again at our pine seed example:

- What kind of investigation can you plan and carry out to provide evidence that the basic structure of all living things are made of cells?

- What evidence can you gather that proves this pine cone came from a living thing?

- How long do you think the cells in the pinecone will stay alive after it falls from the tree?

4.2 Function of Cell Parts (7.3.2)

Explore this Phenomenon

All living things must have energy to survive. The sheep in this picture are eating grass to get energy to live. If trees do not eat, construct an explanation as to how they get the energy they need for survival?

7.3.2 Functions of Cell Parts

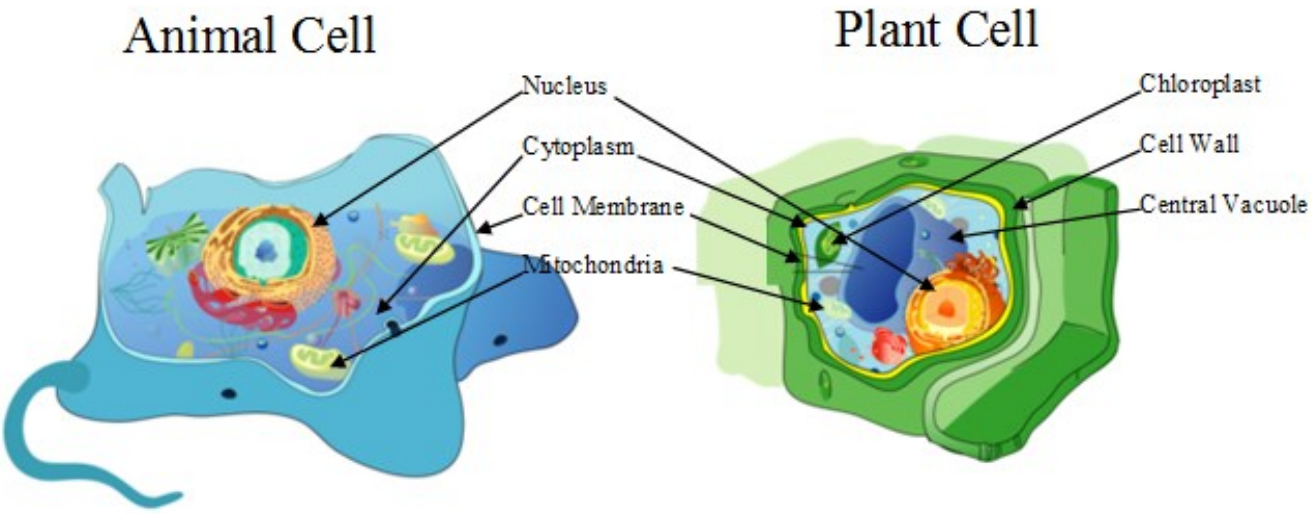
Develop and use a model to describe the function of a cell in living systems and the way parts of cells contribute to cell function. Emphasize the cell as a system, including the interrelating roles of the nucleus, chloroplasts, mitochondria, cell membrane, and cell wall.

In the last section you were able to analyze how the structure and number of different cells contribute to an organism. In this section you will see how different cell parts contribute to the function of the cell. Pay attention to how the shape and size of the cell parts might contribute to their function in the cell.

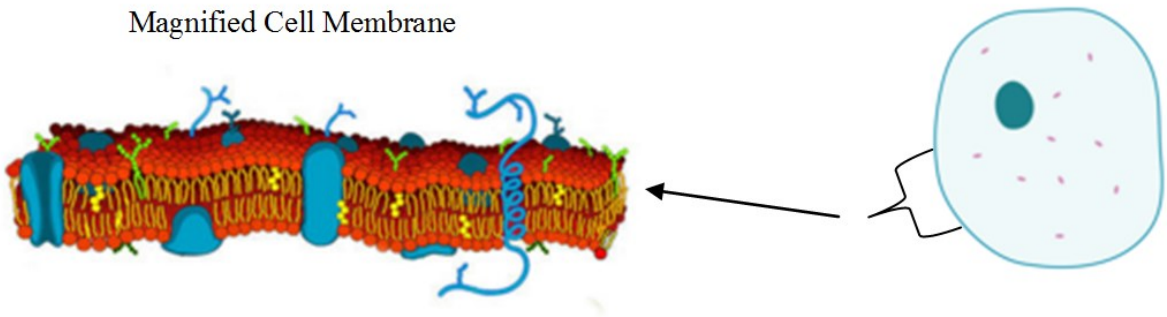
Organelles

Cells are defined as the basic unit of all living things. This means that the cell is the smallest unit that can still be considered living. Cells are a working system of parts just as a bicycle is a working system of parts. You can break a bicycle down into smaller parts, but it will no longer function as a bicycle. If a cell were broken down further, it would no longer be considered a living thing.

But what makes up a cell? Cells are made up of smaller structures called organelles. Organelles are common to most cells. The word organelle means “little organs”. Each organelle has its own function, or job, in the cell to keep the cell alive. The following information describes the structure and function of some organelles in cells:

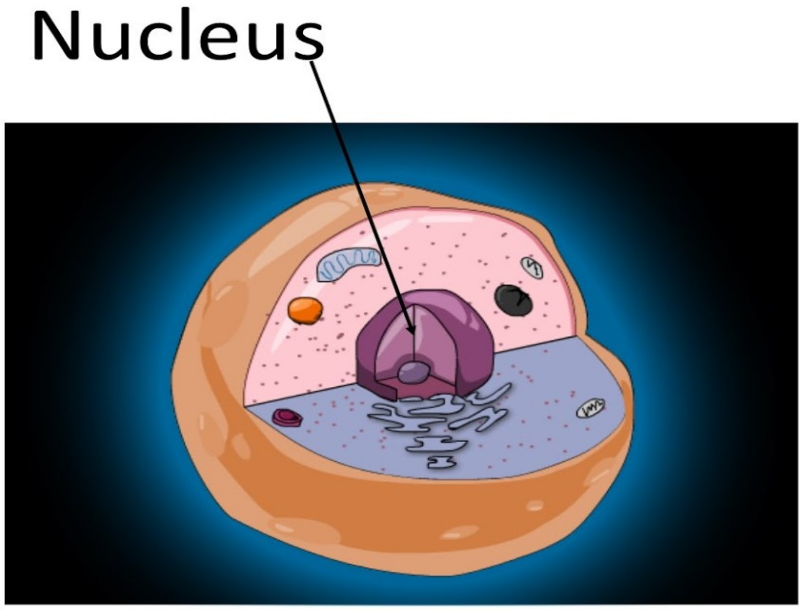


Cell Membrane



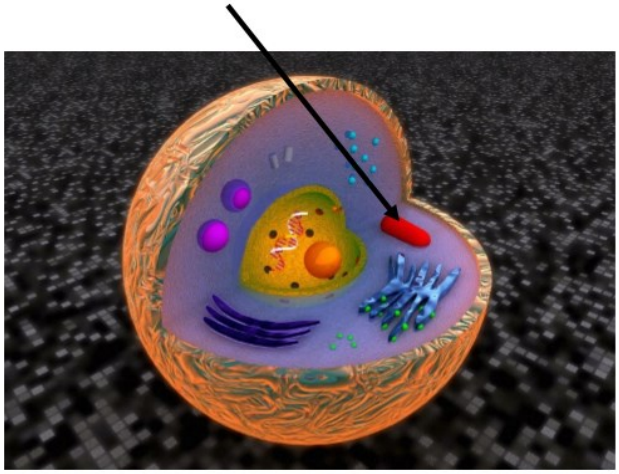
The cell membrane is the layer surrounding the cell. The function, or job of the cell membrane is to hold all of the cell's contents together and to control what goes in and out of the cell. The cell membrane is semipermeable, which means that some things can freely cross it and some things cannot. This helps the membrane control what can or cannot cross into and out of the cell. Food, water, oxygen and waste products are examples of particles that need to pass the membrane to get into and out of the cell.

Nucleus



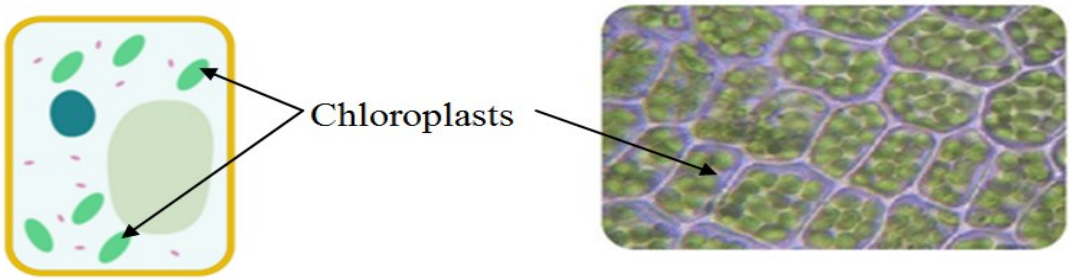
The nucleus is the control center of the cell. It contains the genetic information (DNA) and controls all the activities of the cell.

Mitochondria



All cells need energy to survive. The mitochondria is sometimes called the powerhouse of the cell. In the mitochondria, small molecules of food are broken apart. The energy that was holding the molecules together is released for our use. Food is the energy source for our bodies. Just as we use the stored energy in wood to make a fire to heat some water, the food that we eat needs to be broken down in order to release energy so that our bodies can function. Mitochondria are responsible for doing this in cells. The process whereby food is broken down to release energy is called cellular respiration.

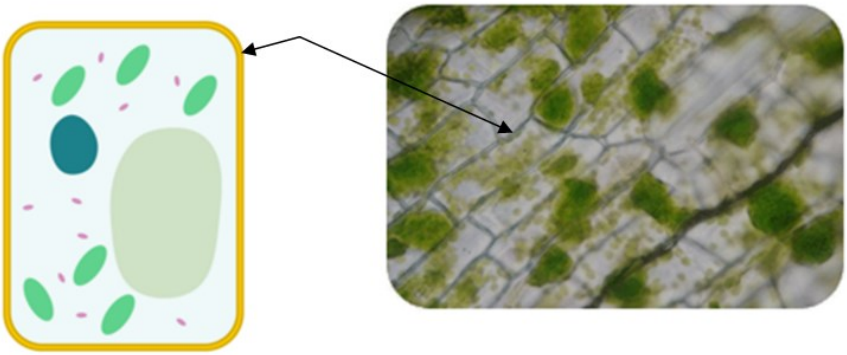
Chloroplast



Plants do not consume food like animals do. They have to make their own food in order to release energy needed for survival. The chloroplasts are organelles in plant cells that make food through a process called photosynthesis. Chloroplasts are only found in plant cells, but not in animal cells. These green structures make food for the plant by converting the energy of sunlight into sugar using carbon dioxide and water.

Cell Wall

Plant cells need a cell wall. The cell wall is a rigid outer barrier that supports and protects the cell. Plants do not have a skeleton to offer the strength and support like an animal does.



The cell wall in plant cells is the outermost layer of the cell.

The Cell as a System

Each organelle in the cell plays a key role in helping the cell to survive. The nucleus tells the organelles what to do and when to do it. The cell membrane allows materials in and out that the organelles need to do their jobs. The chloroplasts in the plant cell produce the food that plants need to survive. The mitochondria takes the food that is produced by the chloroplasts or let in by the cell membrane and releases the energy stored inside the food. The energy is then used by the cell to do other jobs. The cell wall in plants helps protect the cell and provides strength for the plant to grow tall. How are these functions of the organelles similar to the functions of other systems you know?

