THE LEARNING OF SCIENCE BEGINS WITH WHY?

The **ULTIMATE** course book for young scientists

LAKSHYA PAWAN SHYAM KAURA

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Milton Academy is an independent college preparatory K–12 school, boarding and day in grades 9–12, located eight miles south of Boston. Milton Academy cultivates in its students a passion for learning and a respect for others. Embracing diversity and the pursuit of excellence, we create a community in which individuals develop competence, confidence and character. Our active learning environment, in and out of the classroom, develops creative and critical thinkers, unafraid to express their ideas, prepared to seek meaningful lifetime success and to live by our motto, “Dare to be true.”

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FOREWORD

With joy and enthusiasm, we share with you *The Learning of Science Begins with Why?* The Saturday Course at Milton Academy has partnered with author Lakshya Kaura to bring his book to life and into the classroom. Lakshya is a young science teacher in Ballabgarh, Haryana, India. He was recognized as one of the top-ten innovators across Australia and Asia by Google Science Fair in 2013 and honored as a National Innovator by two presidents of India.

A flagship program for Milton Academy's commitment to authentic engagement between independent and private schools, The Saturday Course was established in 1978 and has continued to grow since. One thousand students are currently enrolled in the program. Beginning as a Saturday Course teacher nearly 25 years ago, Kristan Burke became Director in 2007 and has led the program since. She is proud of its impact on academically advanced students from throughout the Boston area.

Lakshya's book includes science experiments that work well because of their accessibility and inclusion of inexpensive, everyday objects. With similar resourcefulness, Saturday Course students will experiment, analyze and share the results with their peers from Ballabgarh, India. With thousands of miles between the classrooms, the experiments are the same—but will the conclusions be as well? Students: Sharpen your pencils and get ready to ask *Why?*

Todd Bland, Head of School • Milton Academy

Playful Balloon

Ask a Question

Can we blow air into a balloon that is inside a bottle? What must we do in order to inflate a balloon inside a bottle?

Background Research

We cannot inflate a balloon once it is placed inside a bottle. If we attempt to blow air into a balloon inside a bottle, the air inside the bottle will not allow us to do so. We must remove the air from inside the bottle first, and this experiment will show us how.

Hypothesis

If a deflated balloon is fitted into the open mouth of a bottle, it can be inflated, but only by making another hole in the bottle.

Materials Required

1. Plastic bottle
2. Compass
3. Balloon
4. Rubber band

Experimental Procedure

1. Insert a deflated balloon inside a bottle and fit the mouth of the balloon over the neck of the bottle. The balloon will be hanging inside the bottle. Now try to inflate the ballon by blowing air. Note your observations.
2. Carefully use the sharp point of a compass to make a small hole at the bottom of the bottle.
3. Try to inflate the balloon again.
4. Note your observations.
5. Close the hole at the bottom of the bottle with your finger and then try to blow air into the deflated balloon.

6. Note your observations.
7. Remove your finger from the hole and blow air into the balloon. As soon as the balloon is inflated, cover the bottom hole again with your finger and take your mouth away from the neck of the bottle. Did air escape out of the open mouth of the balloon? Note your observations.

Result

A balloon placed inside a bottle can be inflated only after we make a hole elsewhere in the bottle and then blow air into it.

Analysis

1. The balloon inflated easily once the bottle had a hole in its bottom. We must be able to force air inside a balloon in order to inflate it, but the empty bottle is already filled with air. So when we try to blow air into the balloon, it does not allow us to do so, as the air in the bottle exerts pressure on the balloon. When we blow into the balloon, our lungs are not able to exert enough pressure to force the air out of the bottle since there is no place for the air to escape. But when we make a hole at the bottom, air escapes and the balloon inflates.
2. If we cover the hole in the bottom of the bottle, we are not able to blow air into the balloon, no matter how hard we try.
3. Once it is inflated, the balloon does not deflate, even when its neck is open, if we cover the hole at the bottom of the bottle with our finger. This happens because the pressure inside the bottle equals the pressure outside the balloon. The only noticeable change is that the balloon contracts slightly.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that the air inside the balloon needs to be removed to make room for the expansion of the balloon.

Thinking Cap

1. We use a straw to drink water or some other liquid. Sometimes we are able to suck easily while at other times we need to adjust the straw. Why is this so?
2. Droppers are used to remove liquid from a bottle. How does this work? Can all liquids be drawn out with a dropper? Does the nature of the liquid affect the functioning of a dropper?

Rusting Fruit

Ask a Question

Cut apples turn brown if left in the air for some time. Why do some sliced fruits develop a brown tinge when they are left in the open? What is this brown substance?

Background Research

If we place freshly cut fruit in open air, we will observe that with time the surface of the fruit turns brown. The brown color is produced by a reaction called oxidation. Oxidation is a process in which an element reacts with oxygen in the air. Fruits like apple contain iron. When we cut a fruit, its cells are damaged, and iron in the cells is exposed to the air, allowing oxygen in the air to react with enzymes and other chemicals. This forms rust on the surface of the fruit. Some substances like vitamin C can be used to reduce the speed and extent of the oxidation process.

Hypothesis

If we sprinkle lemon juice (which is acidic) on the surface of slices of freshly cut fruit, the process of rusting (oxidation) slows down.

Materials Required

1. Apple
2. Banana
3. Lemon
4. Knife (teacher will help)
5. Chopping board
6. 2 plates
7. Fresh water in a bowl
8. Chalk
9. Small bowl
10. Handkerchief

Experimental Procedure

1. Place two plates beside each other on a table.
2. Use a piece of chalk (or a pencil and paper) to write "A" in front of one plate and "B" in front of the other plate.
3. On the chopping board, use the knife to cut the lemon in half. Have the help of a teacher or an adult for this process.
4. Squeeze the two halves of the lemon and let the juice go into a small bowl.
5. Wash your hands.
6. Slice the apple or peeled banana into pieces using the knife and the chopping board.
7. Place half of the slices of apple or banana on plate A and the other half on plate B.
8. Sprinkle fresh water on the slices of fruit on plate A.
9. Sprinkle lemon juice from the small bowl on the slices of fruit on plate B.
10. Wash and dry your hands.
11. Record the color of each fruit after 5 minutes, 10 minutes, 15 minutes, and then after 20 minutes.

Time	Color of fruit/vegetable on plate A	Color of fruit/vegetable on plate B
5 minutes		
10 minutes		
15 minutes		
20 minutes		

Result

The slices of fruit on plate B took a longer time to turn brown while the fruit slices on plate A turned brown quickly.

Analysis

Lemon juice contains citric acid, which changes the structure of the enzymes in fruits like apples, bananas, and pears, and in vegetables like potatoes and eggplants. This enzyme is needed for the reaction of iron on the surface of the cut fruit and vegetables with oxygen in the air (called an oxidation reaction). This oxidation reaction is responsible for the development of the brown color on the cut surface of the fruit. Citric acid containing vitamin C is an antioxidant, a substance that does not allow oxidation to occur. It resists enzymes responsible for oxidation, thus slowing down the process of turning the fruits/vegetables brown.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. The rusting of fruits containing iron is slowed when lemon juice is added to the surface of the fruit.
2. Lemon juice is an antioxidant.