How are plant and animal cells different?

Even though plants and animals are both made of cells, plant cells differ in some ways from animal cells.

First, in addition to a cell membrane, plant cells have a cell wall that supports and makes the cell somewhat rigid. Plant cells need this cell wall because they do not have a skeleton to offer the strength and support that an animal does. A cell wall gives the plant cell strength and protection. It is the strength of trillions of cell walls in trees that make them strong enough to grow as tall as they are. Animals do not need cell walls. They only have a cell membrane.

Second, plant cells have chloroplasts that capture the sun's energy to convert carbon dioxide and water to sugar. They make their own food. Since animals have to get food to eat from other sources, they do not need chloroplasts.

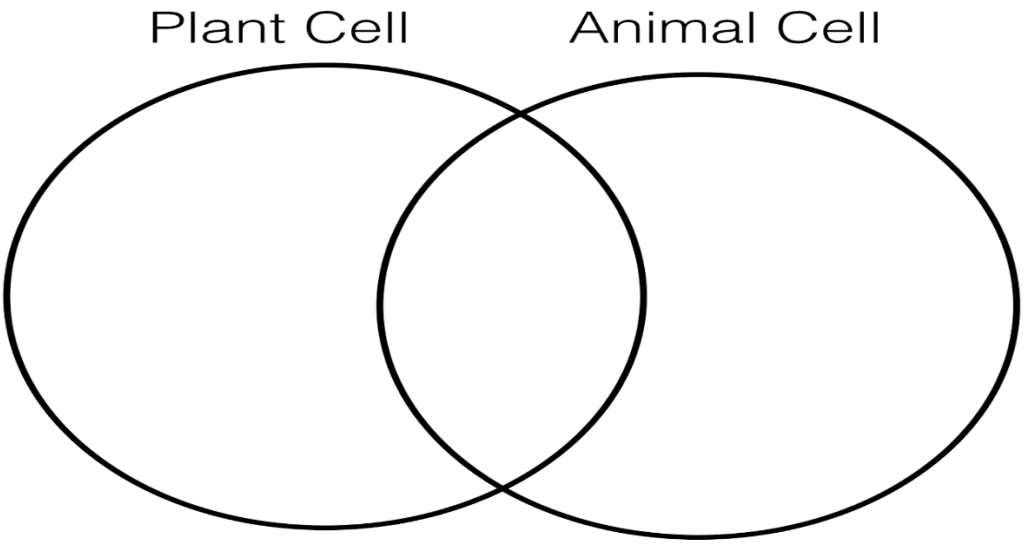
Plant cells also have a large central vacuole that stores water for the plants to use for photosynthesis. Animal cells do not need to store water this way and have very small vacuoles.

Think like a Scientist

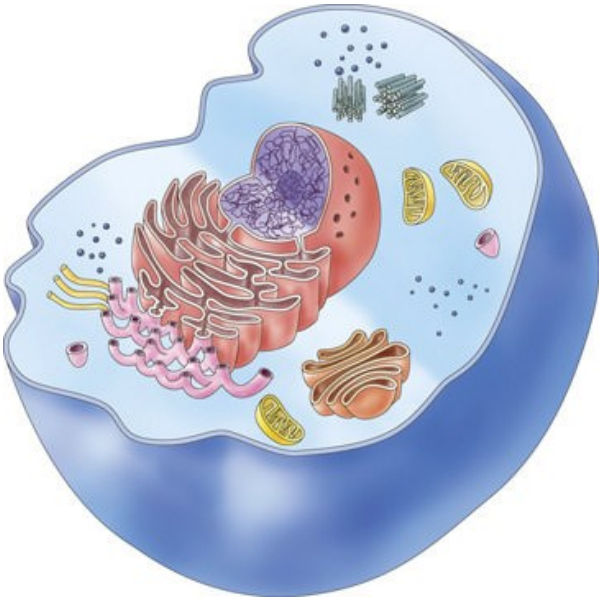
Fill in the table below! Put a checkmark for each organelle/structure that is found in each cell type.

Organelle/Structure	Plant Cell	Animal Cell
Cell Wall		
Cell Membrane		
Nucleus		
Mitochondria		
Chloroplast		
Central Vacuole		

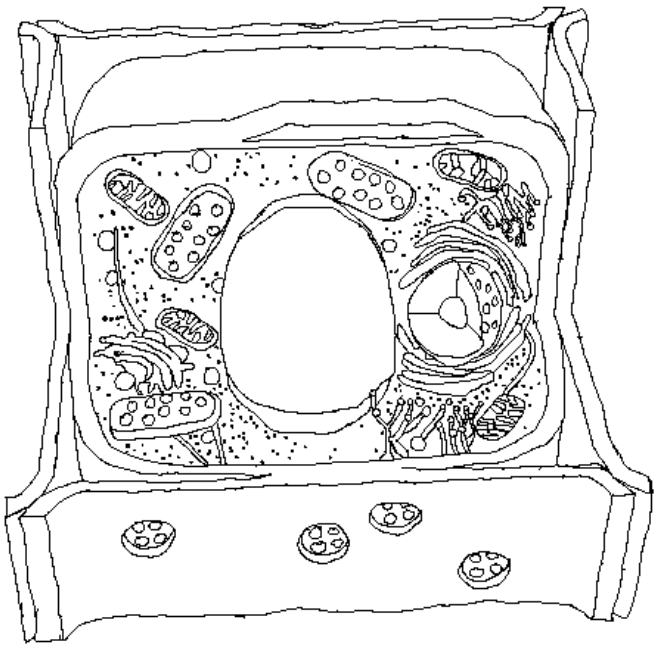
Fill out the following Venn diagram comparing and contrasting plant cells and animal cells.



Label the following cell with the correct animal cell parts.



Label the following cell with the correct plant cell parts.



Putting It Together

Trees don't eat like the sheep in the image above. Construct an explanation as to how they get the energy they need for survival. Be sure to include the organelles in the cells that contribute to these different functions.

4.3 Organization of the Human Body (7.3.3)

Explore This Phenomenon

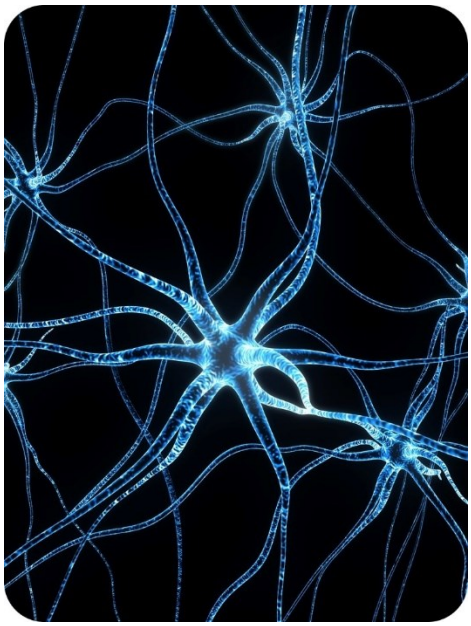
What is happening inside this boy's body to make him sweat?

7.3.3 Organization of the Human Body

Construct an explanation using evidence to explain how body systems have various levels of organization. Emphasize understanding that cells form tissues, tissues form organs, and organs form systems specialized for particular body functions. Examples could include relationships between the circulatory, excretory, digestive, respiratory, muscular, skeletal, and nervous systems. Specific organ functions will be taught at the high school level.

Cells make up the tissues that make up organs and organ systems. Each of these systems contributes to the function of the organism as a whole. In this section analyze how systems that have specific functions work together to perform all the functions of life. Ponder what would happen to the organism is one of the systems stopped working.

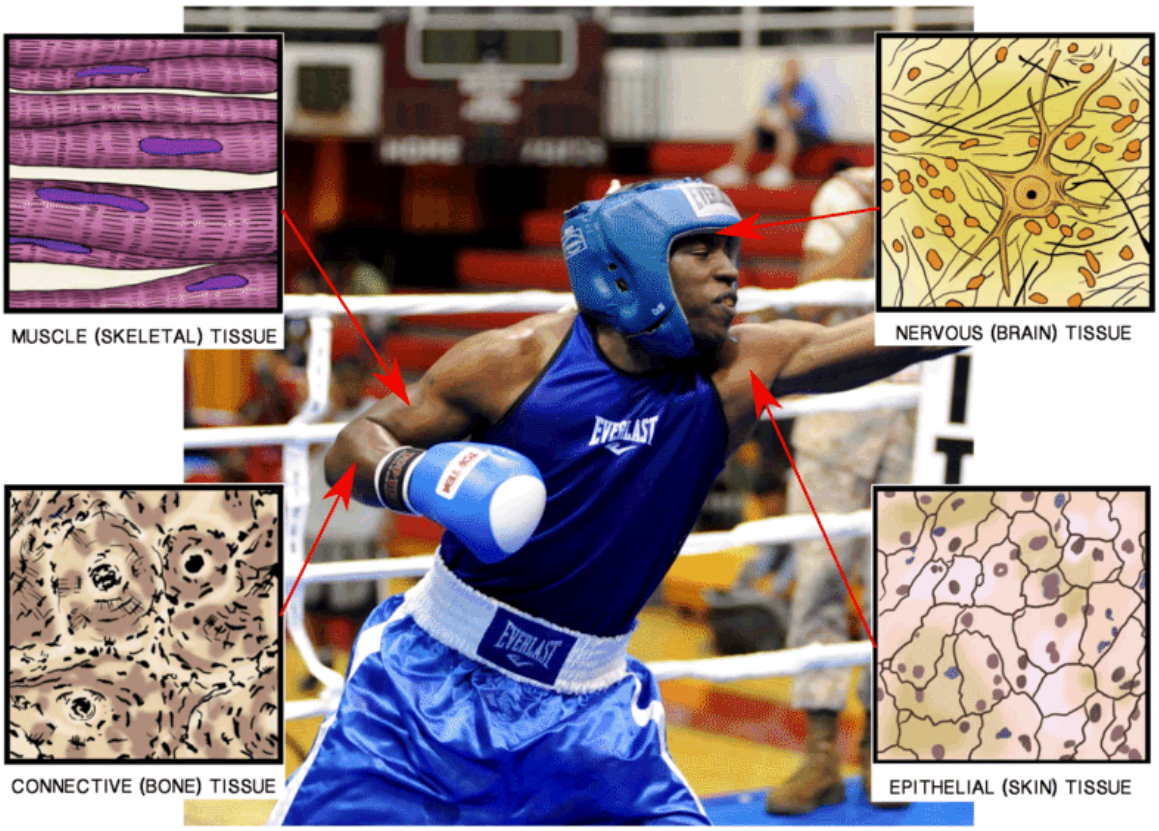
Organization of Your Body: Cells, Tissues, Organs



Cells, like these nerve cells in the picture above, do not work in isolation. To send orders from your brain to your legs, for example, signals pass through many nerve cells. These cells work together to perform a similar function. Just as muscle cells work together, bone cells and many other cells do as well. A group of similar cells that work together is known as a tissue.