Thinking Cap

1. We eat foods that are rich in antioxidants. What is the need for these foods in our body?
2. How is the process of oxidation helpful in giving us energy from the food we eat?

Balloon Wheel Cart

Ask a Question

We often hear that every action has an equal and opposite reaction. What does this mean? How can we prove it experimentally?

Background Research

When gases escape from a launched rocket, they move in a downward direction as the rocket moves up (in the opposite or upward direction). Air can also exert force that can be used to move an object in the opposite direction. How much air and how much force will be required to move an object? That will depend on how heavy the object is. We can design an experiment to find out.

Let's use the force of air to move a light object (say a cart) that is on wheels.

Hypothesis

If we attach an air-filled balloon to a toy cart on wheels and release the air from the balloon, the cart will move in a direction that is opposite to that of the air released by the balloon.

Materials Required

1. Empty water bottle made of thin plastic
2. Scissors
3. Knife (should not be very sharp and teacher/adult will help)
4. Ruler
5. Medium-sized balloon
6. Plastic tape with strong adhesive
7. 4–5 drinking straws
8. 2 pencils of same size
9. 4 wheels from any toy or 4 ball bearings

Experimental Procedure

1. Take a plastic bottle and measure its length with a ruler. Label the length as "h." Use a pen or a pencil to mark the center of the bottle horizontally at half its length (h/2).
2. Using a knife, make a small cut in the center of the bottle at h/2. Enlarge the cut with the scissors.
3. Place four ball bearings or wheels of a toy between two pencils. Keep two wheels on each side of the pencil. Take two or three straws and hold them together with a piece of tape.
4. Place the straws inside the bottle and move the ends out through the slit. Fasten the balloon at this end of the straws and wrap the tape around so that no air can escape.
5. Use two small pieces of tape to stick the bottle to the two pencils. With your hands, push the cart that you have just made to check whether it is moving smoothly.
6. Blow air into the balloon through the straws and close the ends of the straws tightly, either with your fingers or your palm so that the air does not escape the balloon.
7. Place the cart on a table or on the ground and slowly remove your palm/fingers.
8. What do you observe? Which direction is the cart moving? Which direction is the air inside the balloon moving? Note your observations.
9. Draw a diagram to show the movement of the air and the cart.

Result

The cart moves in a direction opposite to that of the air released from the balloon.

Analysis

The bottle does not move on its own when it is at rest. Some force is required to make the cart move, and the force exerted by the air can be used to move the cart. In this experiment, an air-filled balloon is used to move the cart in a direction opposite to that of the air released by the balloon.

Compare a rocket to a balloon with air escaping from it. In a rocket, burning fuel and expanding gas released downward (action) propel the rocket upward (opposite reaction). Likewise, in a balloon, the air is released in one direction (action) and the balloon flies in the opposite direction as it deflates (reaction).

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that every action has an equal and opposite reaction. When a force is applied in a particular direction, an equal and opposite force acts in the opposite direction.

Thinking Cap

1. If we hold a ball or balloon in our hands and apply force, what happens?

Fireproof Balloon

Ask a Question

Can we prevent a balloon placed on a candle flame from melting?

Background Research

Thermal conduction is the ability of a substance to allow heat to pass through it. Passing of heat through a substance increases its temperature, and the temperature tells us how much a substance is heated. Water is a conductor of heat, which means that it allows heat to pass through it easily. It also absorbs heat easily, but slowly, and for this reason, it takes time to prepare tea or food on a stove. Because water also releases heat slowly, areas near the sea are cooler during summers than areas farther from the sea.

Hypothesis

If we use a candle to heat a balloon half filled with water, then it will take a longer time to burst in comparison to a balloon filled only with air.

Materials Required

1. 2 medium-sized balloons (both should be of same size)
2. Candle
3. Matches (teacher will light the matches)
4. String
5. Stopwatch
6. Tap (room-temperature) water

Experimental Procedure

1. Take a balloon, inflate it with air, and tie its neck closed to prevent air from escaping.
2. With the help of the teacher or an adult, light a candle using matches.
3. Bring the air-filled balloon near the flame of the burning candle and start the stopwatch. What do you observe?

4. Take the second balloon. Fill it halfway with water. Then blow up the balloon with air and close its neck tightly with string.
5. Bring it near the burning candle and start the stopwatch. What do you observe?

Precaution

Maintain a safe distance between the flame of the candle and the balloons.

Results

When brought near the flame of the burning candle:

1. The first balloon, which had only air inside it, bursts immediately.
2. The second balloon, which was half filled with water, did not burst immediately. It burst after nearly 90 seconds.

Analysis

1. A balloon is made up of rubber (latex). Rubber gets heated easily and becomes weak.
2. When the air-filled balloon comes near the flame of the burning candle, the rubber becomes hot. The air inside expands due to heating, and the balloon bursts.

In the case of the second balloon, there is water in it. When the balloon is heated, the water inside the balloon absorbs much of the heat from the rubber of the balloon. This is then transferred to the air inside the balloon. The rubber does not become weak easily and the balloon takes time to burst.

Conclusion

Our hypothesis is supported by the experimental results. From this experiment we conclude that:

1. Water is a good absorber of heat.
2. Water absorbs the heat from the candle flame, delaying the bursting of the balloon.

Thinking Cap

1. Can we use some other liquid in place of water in the above experiment?
2. Why do penguins have a black coat on their skin?

Sparking Lemon Peel

Ask a Question

Can we make fuel from an ordinary orange/lemon peel?

Background Research

Cooking food and running cars, buses, rockets, and airplanes have one common requirement: fuel. Gasoline, diesel, LPG (cooking gas), natural gas, wood, kerosene, cow dung cakes, and bio-gas are some substances used as fuel to run vehicles, as well as for cooking food. Fuel is a substance that burns to give us energy and this energy is used to perform different tasks. Do you know which fuel is used in rockets? It is a gas called hydrogen. Hydrogen releases a lot of energy when it burns and helps a rocket to move into space, away from Earth!

Can you think of other substances that can give us energy when they burn? Let's understand more about these substances with the help of this experiment.

Hypothesis

If we squeeze the peels of citrus fruits and let the juice from the peels fall on a flame, we will get energy in the form of sparks.

Materials Required

1. Orange/lemon peels
2. Candle
3. Matches (teacher will light the matches)
4. Tongs

Experimental Procedure

1. Take the peel of an orange/lemon.
2. Light the candle with a match (teacher will light the match).
3. Squeeze a piece of the orange/lemon peel between two fingers of your hand and direct the juice drops to the flame of the candle.

4. Observe the flame.
5. Try the same activity with the skins of other fruits and vegetables.

Result

Drops of oil from the orange/lemon peel burn, which results in a flame that gives off energy. This can be used as fuel.