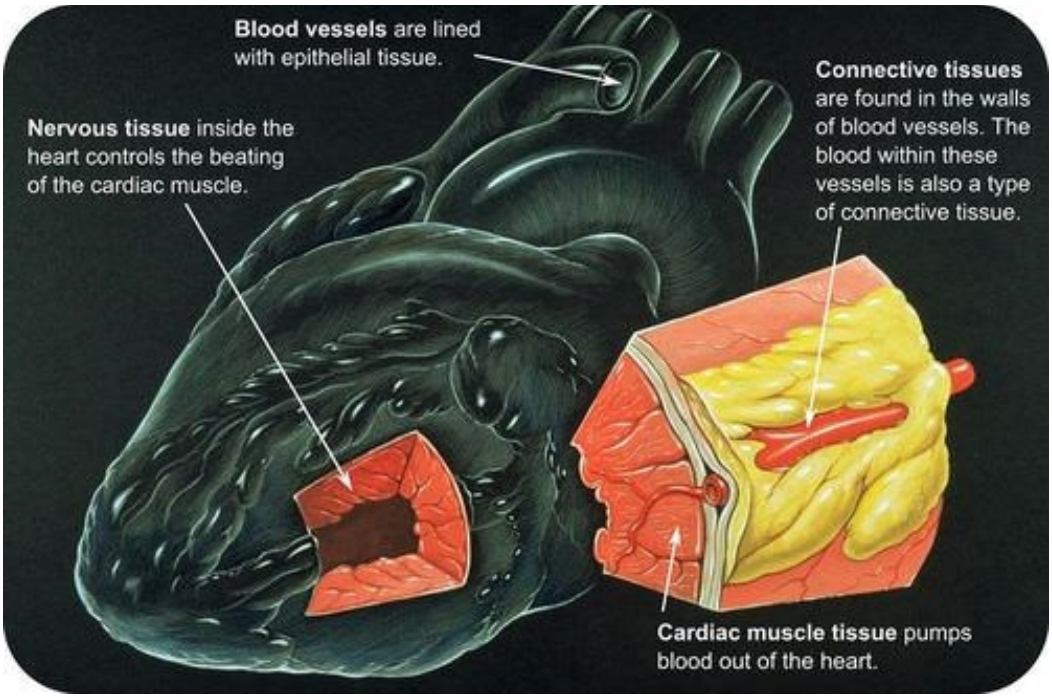
Cells Form Tissues

A group of cells that work together form a tissue. Your body has four main types of tissues, as do the bodies of other animals. These tissues make up all structures and contents of your body. An example of each tissue type is pictured in the picture below.



Groups of Tissues Form Organs

A single tissue alone cannot do all the jobs that are needed to keep you alive and healthy. Two or more tissues working together can do a lot more. An organ is a structure made of two or more tissues that work together. The heart is made up of the four types of tissues.



Groups of Organs Form Organ Systems

Your heart pumps blood around your body. But how does your heart get blood to and from every cell in your body? Your heart is connected to blood vessels such as veins and arteries. Organs that work together form an organ system. Together, your heart, blood, and blood vessels form your circulatory system.

What other organ systems can you think of?

Organ Systems Work Together

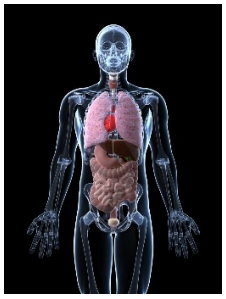
Seven of your body's organ systems are shown below. Your organ systems do not work alone in your body. They must all be able to work together. Your skeletal and muscular system work together so you can dance. Your nervous system and muscular system work together to help you read this book.

One of the most important functions of organ systems is to provide cells with oxygen and nutrients and to remove toxic waste products such as carbon dioxide. A number of organ systems, including the circulatory and respiratory systems, all work together to do this.

Organ System	Major Tissues and Organs	Function
Circulatory	Heart; blood vessels; blood	Transports oxygen, hormones, and nutrients to the body cells. Moves wastes and carbon dioxide away from cells.
Excretory	Kidneys; urinary bladder	Removes extra water, salts, and waste products from blood and body; controls pH; controls water and salt balance.
Digestive	Esophagus; stomach; small intestine; large intestine	Digests foods and absorbs nutrients, minerals, vitamins, and water.
Respiratory	Trachea, larynx, pharynx, lungs	Brings air to sites where gas exchange can occur between the blood and cells (around body) or blood and air (lungs).
Muscular	Cardiac (heart) muscle; skeletal muscle; smooth muscle; tendons	Involved in movement and heat production.
Skeletal	Bones, cartilage; ligaments	Supports and protects soft tissues of body; produces blood cells; stores minerals.
Nervous	Brain, spinal cord; nerves	Collects, transfers, and processes information.

Systems Working Together Form an Organism

When body systems interact you get an organism. Though these systems seem to function alone, they need to work together to make a living organism. If one of the systems is not working properly, it can cause illness and death to the organism.



Putting It Together

Look at the image above. Beginning at the cellular level construct an explanation as how the different body systems work together to keep this boy cool.

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4. The outline of onion cells are visible under a light microscope.
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11. The four main types of tissue are nervous tissue, epithelial tissue, connective tissue, and muscle tissue

12. Illustration of how the four tissue types work together in the heart .

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CHAPTER 5

Strand 4: Reproduction and Inheritance

Chapter Outline

The great diversity of species on Earth is a result of genetic variation. Genetic traits are passed from parent to offspring. These traits affect the structure and behavior of organisms, which affect the organism's ability to survive and reproduce. Mutations can cause changes in traits that may affect an organism. As technology has developed, humans have been able to change the inherited traits in organisms which may impact society.

5.1 Types of Reproduction (7.4.1)

Explore this Phenomenon

Do organisms always have two parents? Write to explain your thinking.

Above is a picture of a desert grassland whiptail. All members of this species are females! How is it possible that new offspring can be born when there are no males in the population? What traits do the babies inherit from their mothers?

7.4.1 Types of Reproduction

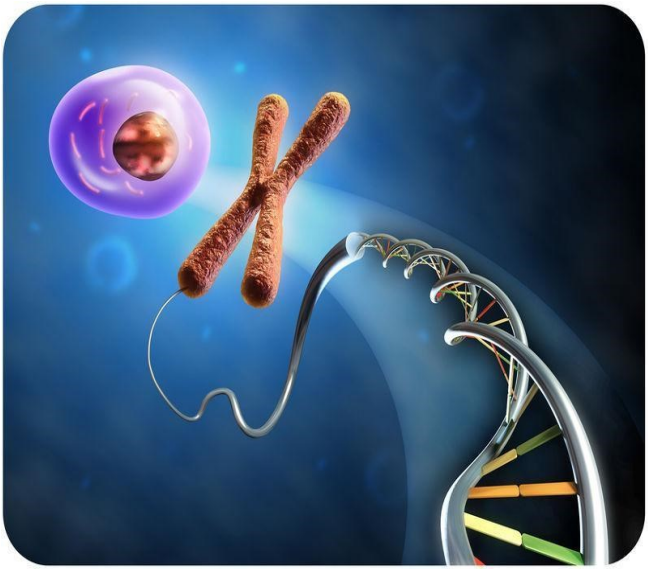
Develop and use a model to explain the effect that different types of reproduction have on genetic variation, including asexual and sexual reproduction.

Our genes that we inherit from our parents determine our traits. In this section analyze how the number of parents an organism has can effect it's genetic variation.

Heredity: Passing on Traits

Have you ever wondered why some people throw a baseball or softball with their left hand when most others use their right hand? Why do some people skateboard with their left foot forward while others skate with their right foot forward? Why are some tulips red and other tulips white? The answer to these questions is heredity. Heredity is the passing of traits and characteristics from parents to their offspring. Genetics is the study of how traits are passed from parents to their offspring.

DNA, Genes, Chromosomes



To understand genetics, you need to understand what causes the traits that are expressed or shown in an organism. The information used to code all the traits are located on structures called chromosomes. Chromosomes are located in the nucleus of every cell in your body.

You have probably heard the phrase, “It’s in your genes.” Genes are tiny sections of chromosomes that contain codes for the traits that we carry. A single chromosome can contain thousands of genes, making it responsible for controlling certain traits that appear in an individual. Genes are composed of DNA. When you build a house, you need a blueprint, or a set of instructions that tells you how to build it. DNA is like the blueprint for living organisms. The genetic information in the DNA is a set of instructions for building proteins. These proteins tell your cells what to do and what to become and build what your body looks like. Change in the DNA sequence (blueprint) account for the differences in traits among the various species of living things.

Reproduction

Animals and other organisms cannot live forever. Organisms must reproduce so their species will survive. But what does it mean to reproduce? Reproduction is the ability to make the next generation, and is one of the basic characteristics of life. Two methods of reproduction are:

1. Asexual reproduction, the process of forming a new individual from a single parent.
2. Sexual reproduction, the process of forming a new individual from two parents.

There are advantages and disadvantages to each method, but the result is always the same: a new life begins.

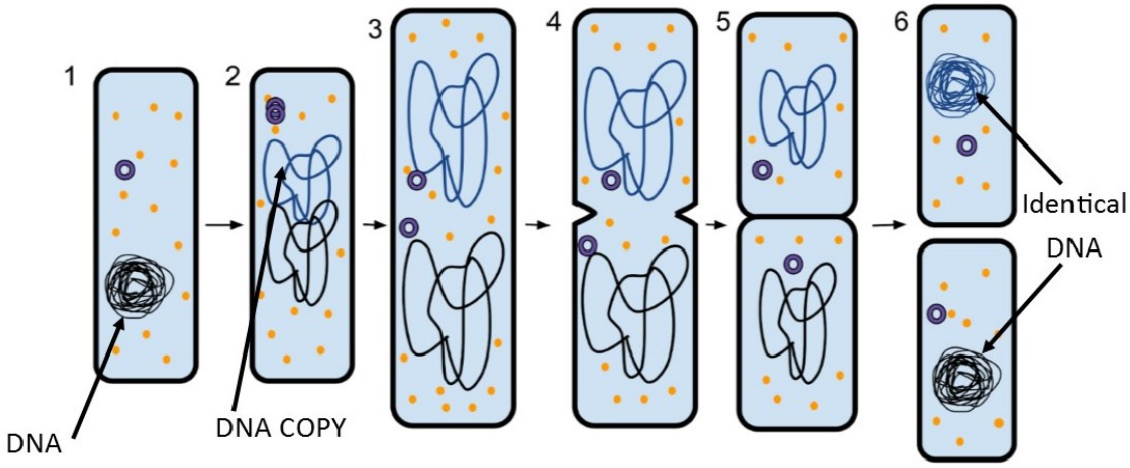
Asexual Reproduction

When humans reproduce, two parents are involved. DNA must be passed from both the mother and father to the child. But having just one parent is possible in other complex organisms, including some insects, fish, and reptiles. These organisms can reproduce asexually, meaning the offspring (“children”) have a single parent and share the exact same genetic material as the parent.

The advantage of asexual reproduction is that it can be very quick and does not require the mating of a male and female organism. The disadvantage of asexual reproduction is that organisms do not receive a mix of traits from both parents. An organism that is born through asexual reproduction only has the DNA from the one parent. In fact, the offspring is genetically an exact copy of the parent. This results in offspring that have the exact same traits as the parent. This can cause problems for the individual. For example, if the parent has a gene that causes a particular disease, the offspring will also have the gene that causes that disease. Organisms produced sexually may or may not inherit the disease gene because they receive a mix of their parents’ genes.

Types of organisms that can reproduce asexually include:

1. Bacteria reproduce through binary fission, where they grow and divide in half. First, their DNA replicates and the cell enlarges. The cell then divides into two cells as new membranes form to separate the two cells. After cell division, the two new cells each have identical DNA. This simple process allows bacteria to reproduce very rapidly.
2. Flatworms, an invertebrate animal species, can divide in two. Each half regenerates into a new flatworm identical to the original, a process called fragmentation.
3. Different types of insects, fish, and lizards can reproduce asexually through a process called parthenogenesis. Parthenogenesis happens when an unfertilized egg cell grows into a new organism. Parthenogenesis is common in honeybees. In a hive, the sexually produced eggs become workers, while the asexually produced eggs, produced by parthenogenesis, become drones.



Bacteria reproduce by binary fission.

Shown is one bacterium reproducing and becoming two bacteria.

Sexual Reproduction

During sexual reproduction, two parents are involved. Most organisms, including plants, have both males and females, with the male producing sperm and the female producing eggs. When a sperm and egg meet during fertilization, a zygote, the first cell of a new organism, is formed. This process combines the genetic material (DNA) from both parents. The resulting organism will be genetically unique, because they will have a mix of its parent's traits.

During sexual reproduction, a sperm fertilizes an egg.

Animals produce sex cells called eggs or sperm, which contain genetic material from the parent. Sex cells have half the amount of the genetic material of a regular body cell. In humans, sex cells have one set of 23 chromosomes. Normal human cells have 46 chromosomes, 23 of these chromosomes came from the individual's mom and 23 came from the individual's dad. These two sets of chromosomes combine in the new human, giving him or her traits from both parents.

Plants can also reproduce sexually, but their reproductive organs are different from animals'. Plants that have flowers have their reproductive parts in the flower. The sperm is contained in the pollen, while the egg is contained in the ovary, deep within the flower. Many plants need pollinators, like butterflies and honeybees, to bring the pollen from one flower to another flower, to fertilize the egg. The egg grows into an embryo inside of a seed. When the seed is planted, the embryo grows into a new plant that has a combination of traits from both of its parents.

Butterflies receive nectar when they deposit pollen into flowers, resulting in cross-pollination.

Check This Out

Aspen trees can be found in the mountains in Utah. Aspen trees can reproduce sexually by creating pollen and eggs, but apsen trees can also reproduce asexually. They can send up new stems from their roots. This stem becomes a new tree. Because it was created from the roots of the parent tree, it has the exact same DNA and traits as the parent tree. How could scientists test whether a group of aspen trees were made through sexual or asexual reproduction?

Some other organisms that reproduce both asexually and sexually are starfish, hydra, sponge, and some plants and fungi.

Putting It Together

- All desert whiptail lizards are female. Explain how these lizard reproduce.
- Using your knowledge of inheritance, describe the traits of the offspring of these lizards.
- How would having identical traits be an advantage?
- How would having identical traits be a disadvantage?

5.2 Adaptations for Reproduction (7.4.2)

Explore this Phenomena

If you go to a flower store, you will see flowers in many different bright colors. Construct an explanation for why the flowers are brightly colored.

7.4.2 Adaptations for Reproduction

Obtain, evaluate and communicate information about specific animal and plant adaptations and structures that affect the probability of successful reproduction. Examples of adaptations could include nest building to protect young from cold, herding of animals to protect young from predators, vocalization of animals and colorful plumage to attract mates for breeding, bright flowers attracting butterflies that transfer pollen, flower nectar and odors that attract insects that transfer pollen, and hard shells on nuts that squirrels bury.

Plants and animals have many structures that help them survive. As you read this section, specifically examine the different structural adaptations that increase the organism's reproduction rates and offspring survival.

Reproduction

In the previous section, you learned that organisms need to reproduce in order to ensure that their species continues to live on the earth. Successful reproduction can be described as having offspring that also live long enough to reproduce. Animals and plants have a number of strategies and adaptations that increase the odds for successful reproduction.

Plant Reproductive Adaptations

Some flowers have very strong scents. Others have sweet nectar. These traits attract animals. The animals they attract may include insects, birds, mammals, and even reptiles. Why do you think it is important for the plants to attract animals? Animals are able to transfer pollen from one plant to another and carry seeds from one place to another. While visiting a flower, an animal picks up pollen. The animal then travels to another flower and transfers the pollen to fertilize the egg resulting in offspring.

Some plants utilize their fruit to attract animals to transport the seeds they create to another location. When a horse eats an apple, it does not digest the apple seeds. As the horse travels and eliminates waste, the seeds are dispersed over a large area.

Other plants developed additional traits that aid in reproduction through seed dispersal.

Dandelion seeds have tiny “parachutes.” Maple seeds have “wings” that act like little gliders. Burdock seeds are covered with tiny hooks that cling to animal fur.

Some plants rely on seeds getting stuck in animal fur. Once stuck, the seeds are carried off to another location. Eventually, the seeds fall off and grow into a new plant.

Other plants developed traits to better disperse their seeds using the wind. With time, plants develop better and better traits to help them reproduce.

Animal Reproductive Adaptations

Some of the most important animal adaptations involve mating. Mating is the pairing of an adult male and female to produce young. Adults that are most successful at attracting a mate are most likely to have offspring. Traits that help animals attract a mate and have offspring increase their ability to survive. As the genes that encode these traits are passed to the next generation, the traits will become more common in the population.

In many species, females choose the male they will mate with. For their part, males try to be chosen as mates. They show females that they would be a better mate than the other males. To be chosen as a mate, males may perform courtship behaviors. These are special behaviors that help attract a mate. Male courtship behaviors get the attention of females and show off a male's traits. These behaviors are often observed as direct competition between males.

Different species have different courtship behaviors. One example is a peacock raising his tail feathers. The colorful peacock is trying to impress females of his species with his beautiful feathers. Another example of courtship behavior in birds is the blue-footed booby. He is doing a dance to attract a female for mating. During the dance, he spreads out his wings and stamps his feet on the ground. You can watch the following video of a blue-footed booby doing his courtship dance at: http://www.youtube.com/watch?v=oYmzdvMoUUA.

Courtship behaviors occur in many other species. For example, males in some species of whales have special mating songs to attract females as mates. Frogs croak for the same reason. Male deer clash antlers to court females. Male jumping spiders jump from side to side to attract mates.

Adaptations for Caring for Young

In most species of birds and mammals, one or both parents care for their offspring. Caring for the young may include making a nest or other shelter. It may also include feeding the young and protecting them from predators. Caring for offspring increases their chances of surviving. Birds called killdeers have an interesting way of protecting their chicks. When a predator gets too close to her nest, a mother killdeer pretends to have a broken wing. The mother walks away from the nest holding her wing as though it were injured. The predator thinks she is injured and will be easy prey. The mother leads the predator away from the nest and then flies away.

This mother killdeer is pretending she has a broken wing. She is trying to attract a predator's attention in order to protect her chicks. This behavior puts her at risk of harm. How can it increase her fitness?

In most species of mammals, parents also teach their offspring important skills. For example, meerkat parents teach their pups how to eat scorpions without being stung. A scorpion sting can be deadly, so this is a very important skill. Teaching the young important skills makes it more likely that they will survive. This is especially important for many species of birds and mammals, because they have fewer offspring than other types of animals.

To obtain additional information regarding animal reproductive adaptations you can view the following videos:

- Behavior on a Sage Grouse at http://www.youtube.com/watch?v=QYMHbFUTgAY(1:15)
- Elk Fighting in River at http://www.youtube.com/watch?v=GUQcMZLZpx8 (2:45)

Putting It Together

Now that you have obtained and evaluated information regarding reproductive adaptations, construct a new explanations as to why flowers have such bright colors. Compare your new explanation to your original idea. How has your thinking changed?

5.3 Mutations (7.4.3)

Explore this Phenomena

- This baby was born with 2 thumbs on one hand. This trait was not inherited (passed down from parents). Where would she have gotten this trait?

- Do you think this trait is beneficial to this baby? Why or why not?

7.4.3 Mutations

Develop and use a model to describe why genetic mutations may result in harmful, beneficial, or neutral effects to the structure and function of the organism. Emphasize the conceptual idea that changes to traits can happen. Specific changes of genes at the molecular level, mechanisms for protein synthesis or specific types of mutations will be introduced at the high school level.

Your DNA controls your traits. Changes in the structure of your DNA, called mutations, could cause changes to your physical traits or affect how certain body parts function. As you read and see mutations in real life, see if you can determine which mutations will be helpful, harmful or neutral to the organism's life?

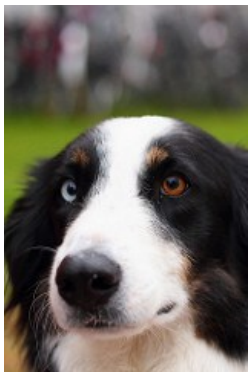
Mutations

The process of DNA replication before a cell divides is not always 100% accurate. Sometimes the wrong code is inserted in the new strand of DNA. This wrong code could become permanent. A permanent change in the sequence of DNA is known as a mutation. Once DNA has a mutation, that mutation will be copied each time the DNA replicates. After cell division, each resulting cell will carry the mutation and the resulting trait.

Are Mutations Good or Bad?

A mutation in the DNA may have no effect. However, sometimes a mutation can cause a protein to be made incorrectly. A defect in the protein can affect how well the protein works, or whether it works at all.

Sometimes the resulting trait does not help or harm the organism, it is neutral. For example, heterochromia is a mutation that causes two different colored eyes. Having two different colored eyes does not help or harm the organism's chance of survival so it would be considered a neutral mutation.



Usually the loss of a protein function is detrimental to the organism and makes it harder to survive. This rare albino alligator has the mutation for albinism. Albinism is a mutation in a gene for melanin, a protein found in skin and eyes. Such a mutation may result in no melanin production at all or a significant decline in the amount of melanin. The resulting color will make it harder for the alligator to camouflage with its surroundings. This mutation has a negative impact on the alligator's chance for survival.

This rabbit also has the mutation for albinism. If this population of rabbits lives in a dark forest this mutation would be harmful. However, would this mutation be harmful if the population of rabbits lived in the snowy arctic? In rare circumstances a mutation can help an organism survive in their environment. For example, humans have the ability to see more colors than other animals. This ability is the result of a mutation that occurred a long time ago. Organisms that have those beneficial mutations are more likely to survive and pass the mutation to future generations.

Causes of Mutations

Some mutations are not caused by errors in DNA replication. Mutations can happen spontaneously, and they can be caused by mutagens in the environment. Some chemicals, such as those found in tobacco smoke, can be mutagens. Sometimes mutagens can also cause cancer. Tobacco smoke, for example, is often linked to lung cancer.

Putting It Together

- Describe an environment where this mutation would be beneficial.

- Describe an environment where this mutation would be harmful.

5.4 Genetic Changes Caused by Humans (7.4.4)

Explore this Phenomenon

- If you could have any type of dog what would it be? Why?
- Police officers often use German Shepherds as police dogs. Why do you think that is?
- All dogs are descendants of wolves. Make a claim to describe why their characteristics are so different wolves and from each other.