Analysis

Peels of oranges, lemons, and other citrus fruits can be used to make fuel. Peels of this kind of fruit contain oil, and this oil is combustible, which means it can burn. When we burn this oil, it produces a flame and provides us energy in the form of heat, which can be used as fuel. Did you know that oil from citrus peel is used to make insecticides?

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Fuels are substances that give us energy.
2. Peels of fruits like oranges and lemons can be used as fuel.

Thinking Cap

1. If we can get energy from fruit peel, should we start using this as fuel? Justify.
2. What is the fuel for our body? How do we get energy from it?

Bottle Fountain

Ask a Question

How do garden sprinklers rotate? Why do they rotate only in a circular motion?

Background Research

We may have seen sprinklers that are used to water gardens and fields. These sprinklers rotate continuously in a circular motion as they spray water. Let us conduct an experiment to learn how these sprinklers rotate and why they do so only in a circular motion.

Hypothesis

If we hang a bottle filled with water and make four holes at the lower end on all four sides, then the bottle will move in a circular direction.

Materials Required

1. Plastic bottle (rectangular or square in shape)
2. Strong string
3. Nail
4. Water

Experimental Procedure

1. Take a square plastic bottle, and with the help of a teacher or an adult, make four holes, one on each side, toward the bottom of the bottle.
2. Suspend the bottle from your hand by using some strong string tied around the bottle to form a handle.
3. Make sure the bottle can rotate freely when you hold the string.
4. Cover all the holes with your hands and fill the bottle with water.
5. Remove your fingers.
6. Observe what happens to the bottle. Is the bottle moving like a sprinkler?

Result

Water flows out through the holes and the bottle starts moving in a circular motion.

Analysis

Water gushing out of the bottle applies an opposite force on the bottle. This force is applied to all four corners of the bottle in a uniform direction, resulting in the bottle rotating in a circular path. This process continues until all the water is drained out. A sprinkler works on a similar principle.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Water flowing out from a hole in the bottle exerts force.
2. If four holes are made in the bottle, the forces act so that the bottle moves in a circular path (just like a sprinkler).

Thinking Cap

1. Is the speed of water coming out of all the holes equally? If we make additional holes above and below the existing holes, what will happen?
2. How can we adjust the distance to which the water will be sprinkled when we use our bottle sprinkler?

Charged Balloons

Ask a Question

Why does our hair stand on end when we take off a sweater or a synthetic piece of clothing in the winter? Why is our hair attracted to wool? Can two balloons attract each other?

Background Research

Sometimes after we have used a comb on our hair, it begins to attract small pieces of paper. This happens because the comb becomes charged when we comb our hair. The charged comb is able to attract pieces of paper, which have a neutral charge.

We might think: How does the comb become charged? Let us charge balloons and observe them both repel and attract each other.

Hypothesis

If we rub two air-filled balloons with woolen clothes, they will repel each other. But if we place a piece of paper between these balloons, they will be attracted to each other.

Materials Required

1. Woolen cloth
2. 2 balloons
3. Strip of paper
4. String

Experimental Procedure

1. Inflate two balloons.
2. With the help of a string, connect these two balloons to each other.
3. Rub the surface of these balloons with a woolen cloth.
4. Suspend the two balloons with the help of the string. What do you see? Are they attracting or repelling each other? Note your observations.

5. Take a strip of paper.
6. Place this paper strip (scale) between the balloons. What do you observe? Are the balloons repelling or attracting each other? Note your observations.

Result

When we rub balloons with a woolen cloth, they repel each other. However, when we place a paper strip in between these balloons, they become attracted to each other.

Analysis

As we rub the surface of the two balloons with a woolen cloth, they both receive the same charge. We know that like charges repel each other, so the two balloons repel each other. When a neutral (without charge) paper strip is placed in between the balloons, each balloon creates an opposite charge on the paper and gets attracted to the paper. It seems to us that both balloons are attracting each other, but in reality both balloons are attracted to the paper strip.

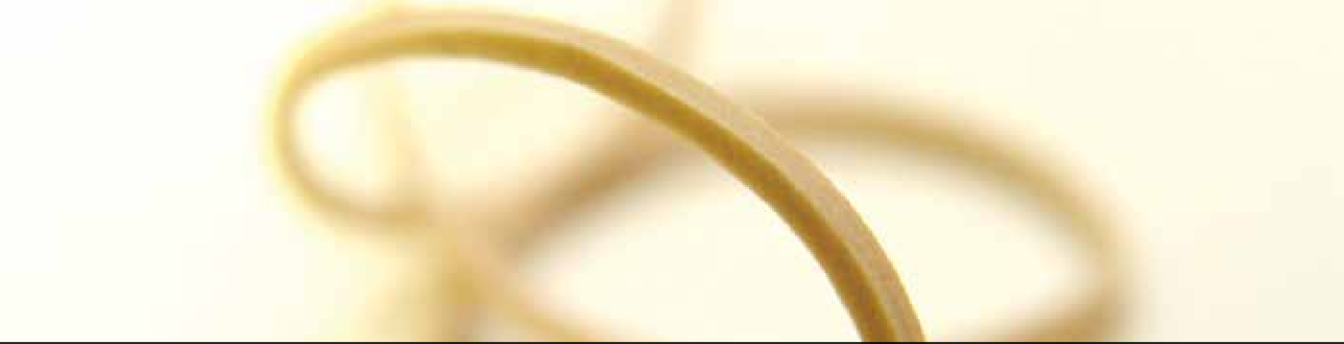
Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. There are two types of charges: positive and negative. Same charges repel each other, while opposite charges attract each other.
2. When we rub two different materials together, one becomes positively charged and the other negatively charged. This is called static electricity.

Thinking Cap

1. Can we use static electricity to generate current?
2. On a humid day, we usually experience less static electricity. Why is that so?



Musical Teeth

Ask a Question

Can we hear sounds from within our body? Will these sounds be different from the sounds we hear from outside our body?

Background Research

Sounds are an important part of our world, even the sounds of our own voices. If we whisper, we are able to hear clearly what we said, but a friend standing at a distance might not hear us clearly. Why is this so? We may have seen some vocalists closing one ear and singing. Why do they do this? Our voices sound different when we hear them ourselves than if we hear them on a videotape or tape recorder. This is because we use our collective hearing to hear our voice from both outside as well as inside our body, making our voice sound different than what others hear.

Hypothesis

If we stretch and pluck a rubber band after holding it between our front teeth, then we will hear the collective sound, that is, our voice from outside as well as from inside our body.

Materials Required

1. Large rubber band
2. Matches (for plucking)

Experimental Procedure

1. Take a large rubber band and hold it between your front teeth.
2. Stretch the rubber band with one finger of your left hand (do this carefully so you don't hurt yourself).
3. Take a match in your right hand and pluck the stretched rubber band two or three times.
4. Did you hear a sound? How clear was the sound?