7.4.4 Genetic changes caused by Humans

Obtain, evaluate, and communicate information about the technologies that have changed the way humans affect the inheritance of desired traits in organisms. *Analyze data from tests or simulations to determine the best solution to achieve success* in cultivating selected desired traits in organisms. Examples could include artificial selection, genetic modification, animal husbandry, and gene therapy.

Organisms inherit traits from their parents. By selecting for desirable traits in breeding of plants and animals, humans can cause the inheritance of those traits. For example, humans domesticated dogs by selecting young wolves that were calm and obedient. Look for other examples of humans affecting the inheritance of traits and see how it affects your life today.

Artificial Selection

Artificial selection occurs when humans select which plants or animals to breed in order to pass on specific traits to the next generation. Two organisms with desirable traits are crossed to produce offspring with those same traits. By selecting and crossing individuals with the traits we want for several generations, scientists are able to increase the chance that the offspring will have those desirable traits.

Dairy cows like this Holstein are carefully bred for traits that will give them better strength and produce more milk.

One of the areas where artificial selection gives the most benefit is in farming and ranching. For example, farmers practice animal husbandry where a farmer may choose to breed only cows that produce the most milk. Farmers would also avoid breeding cows that produce less milk. In this way, selective breeding of the cows would increase milk

quality and quantity. By selecting the individuals with the traits we want for reproduction, farmers can improve the quality of their animals.

Even plants are selectively bred. Fruits and vegetables are bred to increase size, flavor, and production. Generations of farmers have harvested corn with the largest kernels to produce the corn we have today.

Over time, selective breeding has modified teosinte's few fruit cases (left) into modern corn's rows of exposed kernels (right). Selective breeding of crops such as corn and wheat gave early humans the freedom to develop civilizations.

Genetic Modification

Genetic engineering is a research field that tries to find ways to change the genetics of living organisms so that the organisms have more desirable traits to people.

This technology has led to less crop damage and increased farm production. This allows farmers to produce more food on less land. Crops have also been engineered that produce better tasting food with a longer shelf life.

Farming is not the only field that benefits from genetic engineering. Advances in medical research have improved life for people with certain diseases. Diabetes is a disease that limits the body's ability to create or use an important hormone called insulin. Insulin is important because it helps to remove sugar from the bloodstream and put it in cells where

it can be used by the mitochondria to produce energy. Until a few years ago, insulin was extracted from non-human sources. It worked, but was not a perfect solution to the problem. In recent years scientists have found ways to engineer (create) human insulin using bacteria. The human gene that produces insulin is inserted into bacteria. The bacteria then produce human insulin as they reproduce. Then insulin is then harvested from the bacteria and used in patients so that diabetics can have a more normal life.

What Cloning Is, and What Cloning Is Not

Dolly, a sheep, was the first mammal to be cloned.

Several years ago, researchers shocked the world when they announced that a sheep had been cloned. A clone is an exact genetic duplicate of a living organism, like an identical twin, but born at different times. DNA from a cell from one female is inserted into an empty egg cell from a different female. Because a complete set of DNA is injected, the cell is tricked into thinking it has been fertilized. It then grows and develops inside the host mother's womb. Scientists cannot and probably will never be able to send an organism through a machine and have a clone walk out the other side like you see in some movies. Clones have to grow, develop, and learn just as any other living thing does. Even though the clones have identical DNA, the expression of the clone's traits would be subject to the environment in which it was raised.

Gene Therapy

Gene therapy is the insertion of genes into a person's cells to cure a genetic disorder. Gene therapy could not be used to cure diseases that are caused by viruses, like AIDS. It only works to fix disorders caused by a faulty gene. The patient would have had this disorder from birth.

Gene therapy uses a vector, or carrier molecule, for the gene. The vector helps incorporate the desired gene into the patient's DNA. Usually this vector is modified viral DNA in which the viral genes have been removed. Don't worry, the virus used in gene therapy has been deactivated, meaning it is not harmful to the human body. Though gene therapy is still in experimental stages for diseases like hemophilia and cystic fibrosis, the common use of this therapy may occur during your lifetime. As more research is done and technology improves, scientists will continue to learn more about the genetics of living things and find new ways to improve life on earth.

Putting It Together

- How have humans caused the diversity of traits in dogs?

- Flounder fish live in water with very cold temperatures. Why might scientists want to combine the genes from a flounder fish and a strawberry?

- You want to win the State Fair's giant pumpkin contest. Using your knowledge of artificial selection, construct an explanation as to what you can to do to someday win the contest.

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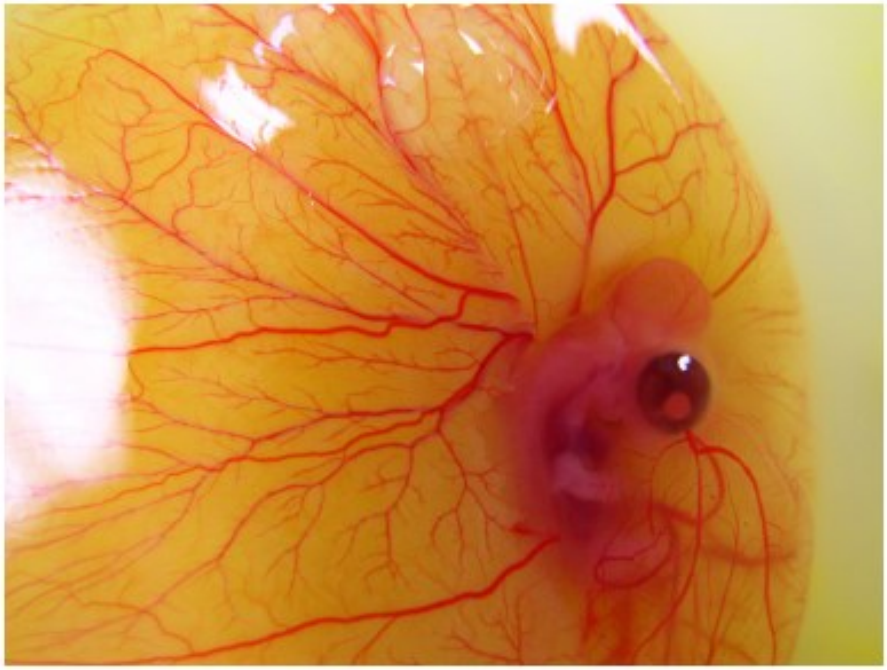
11. Artificial selection created these different breeds of dogs.

CHAPTER 6

Strand 5: Changes in Species over Time

Chapter Outline



Genetic variation and the proportion of traits within a population can change over time. Additional evidence of change over time can be found in the fossil record, anatomical similarities and differences between modern and ancient organisms and in embryological development.

6.1 Developing Traits that Affect Survival (7.5.1)

Explore this Phenomenon

Temperatures in Finland, a country near the North Pole, have been rising in recent years. Tawny Owls in Finland used to be found most often with gray feathers. In the last 30 years, brown feathers have become more and more common in the Tawny Owl. Construct an explanation for why you think this is happening.

7.5.1 Developing Traits that Affect Survival

Construct an explanation that describes how the genetic variation of traits in a population can affect some individuals' probability of surviving and reproducing in a specific environment. Over time, specific traits may increase or decrease in populations. Emphasize the use of proportional reasoning to support explanations of trends in changes to populations over time. Examples could include camouflage, variation of body shape, speed and agility, or drought tolerance.

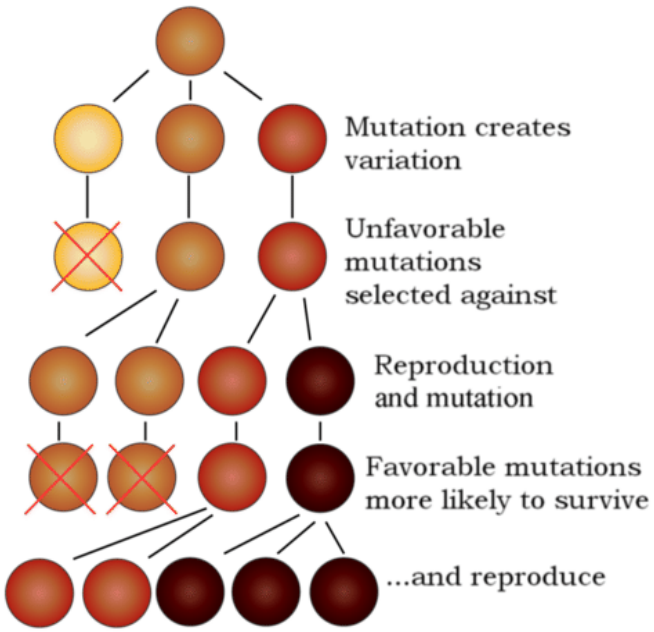
There are many different environments in which living things inhabit all across the world. The environments helped to shape the traits of the organisms that live in them. For example, the harsh heat of the desert influenced the traits of the cactus while polar bears have adapted to living in the arctic. In this chapter see if you can identify additional cause and effect relationships between an organism's traits and the environment in which it lives.

Adaptation and Evolution of Populations

Look at the above picture of the moth. Why would an organism match its background? An organism that blends with its background is more likely to avoid predators. If it survives, it is more likely to pass on this beneficial trait to its offspring. This moth appears to be well adapted to its environment. It is less likely to be eaten by a bird than a dark colored moth on the tree.

Variation and Adaptation

Even though they may look very similar, most organisms of the same species have some physical differences. This is because their genes are different. These differences in traits are called variations. For example, there are lots of variations in the color of human hair. Hair can be blonde, brown, black, or even red. Hair color is a trait determined by genes. At some time in the past, a variation probably came from a mutation. Mutations are natural changes to DNA. Some are harmful, but many are neutral and some are beneficial. If a mutation is harmful, the organism may not live long enough to reproduce. If the mutation is beneficial, that organism may have a better chance to survive. An organism that survives is likely to have offspring. If it does, it may pass the mutation onto its offspring.



Genetic mutation is central to the creation of biological diversity.

Traits that help organisms survive are called adaptations. Many adaptations protect organisms from the external environment.

Cacti have thick, water-retaining bodies that help them conserve water.

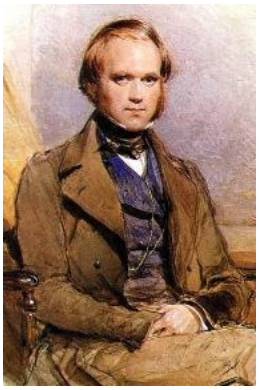
Poison dart frogs have toxins in their skin. Their bright colors warn potential predators not to take a bite!

How Adaptations Develop

Think about a population of oak trees. Imagine that a fungus has arrived from Asia to North America. Most of the North American oak trees are killed by the fungus. But a few oak trees have a mutation in their DNA that gave them the ability survive the fungus. Those oak trees are better adapted to the new environment than the others. Those trees have a better chance of surviving. They will probably reproduce and their offspring may inherit that favorable mutation. The other trees that do not have this mutation will die. Eventually, the population of oak trees will change so that most trees will have the trait to survive the fungus. This is an adaptation. Over time, traits that help an organism survive become more common. Traits that hinder survival eventually disappear.