5. Now stretch the rubber band between two fingers of your left hand.
6. Take a match to pluck the stretched rubber band (be careful not to hurt yourself).
7. Did you hear a sound? How clear was it? Was it clearer than the sound you heard when the rubber band was stretched between your hand and your teeth?

Result

The sound you heard when the rubber band was placed between your teeth and your hand was very clear when compared to the sound you heard when the rubber band was stretched just between your fingers.

Analysis

Sound is a form of energy. It travels through the air in the form of vibrations or moving back and forth. These vibrations get weaker as they travel through the air. So as we move farther away from the source of the sound, the sound appears fainter to our ears. Sound can also travel through our body.

The sound you heard when the rubber band was placed between your teeth and your hand was very clear because you heard from both sources: sound from outside as well as from inside your body.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that sound does travel within our body.

Thinking Cap

1. Record your voice and listen to it. Why do you hear a different sound from what you expected?
2. Animals sense danger before humans do (very few animals die in a hurricane or a tsunami). How is that related to their sense of hearing?

Air-Filled Soil

Ask a Question

Does soil contain air? How do animals and insects that live under the soil receive air (oxygen) in the soil?

Background Research

Have you noticed that animals and insects like earthworms and beetles wriggle out of the soil when it rains? Why is that? That happens because when it rains, the air spaces in the soil are filled by rainwater. Because of this, animals are unable to get a regular supply of oxygen, so they wriggle out of the soil to breathe.

Hypothesis

If we pour water into a soil-filled jar, bubbles of air will come out from the soil (showing that soil contains air).

Materials Required

1. Jar
2. Soil
3. Water

Experimental Procedure

1. Collect soil in a jar.
2. Slowly pour water into the soil.
3. Observe carefully.
4. Note your observations.

Result

We can see air bubbles coming out of the soil.

Analysis

To the naked eye, soil particles seem to be densely packed together.

The reality is actually different. There are spaces in between soil particles. These spaces are called pores. When the soil is "dry," pores are largely filled with air. When we pour water in the soil, water enters these pores, allowing the air to exit in the form of bubbles.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that soil contains air (which is necessary for the survival of the animals that live in the soil).

Thinking Cap

1. Soils have different colors. What gives color to the soil?
2. The number of earthworms in the soil has decreased over the years. What could be the reason (changes in soil) that has led to this development?

Paper Cup Phone

Ask a Question

Can we use a simple phone made from paper cups and a string to communicate? How does it work? What happens if we pinch the string between the two cups?

Background Research

Sound is something that we hear with our ears. We can hear many kinds of sounds: music, car horns, someone speaking. Have you ever tried to find out how sound is produced and how it travels from one place to another?

The air around us consists of many tiny particles that we cannot see with our eyes. When we speak, our vocal chords (located inside our necks) vibrate, that is, they move back and forth. Since air particles are in contact with our bodies, they also start vibrating in the same way. Gradually, all the air particles around us vibrate. A person who is nearby is also in contact with those air particles. The vibrating particles make the eardrum in the ear of the other person vibrate, and so the person hears what we are saying.

Communication with our friends who are away from us is possible through a phone. If you want to communicate with a friend sitting at the other end of your home, make you own phone. Let's learn this by doing a simple and interesting experiment.

Hypothesis

If we connect two cups with a long string and speak into the first cup, our voice will travel to the second cup at the other end of the string.

Materials Required

1. 2 plastic or paper cups (the kind used for hot or cold drinks)
2. Pin or a safety pin
3. Pencil

4. String
5. Tape measure
6. Scissors

Experimental Procedure

1. With the help of a teacher or an adult, make a small hole in the base of each of the cups using a pin or a safety pin or a pencil.
2. Cut a long string approximately 15 yards (15 meters) long.
3. Place both cups so that their bottoms are together.
4. Pass one end of the string through the hole of one cup and take it out through the hole of the second cup.
5. Tie a tight knot at both ends of the string so that the string does not come out of the cups when the string is stretched.
6. Give one cup to your friend and keep one cup for yourself.
7. Ask your friend to walk where the string stretches to its full length.
8. Ask your friend to say something in the cup and put your cup to your ear.
9. Now ask your friend to place the cup close to his or her ear and you speak something in your cup.
10. Note your observations.

Result

Both friends are able to communicate with each other with the help of the paper cup phone.

Analysis

When you speak in your cup, sound waves (like water waves) are created. These waves strike the bottom of the cup and it starts vibrating. These vibrations are carried to the string, which is in contact with the bottom of your cup, making the string vibrate. These vibrations travel from your side to your friend's side through the whole length of the string and reach the bottom of your friend's cup. The vibrations hit your friend's eardrum and your friend is able to hear what you said. Sound travels through solids (cups and string).

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Sound travels from one place to another in the form of waves (vibrations).
2. Sound can travel through solids.

Thinking Cap

1. If two astronauts are in space, how will they talk to each other?
2. Why do people place their ears on railroad tracks to find out whether a train is arriving?

Making a Colored Flower

Ask a Question

How can we change a flower using our favorite color? Flowers placed in a glass or vase containing water remain fresh for a longer time than those without water. Why is this so?

Background Research

Water and minerals from the soil reach the petals of flowers. This movement goes against gravity. How is such a process possible? What will happen if we place a flower in a glass of colored water? In this experiment, we will color white flowers with our favorite colors.

Hypothesis

If we take a white flower and split the stem down the middle and insert it in two glasses, each with a different color of water, the white flower will get both of these different colors on its surface.

Materials Required

1. White flower
2. Different food colors
3. Knife
4. Drinking glasses

Experimental Procedure

1. Fill two glasses with water.
2. Mix one food color in each glass, say blue and red.
3. Take a white flower with a long stem.
4. Split the stem in two parts with the help of a teacher or an adult. Place both parts in the two glasses (one part in each glass).
5. Check the flower after a few hours. Note its color. Compare it with the original white flower.

Result

The flower develops spots of both colors: blue and red.

Analysis

Plant stems contain many small tube-like structures called the xylem, derived from the Greek word xylon meaning "wood." The xylem carries water and nutrients up from the root to the upper parts of a flower/plant. When water evaporates from the surface of the petals, a force is generated that sucks more water through the xylem. This phenomenon of a liquid flowing through narrow spaces in opposition to gravity is called capillary action. In this experiment, the xylem carries both colors to the flower, changing the white flower to blue and red (the colors remain on the flower after the colored water evaporates).

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. In flowers and plants, xylem vessels carry water and nutrients up from the roots by a process called capillary action.
2. Evaporation of the water at the surface of the petals results in an upward pull of the water.

Thinking Cap

1. How are substances transported in human beings?
2. Do all animals have blood vessels—arteries and veins—like human beings?

Balloon Wrestling

Ask a Question

Does air have any weight?

Background Research

All of us have probably seen or played with a soccerball. Try to hold a deflated soccerball in one hand and an inflated one in the other hand. Do you feel any difference in weight between the two? The deflated one is light, as there is no air in it, while the inflated soccerball is heavy, since it is filled with air. Let's prove that air has weight with an experiment.

Hypothesis

If we tie two identically inflated balloons at opposite ends of a stick and puncture one of the balloons, the stick will dip toward the balloon that is not punctured.

Materials Required

1. Hanger or a wooden stick
2. 2 balloons
3. Tape
4. String
5. Sharp needle or pin (teacher or adult will help)

Experimental Procedure

1. Inflate the balloons until they are of the same size. Tie each balloon with a knot so that air does not escape.
2. Use pieces of string to tie one balloon to each end of the hanger/stick.
3. Tie another piece of string around the center of the hanger/stick and use as a handle and hang so that both balloons are balanced.
4. Hang the ballons at the side of a table so that the balloons do not touch the table.

5. Note the position of the stick. Is it balanced or is it dipping in some direction?
6. Make sure the two balloons are still balanced.
7. Prick 1 balloon with a needle or pin.
8. Note the position of the stick. In which direction does it dip?

Result

The end of the stick/hanger with the deflated balloon rises.

Analysis

The stick dips down in the direction of the inflated balloon. This indicates that the balloon with air is heavier than the punctured balloon because air has leaked out of the punctured balloon. The difference in the weight of the balloons is caused by the weight of air, so we can conclude that air has weight.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment, we conclude that air has weight.

Thinking Cap

1. When we are on the top of a mountain, why do we tire quickly?
2. When we are underwater, does water exert pressure on us? How does our body deal with such pressure?

Falling Nails

Ask a Question

Why do steel/aluminum utensils generally have wooden or plastic handles?

Background Research

When you eat hot soup from a steel bowl using a steel spoon, why does the spoon also become hot? A wooden handle does not heat up but a steel handle does. What is the difference between the two materials? Materials can be divided into good and bad conductors of heat. Good conductors of heat are substances that get heated very quickly; all metals are good conductors of heat. Do you know why some cooking pots and pans have copper coating? Copper is one of the best conductors of heat; it heats quickly and thus helps the food to be cooked faster. Materials like wood and plastic take a long time to heat up; they are bad conductors of heat. This is the reason why wooden handles do not become as hot as the metal cooking tools to which they are attached.

Hypotheses

Primary Hypothesis: If we heat one end of a metal rod that is coated with wax and has nails attached to it, the nail closest to the end being heated falls down first.

Secondary Hypothesis: If we heat one end of something metal, the other end also gets heated.

Materials Required

1. Spoke of a bicycle wheel
2. Candle
3. Matches (teacher will light the match)
4. 5 nails

5. Pliers to hold the bicycle spoke horizontally

Experimental Procedure

1. Take a bicycle spoke. On this spoke, mark a point nearly 2/3 inch or 2 centimeters from one end.
2. From that point, fix the nails on the spoke with the help of candle wax at a distance of about 1/3 inch or 1 centimeter from each other.
3. Take care not to spill the hot wax on your hand.
4. Place a candle at the first end and have the teacher help you light it.
5. Start heating the end and keep observing the nails.
6. Note the sequence in which the nails fall.

S. No	Distance of the nail from point A	Sequence in which a nail falls
1.	**3 inches**	
2.	**3.5 inches**	
3.	**4 inches**	
4.	**4.5 inches**	
5.	**5 inches**	

Results

The nail closest to the end being heated falls down first.

Heat travels from the hot end of the metal to the cooler end.

Analysis

The metallic spoke used in the activity, when heated at one end, becomes hot and transfers the heat to the other end of the metal. We can observe that the nails start falling in the same order in which they are fixed to the spoke. Heat gets transferred through tiny particles in the metal rod. These particles, when heated, transfer heat to the neighboring particles. This method of transfer of heat is called conduction.

The particles at the end that is being heated gain energy and become hot. The heat is transferred from the hot end to the colder end of the metal. Because of this transfer of heat, the wax holding the nails melts and the nails start falling. The nail that is closest to the end being heated falls down first. The heat gets transferred from one particle to the other in a sequence, so the nail farthest from the heated end falls last.

Conclusion

Our hypotheses are supported by the experimental results. From this experiment we conclude that:

1. In solids, heat is transferred by conduction.
2. In conduction, heat is transferred from one point to another in a sequence, starting from the hot part and going to the cold part. That is why the nail closest to the end being heated (hot end) falls down first. And the nail farthest from the hot end falls last.

Thinking Cap

1. How does a thermos keep its liquid contents hot?
2. What happens when warm and cold waters of oceans mix?

Potent Seeds

Ask a Question

After a seed is sown in the ground, how do saplings break the earth's crust and come up?

Background Research

When we want to cook beans, it is preferable to soak them in water overnight. When we soak beans overnight, what do we observe in the morning? Has the size of the seeds increased overnight? Why does this happen? Where did the water go?

To understand this process, take a seed and observe carefully.

The outermost layer of the seed is called a seed coat. Can you locate a scar and a very fine hole, called the micropyle, on the seed coat? The water in which seeds are soaked enters the seeds through this hole. When water enters, the seed swells up and needs more space. It pushes things around itself to create space, sometimes even creating cracks in rocks. You do not believe this? Try to find out with the following activity.

Hypothesis

If we sow seeds and water them regularly, they will break the earth's crust and come up through the soil.

Materials Required

1. Small plastic bottle with cap
2. Dry seeds
3. Water

Experimental Procedure

1. Take a small plastic bottle half filled with seeds.
2. Fill the bottle with water, making sure that no space is left in the bottle.

3. Close the bottle tightly.
4. Place the bottle in a safe place.
5. Observe the bottle after one day.

Observation Table

Put a √ or an X mark according to your observations.

S. No	Any increase in the size of seeds?	Any cracks in the bottle?	Is the cap of the bottle swollen ?	Does the water in the bottle reduce?
1.				

Result

The seeds begin the process of germination, causing the cap of the bottle to swell or even a crack to appear on the surface of the bottle. The cap of the bottle also swells.

Analysis

As the seeds swell, the water in which they are soaked disappears. The water enters each seed through the small hole (micropyle), causing each seed to swell, increasing its size. The increased size cannot be contained in the bottle, so the seeds exert pressure on the walls of the bottle, causing the cap of the bottle to swell. This may even result in cracks in the bottle.

Try the same activity in a small bowl. Fill it with seeds and add water. Place a saucer (plate) on the bowl. Leave it overnight. What do you observe in the morning? Yes, the plate has fallen away.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Seeds absorb water and swell.
2. Seeds exert enough force to push the inner surface of a bottle, which creates cracks even in the outer cover of the bottle.

Thinking Cap

1. If plants have no seeds, how will they grow?
2. How long can you store seeds?

Victory over Fire

Ask a Question

How can we extinguish an unwanted fire? Can we put out a fire without blowing air or spraying water?