Other adaptations help an organism move or gather food. Reindeer have sponge-like hooves that help them walk on snowy ground without slipping and falling. Fish at the bottom of the ocean are tiny and use very little energy because there is very little food. Organisms have special features that help them avoid being eaten. Some plants have poisonous or foul-tasting substances in them that keep animals from eating them. Their brightly colored flowers serve as a warning. Skunks release a nasty odor to protect them from predators.

Charles Darwin



In the 19th century, an English natural scientist named Charles Darwin set out to answer the following questions:

- Why are organisms different?
- Why are organisms similar?
- Why are there so many different types of organisms?

Darwin was the first to write and publish a book on how environments could influence the diversity of species. His book, “The Origin of Species,” describes the observations and

evidence that he collected over 20 years of research, beginning with a five-year voyage around the world on a British research ship, the HMS Beagle.

Darwin's travel route

The Galápagos Islands

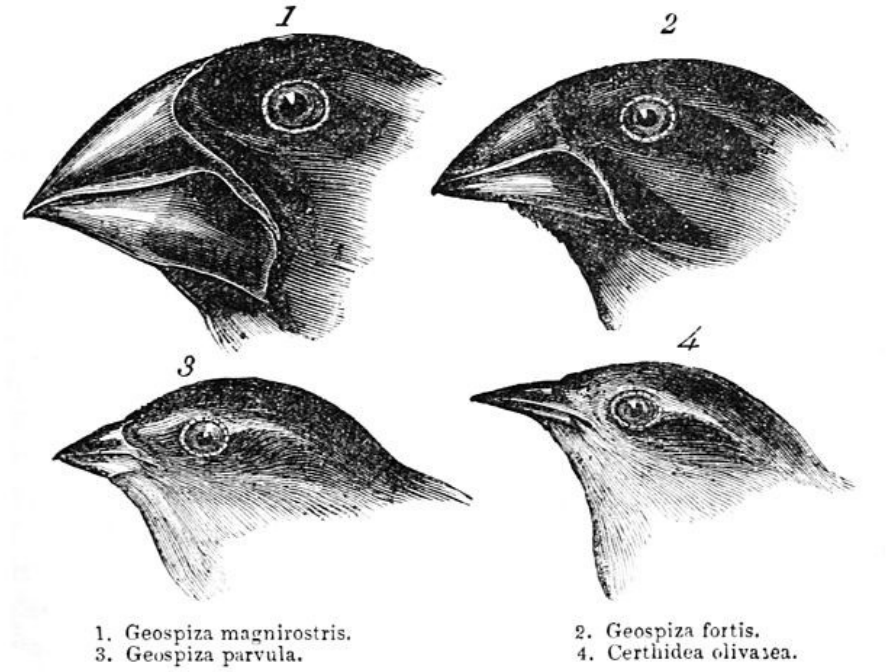
Aboard the Beagle, Darwin visited The Galápagos Islands, a group of 16 volcanic islands near the equator, about 600 miles from the west coast of South America. The islands are famous for their many species found nowhere else.

On the Galapagos, Darwin observed that the same kind of animal differed from one island to another. For example, the iguanas (large lizards) differed between islands. The members of one iguana species spent most of their time in the ocean, swimming and diving underwater for seaweed, while those of other iguana species lived on land and ate

cactus. Darwin wondered why there were two species of iguana on the same set of islands that were so different from one another. What do you think?

The Galápagos iguanas are among the signature animals of the Galápagos Islands. Here both a land iguana and a marine iguana are shown.

Darwin's Finches



The most studied animals on the Galápagos are finches, a type of bird pictured above. When Darwin first observed finches on the islands, he did not even realize they were all finches. But when he studied them further, he realized they were related to each other. Each island had a unique type of finch. The birds on different islands had many similarities, but their beaks differed in size and shape.

The birds came from the same finch ancestor. They evolved as they adapted to different food resources on different islands. The first bird in the picture above uses its large beak to crack open and eat large seeds. Bird #3 is able to pull small seeds out of small spaces.

In his diary, Darwin pointed out how each animal is well-suited for its particular environment. The shapes of the finch beaks on each island were well-matched with the seeds available on that island, but not the seeds on other islands. For example, a larger and stronger beak was needed to break open large seeds on one island and a small beak was needed to eat the small seeds on a different island.

Natural Selection

Darwin summarized his observations and ideas as the principle of natural selection. This principle is one of the most important ideas in life science. Simply stated, an individual in a species that has traits (genes) that are best suited to survive changes in the environment are the ones that live and reproduce. This increases the presence of those traits (genes) in the species until it eventually becomes a characteristic of that species.

Natural selection occurs when:

1. There is some variation in the inherited traits of organisms within a species.
2. Some of these traits will give individuals an advantage over others in surviving and reproducing.
3. These individuals will be likely to have more offspring and pass on the beneficial trait.

Survival of the Fittest

Some people refer to natural selection as “survival of the fittest.” This does not refer to the fastest, strongest, or biggest but rather to the organism that is most “fit” for their environment. Both predators and prey have adaptations that help them survive in their environment. Predator adaptations help them capture prey. Prey adaptations help them avoid predators. A common adaptation in both predator and prey is camouflage, the ability of an organism to blend in with its environment because of its inherited traits.

Imagine how in winter, dark fur makes a rabbit easy for foxes to spot and catch in the snow. Natural selection suggests that white fur is a beneficial trait that improves the chance that a rabbit will survive, reproduce and pass the trait of white fur to its offspring.

Over time, dark fur rabbits will become uncommon. Most of the rabbits in the population will adapt to have white fur.

In winter, the fur of Arctic hares turns white. The camouflage may make it more difficult for fox and other predators to locate hares against the white snow. Some additional examples are shown in the picture below.

Camouflage in Predator and Prey Species.

Can you see the crab in the photo on the left? It is camouflaged with algae. The praying mantis in the middle photo looks just like the dead leaves in the background. Can you tell where one zebra ends and another one begins? This may confuse a predator and give the zebras a chance to run away. These traits show how natural selection has worked over a very, very long time.

Putting It Together

Think back to the Tawny Owl living in the rising temperatures of Finland. Construct an explanation for why this population of owls is seeing a rise in brown feathers over gray and compare it to your original explanation. How did your thinking change?

6.2 Changes to Life over Time (7.5.2)

Explore This Phenomenon

The Utahraptor was discovered in 1973 near Moab, UT. Scientists claim that the Utahraptor is the largest raptor that ever lived. Construct an explanation as to how scientists know it was the biggest raptor.

7.5.2 Changes to Life over Time

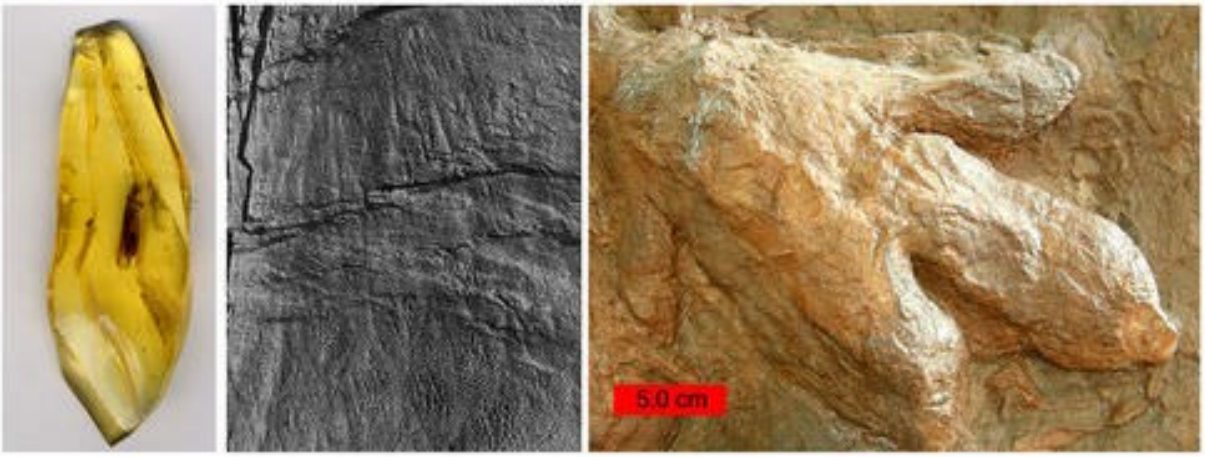
Analyze and interpret **data** for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.

The patterns that we see in the natural world today can help us understand things that happened in the past. Try to identify what patterns found in the fossil record today have helped us tell the story of Earth's history.

The Fossil Record

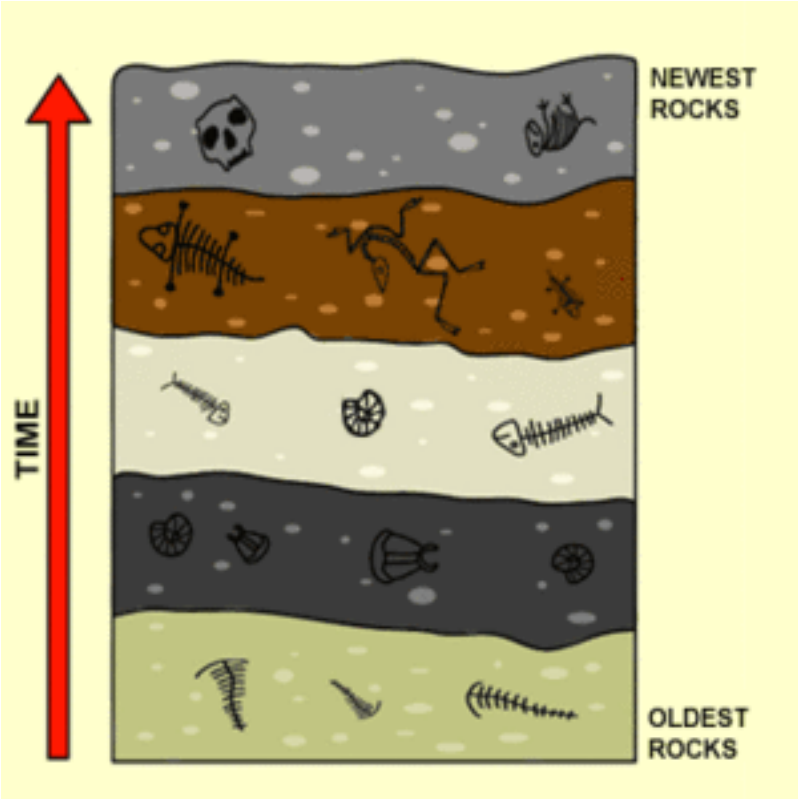
What is on this rock? This rock contains a portion of a fossilized tree fern. Scientists study fossils of plants, animals, and other organisms in order to better understand what life was like on Earth many years ago and how it has changed over time. Fossils are important evidence for the theory of evolution.

Fossils are the preserved remains of animals, plants, and other organisms from the distant past. Because most parts of organisms decompose rapidly following death, fossilization usually preserves only hard body parts like bones, teeth. Other fossils include footprints, burrows, droppings, eggs, nests, and other types of impressions. Animals and plants were also trapped and preserved in sap called amber.