Background Research

Fire is important to us in many ways: We use it for cooking and for keeping ourselves warm. However, fire can also be dangerous. It can cause damage if it burns out of control. If a fire breaks out, we call the fire department to rescue people and control the fire. The fire truck contains water, hoses, and many fire extinguishers. The fire extinguisher cylinders are a common sight in buildings and in homes. The carbon dioxide produced by the reaction of substances in the extinguisher helps to put out the fire. Let us make our own fire extinguisher.

Hypothesis

A mixture of baking soda and vinegar can extinguish a fire.

Materials Required

1. Metal pot
2. Drinking glass
3. Candle
4. Matches (teacher will light the match)
5. Baking soda
6. Vinegar
7. Cardboard

Experimental Procedure

1. Take a drinking glass.
2. With the help of a teacher or an adult, light a candle and place it inside the metal pot.

3. Take the second glass and fill it halfway with the vinegar. Now add baking soda to the vinegar. Note your observation.
4. Cover this glass with cardboard having a hole of approximately 1/3 inch or 1 centimeter in diameter.
5. Now take this frothy glass to the other glass containing the burning candle and tilt it a little so that the gas coming out of the hole is just above the flame of the candle.
6. Observe carefully. Don't pour the froth on the burning candle.

Result

The burning candle is extinguished.

Analysis

How does this candle blow out? To understand, first we have to think what is required most for burning. It's oxygen. Baking soda mixed with vinegar produces carbon dioxide. This gas is heavier than air. So when we take the glass containing the froth that results from combining baking soda with vinegar and pour it on the burning candle, carbon dioxide gas fills the space inside the glass containing the candle and thus cuts off the supply of oxygen. The burning process stops and the fire is extinguished because of the lack of oxygen in the glass.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that carbon dioxide can be used to extinguish a fire by cutting off the supply of oxygen to the fuel.

Thinking Cap

1. How are forest fires caused?
2. If you do not have a fire extinguisher, how will you extinguish a fire caused by gasoline?

Baiting Mosquitoes

Ask a Question

How can we make a simple, effective trap for mosquitoes at home?

Background Research

Mosquitoes are insects that are attracted to dark colors. Since heat is not good for mosquitoes, they generally inhabit dark and cold places. Mosquitoes breed in stagnant water and are responsible for spreading many dangerous diseases, including malaria and cholera. To avoid the spread of disease, it is necessary that we keep our surroundings clean and do not allow water to collect in receptacles outdoors in order to minimize our contact with mosquitoes.

Hypothesis

If we place a black plastic garbage bag inside a metal box and leave it overnight in a dark and cool place, a swarm of mosquitoes will be trapped inside.

Materials Required

1. Dark-colored metal container or box
2. Large black plastic or polyethythene bag
3. Sheet of white paper

Experimental Procedure

1. Take a metal box, preferably one with a narrow opening.
2. Spread the black plastic bag inside the box.
3. Do not cover the box. Keep the box in a cool, dark corner of your home or school for one night. Do not disturb in any way.
4. Next morning, carefully cover the box with its lid and leave it in the sun during the day.
5. After one day of exposure to the sun, uncover the box and take the plastic bag out. Empty the contents onto a sheet of white paper. Several dead mosquitoes will appear on the paper.

Analysis

In this experiment, mosquitoes collect inside the black plastic bag because they are attracted to dark and cool places. Exposing the box to sunlight kills the mosquitoes due to the heat. Using this procedure, we can get rid of as many as 100 mosquitoes at a time without spraying chemicals.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Mosquitoes are attracted to dark colors.
2. Mosquitoes are found in cool and dark places.

Thinking Cap

1. How are mosquitoes related to malaria and other diseases? Do all mosquitoes cause these diseases?
2. Which plants can be used as natural insecticides?

Dinner of Plants

Ask a Question

Where do plants store their "cooked" food? Can we see their food?

Background Research

Trees and plants are the only living beings that make their food themselves. Plants make their food by a process called photosynthesis in the presence of sunlight. They use carbon dioxide (present in the air) and water (in the soil) to make their food. The beautiful green leaves of a tree or plant can prepare food. Surely they do not have a refrigerator, so where do they store their food? In what form is the food stored?

The plants store their prepared food in different parts: roots, trunk, branches, stems, and leaves in the form of a substance called starch. We can test the presence of starch with the help of an experiment: If we apply iodine over any part of a plant that has starch in it, then it will turn bluish black.

Hypothesis

If we apply iodine on any plant substance containing starch, the portion on which iodine is applied turns bluish black.

Materials Required

1. Potato
2. Apple
3. A few grains of rice
4. A few grains of flour from bread
5. Iodine crystals
6. Dropper or spoon
7. Fresh water
8. 4–5 plates

9. Bowl
10. Knife (not sharp)

Experimental Procedure

1. Place slices of apple and potato on two separate plates. Place grains of rice and flour from bread on another plate. You can use more food items if you wish.
2. Put water in a bowl (about 2 ounces or 50 milliliters) so that it is filled only 1/4 of its volume. Mix some iodine crystals into the water.
3. Use a dropper or a spoon to drop this solution on all the materials on the plates.
4. Note the changes in color in each substance.

Precaution

Iodine crystals are harmful for the skin if used without dilution (watering down), and care must be taken. This experiment should be done in the presence of your teacher or an adult.

Result

Potato and rice turn dark blue or black upon application of iodine, indicating the presence of starch.

S. No	Food item	Color seen after application of iodine
1.	**Potato**	
2.	**Rice**	
3.	**Apple**	
4.	**Flour grains**	

Analysis

Proteins, vitamins, fats, carbohydrates, and minerals are components of the food we eat. These components provide nourishment to our body. Some of the carbohydrates contain starch. When starch reacts with iodine, it becomes blue black in color.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that plants prepare their own food. The food is stored as starch in different parts of the plant.

Thinking Cap

1. If food is stored as starch in a plant, does every edible plant contain starch?
2. Some people have a gluten allergy. What is it? What kind of foods do they need to avoid?

When Fire and Paper Wrestle

Ask a Question

Is it possible to boil water in a paper cup?

Background Research

What happens if we place a paper cup on a candle flame? The paper cup will burn. But in this experiment, we will fill a paper cup with water and heat it with a candle. Do you think the paper cup will still burn? Let us understand the science of the heating effect on water.

Hypothesis

If we take a paper cup full of water and place it on a candle flame with a wire mesh between the flame and the paper cup, we will be able to boil water without affecting the paper cup.

Materials Required

1. Candle
2. Matches (teacher will light the match)
3. Paper cup
4. Water
5. Piece of wire mesh

Experimental Procedure

1. Take a paper cup and fill it with water, up to 3/4 of its capacity.
2. With the help of a teacher or an adult, place a piece of wire mesh between the paper cup and the flame of a candle.
3. Place the paper cup on the wire mesh.
4. Do you notice if the paper cup is burning? Or is the water starting to heat up?

Result

The water inside the paper cup starts boiling. The flame of the candle does not burn the paper cup.

Analysis

The heat generated by the flame is distributed over the wire mesh by conduction because the mesh is made of metal. This loss of heat saves the paper cup from burning.

In addition, heat transferred to the paper is absorbed by the water molecules inside the paper cup. The heated water molecules set up a convection current in the water and move up within the cup while the cooler molecules move down. Soon all the molecules in the water are heated by convection and the water starts to boil. Conduction involves the transfer of heat from one molecule to another by contact, while convection involves the movement of heated molecules. So the water in the paper cup is heated and boils but the paper cup does not burn.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that water absorbs heat, and heat in water is transferred to another material by the process of convection.

Thinking Cap

1. Why do you add antifreeze to car radiators?
2. Is a candle flame different from the flame of a gas stove?

Water Floating on Water

Ask a Question

How can we make water float on water?

Background Research

Let's drop some pieces of wood, oil, pebbles, and a few nails in water. We will see that the wood and oil float on the surface at the top of the water while the pebbles and nails sink to the bottom. What is the property that makes some things float while others sink in water? It is called density. Materials that have density that is less than that of water will float on water, while substances with density that is more than the density of water will sink in it. Can we change the density of water? Yes we can by heating or cooling it. Hot water is less dense or lighter than room-temperature water, while cold water is denser or heavier than room-temperature water. Let us become magicians and learn how this is possible by performing an experiment.

Hypothesis

If we take colored hot water and pour it over room-temperature water, the colored hot water will float on the room-temperature water.

Materials Required

1. Glass vessel or drinking glass
2. Room-temperature tap water
3. Hot water
4. Red poster paint or ink
5. Spoon or glass rod

Experimental Procedure

1. Take a clean drinking glass.
2. Fill it halfway with room-temperature water.

3. Put some hot water in the second glass and mix 4–5 drops of red poster paint or ink in it to make red-colored water.
4. Carefully and slowly (with the help of a teacher or an adult) pour the hot colored water in the glass containing room-temperature water using the side of a spoon to help the water slowly slide down into the glass. Do not pour hot water quickly. Perform this step very slowly.

Result

The red-colored hot water remains on top of the room-temperature water for a few moments. It will seem as if the red water is floating on the room-temperature water.

Analysis

From this experiment we have learned that hot water is lighter than room-temperature water. Water is made up of many tiny particles. Density is what determines how close or how far these particles are from one another. If these particles are far from each other, then water has less density. Conversely, if the particles are close to each other, then water has more density. When heat is applied, the particles of water become filled with energy and move away from each other. We can conclude that hot water is less dense than room-temperature water and so it floats on top of the room-temperature water.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Heating makes water less dense.
2. Hot water floats on room-temperature water due to its lower density.

Thinking Cap

1. Can freshwater fish live in saltwater?
2. What happens if the hot water from power plants is allowed to flow into rivers?

Friendship of Two Balloons

Ask a Question

Why do two balloons move closer together when we blow air between them?

Background Research

You must have seen a flag fluttering in the air, a kite flying in the sky, and leaves swaying in the air. This happens due to the movement of air or the flow of air. Have you ever wondered how a plane flies? Do the wings of the plane help in flight? Yes, the wings are responsible for flight, but to understand this we must first understand how air flows. The air on top of the wing travels faster than the air at the bottom of the wing. This causes lower pressure at the top of the wing and higher pressure at the bottom of the wing. We know that air moves from high-pressure areas to low-pressure areas, which creates lift and allows the plane to fly. With this experiment, we will learn how air flows from high-pressure areas to low-pressure areas.

Hypothesis

If we blow air between two equal-sized balloons tied to a stick, the balloons will move closer to each other.

Materials Required

1. 1 yardstick
2. 2 equal-size inflated balloons
3. String

Experimental Procedure

1. Take a yardstick.
2. Take two equal-size balloons and tie strings of the same length to each of them.

3. With the help of the string, suspend each balloon from the stick so that they are at a distance of less than 1 inch or 2 centimeters from each other.
4. Blow air between the balloons and note your observations.
5. Repeat the same experiment with other things, like two balls.

Result

The balloons move closer to each other when air is blown between them.

Analysis

Air is made up of tiny particles that are in constant motion. When we blow air between the balloons, the tiny air particles start moving faster. When air moves fast, the pressure between these balloons decreases, creating a low-pressure zone between the two balloons. There is higher pressure in the atmospheric air around the two balloons compared to the pressure in between them. We know that air moves from a high-pressure zone to a low-pressure zone. Higher pressure of air on either side of the balloons pushes them to move into the lower-pressure zone created by blowing air. In other words, the two balloons move toward each other.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that air moves from a high-pressure area to a low-pressure area.

Thinking Cap

1. Does the difference in air pressure in two places affect the flying of kites?
2. Is it easier to cook in hilly places than in flat areas?

Floating Egg

Ask a Question

If we drop a raw egg in water, will it sink or float? How can we make a raw egg float in water?

Background Research

A substance floats in water when its density is less than that of water. Since the density of a raw egg is higher than that of water, it sinks in water. If we want to make this raw egg float, we have to increase the density of water so that it is higher than that of the egg. Let us see if we can increase the density of water and make the raw egg float!

Hypothesis

If we mix an appropriate amount of salt in water and place a raw egg in the salty (saline) water, the raw egg will float.

Materials Required

1. Raw egg
2. Transparent drinking glass
3. Salt
4. Tablespoon

Experimental Method

1. Take a transparent drinking glass so that you can see from the outside whether the egg is floating or sinking in water.
2. Place a raw egg in the water. Does the egg float or sink? Note your observations.
3. Remove the egg from the glass. Mix one tablespoon of salt with the water in the glass.
4. Repeat the process of placing the egg in the glass. Does the egg float or sink? Note your observations.

5. If the egg sinks, add one more spoonful of salt and repeat the experiment.
6. Keep on repeating the above step until the egg floats in water when it is placed in the glass.

Result

The egg floats when a few tablespoons of salt are added to the glass of water.

Analysis

If we add any soluble (able to dissolve) substance in water, then the density of the water increases (while the density of the egg remains the same). As we keep adding salt, the density of the water gradually increases. At a particular point, the density of the water becomes greater than the density of the egg. At that point, the egg floats in the salty (saline) water.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Adding salt or other soluble (dissolvable) substances increases the density of water.
2. A low-density substance floats in a liquid of high density.

Thinking Cap

1. Sponges and styrofoam are less dense than many other solids. Why is this so?
2. How was Archimedes able to find out that the crown was not made of pure gold?

Count the Drops

Ask a Question

On a rainy day, is it possible to measure how much it has rained? How can we measure rainfall in a particular area?

Background Research

Information about rain is very important to us all. A weather report is broadcast by the National Weather Service. This department collects data such as temperature, air velocity, and humidity. By synthesizing the data, the service makes predictions about the rainfall in an area. How does the National Weather Service know how much it has rained in a particular area?

During the spring, it may rain quite frequently. How can we find out the day on which it has rained more than other days? How can we compare the amount of rainfall this year with the rainfall from the previous year? We can do so with the help of an instrument called the rain gauge. In this experiment, we will make a rain gauge with the help of small plastic bottles.