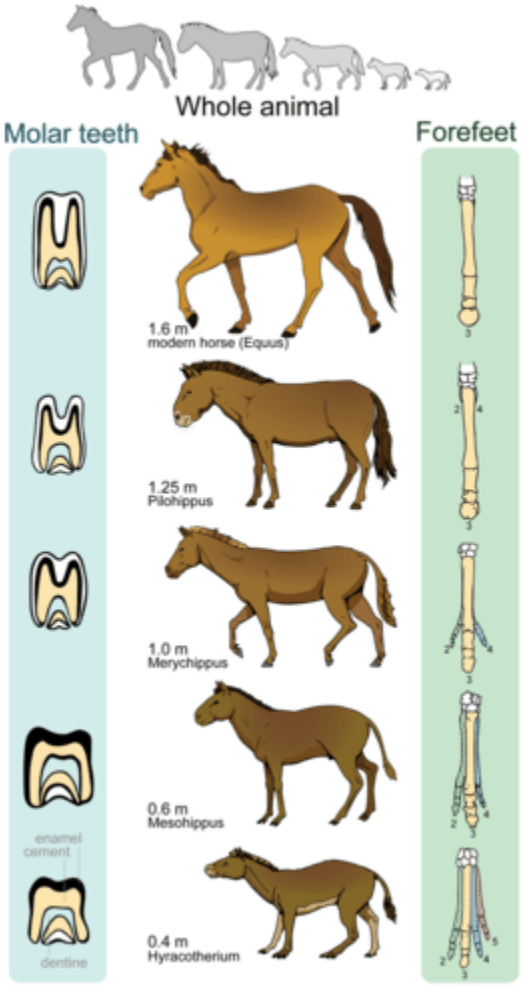


Different types of fossils reveal the history of life. From left to right: Amber preserves an insect intact. Stone etches impressions of Edmontosaurus skin. Rock echoes a dinosaur's footprint.

Paleontologists are scientists who study fossils to learn about life in the past. Fossils are found in rocks. There are many layers of rock in the Earth's surface. Newer rock layers form on top of the older layers so the deepest rock layers are the oldest. Therefore, you can tell how old a fossil is by observing in which layer of rock it was found. The fossils and the order in which fossils appear in the rock is called the fossil record. The fossil record provides evidence for when organisms lived on Earth, how species evolved, and how some species have gone extinct.



Evidence of Animal Evolution



Evolution of the horse. Fossil evidence, depicted by the skeletal fragments, demonstrates evolutionary milestones.

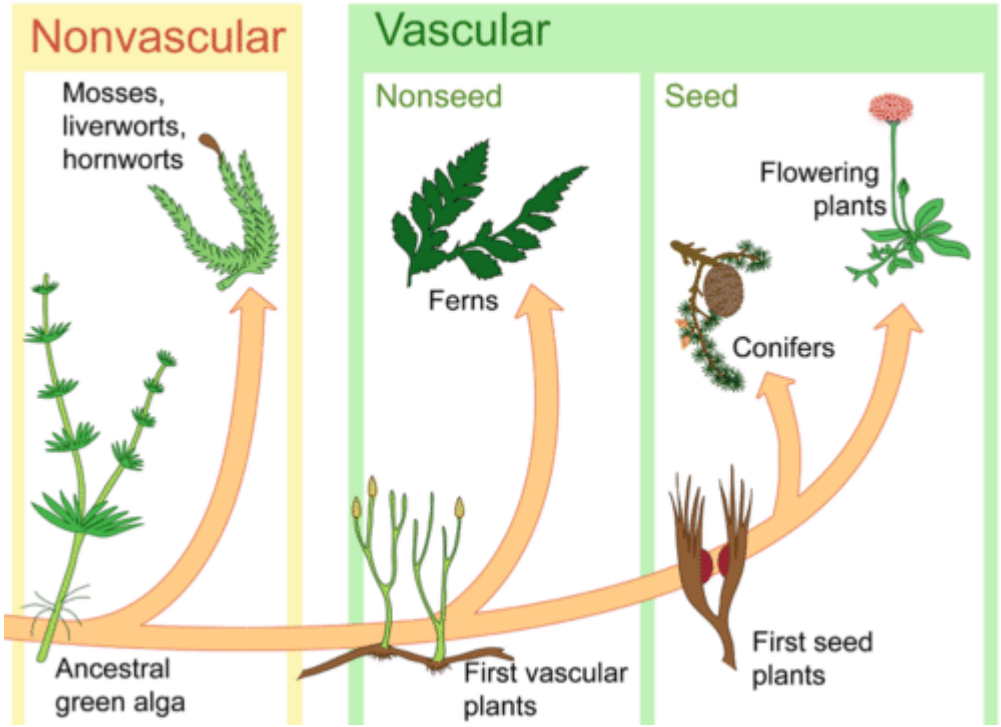
The oldest horse fossils show what the earliest horses were like. They were about the size of a fox, and they had four long toes. Additional evidence in the rock layers shows they lived in wooded marshlands, where they probably ate soft leaves. Through time, the climate became drier, and grasslands slowly replaced the marshes. Later fossils show that horses changed as well.

- They became taller, which would help them see predators while they fed in tall grasses.
- They evolved a single large toe that eventually became a hoof. This would help them run swiftly and escape predators.
- Their molars (back teeth) became longer and covered with cement. This would allow them to grind tough grasses and grass seeds without wearing out their teeth.

Similar fossil evidence demonstrates the evolution of the whale, moving from the land into the sea. Check out this video to learn more: https://youtu.be/lIEoO5KdPvg

Evidence of Plant Evolution

Evolution of plants can also be found in the fossil record. As shown in the figure below, plants are thought to have evolved from an aquatic green alga protist. Later, they evolved important adaptations for land, including vascular tissues, seeds, and flowers. Each of these major adaptations made plants better suited for life on dry land and much more successful.



From a simple, green alga ancestor that lived in the water, plants eventually evolved several major adaptations for life on land.

To analyze additional data regarding fossils you can go to the following websites:

- James Hagadorn, Paleontologist: Traces of Early Animal Life http://shapeoflife.org/video/james-hagadorn-paleontologist-traces-early-animal-life (6:11)
- Jenny Clack, Paleontologist: The First Vertebrate Walks on Land http://shapeoflife.org/video/jenny-clack-paleontologist-first-vertebrate-walks-land (7:04)

Putting It Together

In addition to claiming that the Utahraptor was the largest raptor ever on earth, construct an additional explanation as to how scientists know when it lived, what it ate, and when it went extinct.

6.3 Connecting Modern Organisms to Ancient Organisms (7.5.3)

Explore this Phenomenon

This animal is a Paraceratherium that became extinct over 23 million years ago. It stood over 16 feet tall and was over 4 feet long. How does this animal remind you of animals that live on the Earth today?

Explain your answer:

7.5.3 Connecting Modern Organisms to Ancient Organisms

Construct explanations that describe the patterns of body structure similarities and differences between modern organisms and between ancient and modern organisms to infer possible evolutionary relationships.

Scientists use the fossil record to construct ideas about organisms that have gone extinct. Fossil records show patterns in the traits of ancient organisms that are similar to organisms on Earth today. As you read, see if you can identify any patterns between ancient and modern species?

Evidence of Common Descent

When different species evolve from a common ancestor, we call it common descent. Paleontologists have found evidence of common descent in the fossil record. This evidence has helped scientists develop the theory of evolution.

Fossils are important for estimating when and how species changed over time. We can use fossils to compare the anatomy of different groups of animals to determine how they are related, when they lived, and when they became extinct.

Similar Structures

Modern Crocodile Skull

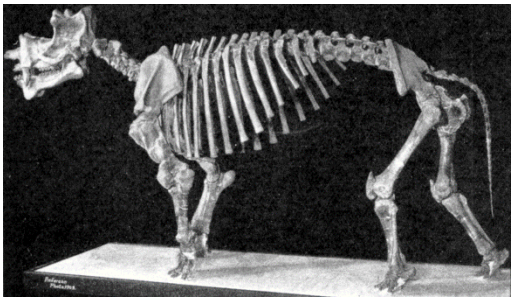
Ancient Megalania Skull

Scientists use fossils to group animals into families. They can use the skeletal structure, size and shape of the skull and the type of teeth to determine how the animals are related. Take a look at these two skulls; the first is a skull of a modern crocodile and the second is an ancient skull of a megalania, which is one of the crocodile's ancestor. What evidence do you see that indicates that they are related?

Are They Related?

Have you ever heard that whales are related to elephants? What evidence do scientist use to determine family relations? Let's take a look at two very different animals that share a common ancestor.

Both the modern whale and the modern elephant are related to the Uintatherium that lived over 50,000 years ago. First let's compare the Uintatherium to its modern descendent, the elephant. What do you notice about their toes?



Fossil of Uintatherium

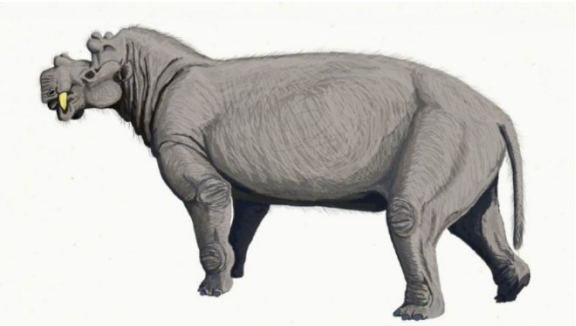
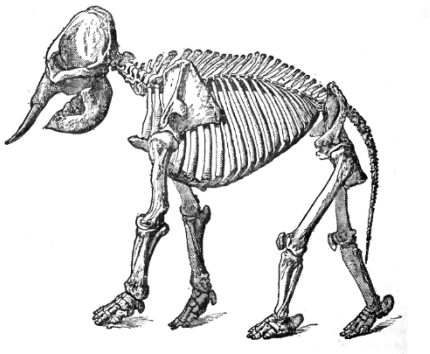


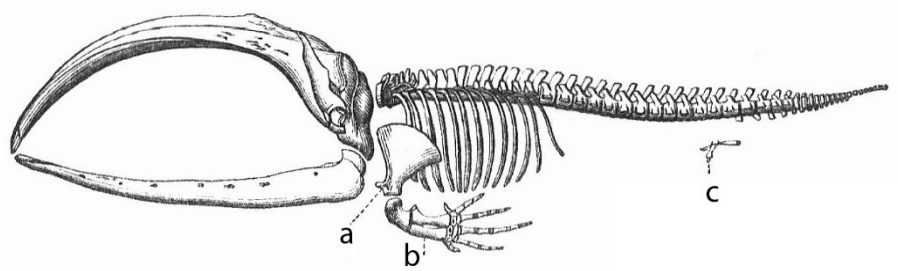
Illustration of a Uintatherium



Modern Asian Elephant

Modern Asian Elephant

Now let's compare the Uintatherium to another one of its modern descendants, the modern whale. What evidence can you find that the modern whales are descendants to the Uintatherium?

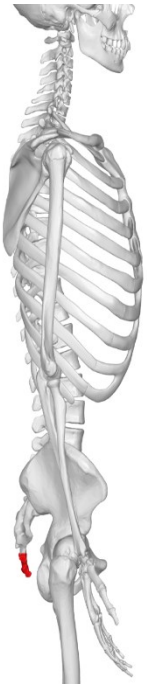


Skeleton of Modern Whale

Now that we have examined evidence that both the modern elephant and the modern whale have a common ancestor, the Uintatherium, what does this tell us about the relationship of elephants and whales today?

Other Evidence from Body Structures

If you look closely at a skeleton, you might notice a triangular bone at the end of the spinal column. This is your tailbone. Why would you have a tailbone when you don't have a tail? You have a tailbone because your ancient ancestors *did* have a tail. These sorts of "left-over" structures are called vestigial structures and support the theory of evolution. We can use them to see how a species has changed over time.

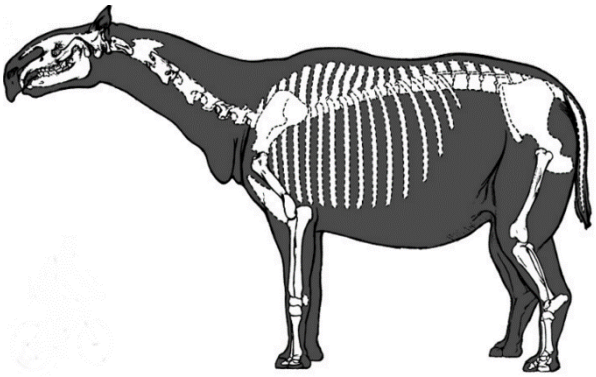


Another example of vestigial structures are ostrich wings. Most birds need their wings to fly, but the wings of an ostrich are too small for flight. They provide evidence for evolution because they show that over generations the ostrich's wing size changed.

Putting It Together

This animal is a Paraceratherium that became extinct over 23 million years ago. It stood over 16 feet tall and was over 4 feet long.

Fossil of a modern White Rhino



Fossil of an ancient paraceratherium

Scientist have said that the Paraceratherium is related to the White Rhino. Construct an explanation to infer possible evolutionary relationships using patterns found in the fossil and skeleton above.

6.4 Comparative Embryology (7.5.4)

Explore this Phenomenon

Analyze the above picture of an animal embryo. Can you tell what animal it is? Make a list of possible animals that it might be. Look at your list. What is similar among the animals on your list? Why did you choose those animals?

7.5.4 Comparative Embryology

Analyze displays of pictorial **data** to compare patterns in the embryological development across multiple species to identify similarities and differences not evident in the fully formed anatomy.

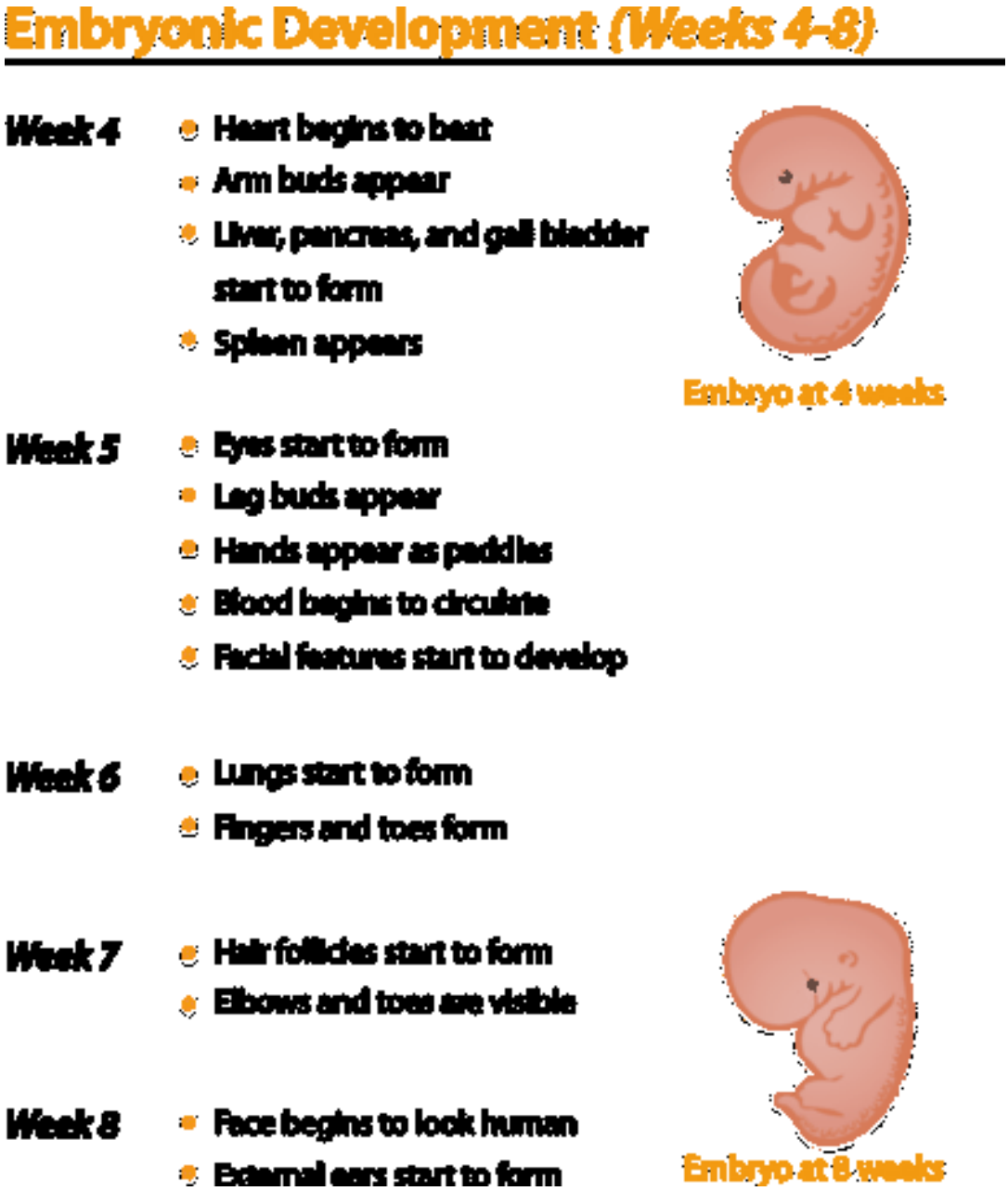
In this section you will analyze embryological development of different species. Scientists look at patterns found between embryos to show how close organisms are related. Look for the similarities and differences between embryos to see if you can predict what embryos are more closely related.

Embryo Growth and Development

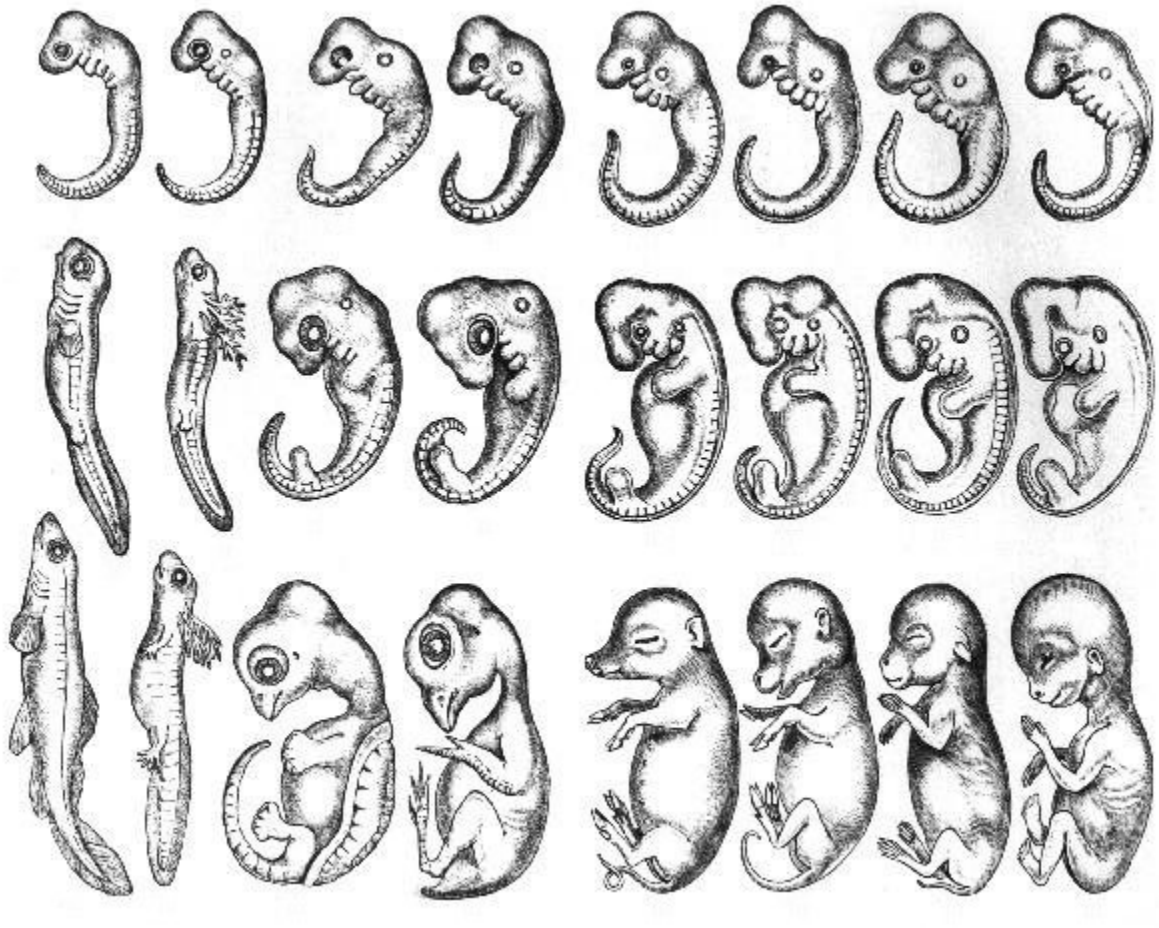
We all start as a single cell and soon grow into an embryo. Notice the remarkable details beginning to form. The eyes, backbone, and limb buds are obvious. Think about the amazing complexity that must be going on inside the embryo, and the tremendous amount of growth and development still to come.

After fertilization in animals occur, the fertilized egg is called an embryo. In humans the embryonic stage lasts through the eighth week following fertilization. During this time, the embryo grows in size and becomes more complex. It develops specialized cells and tissues and starts to form most organs.

A few of the developments that occur in the embryo during weeks 4 through 8 are listed in the figure below. By the eighth week of development, the human embryo is about 30 millimeters (just over 1 inch) in length. It has also begun to move.



(Note: the drawings of the embryos are not to scale.)



This picture above was created by early scientists who were looking for similarities and differences among different species. Though the pictures above were simplified to show similarities and there has been some recent controversy regarding the pictures, it opened the door for other scientists to investigate how embryological development can be one way of showing evolutionary relationships.

Comparative embryology is the study of similar patterns among embryos. Some of these similarities are only present in the embryo form and not in their adult form. For example, all animals that have a backbone have gill slits and tails as some point in their embryonic development. As the animal grows, these characteristics disappear in animals that live on land, but are still present in the animals that live in or around water. Organisms that share traits are more closely related. These similarities in embryonic development show how some animals may share a common ancestor.

To analyze your own data regarding embryos, you can visit these websites:

http://www.pbs.org/wgbh/nova/evolution/guess-embryo.html
http://www.pbs.org/wgbh/nova/evolution/zoo-you.html

Putting It Together

Construct an explanation as to why it is sometimes difficult to identify the species when just looking at the embryos.

How do scientists use embryos to show how closely related animals are?

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Student Notes

Utah Science with Engineering Education Standards