Hypothesis

If we place a handmade rain gauge in the rain, we can measure the amount of rain that falls in a particular area.

Materials Required

1. Plastic bottle
2. Scissors
3. 4 bricks
4. Scale

Experimental Procedure

1. Take a transparent plastic bottle of one quart or one liter.
2. With the help of a teacher or an adult, cut off the upper part of the bottle.

3. Turn this upper part upside down.
4. Dig a hole in the yard and fix this arrangement of the bottle in the ground at a depth of around an 1 inch or 3–5 centimeters. This will prevent the bottle from falling over due to any wind.
5. You can even place bricks around it to provide stability for the plastic bottle.
6. Using this setup, you can measure the rainfall from time to time.
7. Note your readings in the table below:

S. No	Day and time	Rainfall in inches
1.		
2.		
3.		
4.		

Result

The rainfall on ______ day was _______ inches (or centimeters). We are able to measure the rainfall in our area with our rain gauge on any particular day.

Analysis

The rain gauge made using the plastic bottle helps to measure rainfall. The upper part of the bottle works as a funnel and helps the water to collect in the bottle. It also prevents the water inside the bottle from evaporating (because of the narrow opening), which helps to provide a more accurate calculation.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that we can measure the amount of rainfall in an area using a simple and effective instrument called a rain gauge.

Thinking Cap

1. Do all clouds bring rain?
2. Why do some areas receive more rainfall than others?

Soil Erosion

Ask a Question

What makes the paths for rivers? After a period of rain, why does the soil in our fields seem to follow the flow of water?

Background Research

Soil is an important part of nature. Without the land, we would not be able to get water, grow our food, or build our houses. In short, soil has been responsible for the flourishing of life for millions of years. Today's growing population, however, has given rise to new problems. Housing the ever-increasing population has raised the demand for more land area. To satisfy this demand, mankind has mindlessly engaged in deforestation (the cutting down of trees on a large scale) for years, and continues to do so today.

The felling of trees, which anchor the soil with their roots, causes soil erosion. The roots of the trees protect the soil from wind and water erosion and help hold it together. Desertification (the change of land for farming or living into desert or unusable land) is a result of heavy soil erosion.

Hypotheses

Primary Hypothesis: If we pour water in a container with loose soil, the soil particles will get carried away with the water.

Secondary Hypothesis: If we plant saplings in the same vessel, the soil will not get washed away with the water.

Materials Required

1. Container
2. Dry soil
3. Glass of tap or room-temperature water
4. A few saplings or a patch of grass

Experimental Procedure

1. Take an empty container and fill it with soil.
2. Slowly pour water into the container and write down what you observe.
3. Now plant some saplings in that soil. If you are using a grass patch, then press its roots firmly into the soil.
4. Pour some water and adjust the roots of the plants into the soil. The soil is now ready.
5. Pour water slowly into the soil in a similar manner as you did in Step 2 and record your observations.

Result

When water is poured onto the soil in which nothing is planted, the soil gets washed away with the water. However, when we put plants or grass in the soil, the soil particles are not carried away with the water.

Analysis

Roots of plants or trees hold the soil firmly in place and that is why the soil does not get washed away with the water after we have planted grass or plants in the soil. Soil particles not bound by plants or trees are loose and thus they are washed away by water.

Conclusion

Our primary and secondary hypotheses are supported by the experimental results. From this experiment we conclude that:

1. Roots of trees/plants help in holding the soil together.
2. The cutting down of trees leads to soil erosion.

Thinking Cap

1. Is there soil on Mars? What is the difference between the soil on Mars and the soil on Earth ?
2. When Earth was formed, did it have soil? How was the soil formed?

Water Bends a Pencil

Ask a Question

Why does a pencil seem broken when it is placed in a glass of water?

Background Research

Dip your finger in a glass of water. What do you observe? You will see a broken finger. Take it out of the water and look: Your finger is straight again. Actually nothing has happened to your finger when you dipped it in the water. What was affected was the light reflected from the part of your finger that is out of the water and the part dipped in the water.

We know that light travels in a straight line. You can see the flame of a candle only when you are looking at it in a straight line. If something comes in between your line of sight, the flame won't be visible to you anymore.

What will happen if you place a glass of water between the flame and your eyes? A different phenomenon takes place. We call it refraction. This means that when light travels from one medium (like air) to another medium (like water), light changes its path or bends and this bending of light is called refraction. Refraction is due to the difference in densities of the two mediums. We draw a straight line at the point where the light bends and call it normal light. The light from the object is called incident light and the light that bends is called refracted light.

Hypothesis

If we insert a pencil in a glass of water, then it will appear bent at the surface of the water.

Materials Required

1. 2 pencils

2. 2 drinking glasses
3. Water

Experimental Procedure

1. Take two clean empty drinking glasses and two pencils.
2. Fill 3/4 of one glass with water.
3. Now place one pencil in the glass that has water and one in the empty glass.
4. Observe both glasses carefully.

Result

The pencil in the glass filled with water appears to be broken or bent at the water surface. However, the pencil in the empty glass appears to be unchanged: straight and not bent.

Analysis

In this experiment, the pencil in the glass filled with water appears to be bent or broken due to refraction.

In the case of the pencil in the glass without water, light does not bend as it is traveling only in air (a tiny level of refraction occurs at the glass wall but we can ignore it for now). However, in the case of the pencil in the glass filled with water, light first travels in the water and then enters the air (the medium has changed) to reach our eyes. So it undergoes refraction and bends, and the pencil appears to be broken. This "bending" occurs at the surface of the water so we can say at the interface between the air and the water (interface means the point where air ends and water surface begins).

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that light undergoes refraction or bends when it moves from one medium to another.

Thinking Cap

1. How do optical fibers work ?
2. How can you design an experiment to find the refractive index of a liquid using a concave mirror?

Fireproof String

Ask a Question

How can we make fireproof string?

Background Research

We know metals are good conductors of heat. If we apply heat at one end of metal, it transfers heat to the other end by the process of conduction. Wood is a bad conductor of heat. When wood is heated, it does not transfer heat from one end to the other. Instead, it starts burning if sufficient heat is provided.

When heated, string will burn quickly. What if we roll string over metal and then heat it? Will it still burn? Find out for yourself with the following experiment.

Hypothesis

If string is wrapped around the metallic part of a screwdriver and placed over a flame, the string will not burn easily.

Materials Required

1. Screwdriver
2. String, preferably made of cotton
3. Candle
4. Matches (teacher will light the match)

Experimental Procedure

1. Take a screwdriver.
2. Wrap the string around the metallic part of the screwdriver.
3. Light a candle (with the help of a teacher or an adult).
4. Hold the screwdriver with string over the flame for a few minutes .
5. Note your observations. Does the string burn?
6. How much time does it take for the string to start burning?

Precaution

The screwdriver, after being placed over a flame, becomes hot. Store it only after it has cooled down.

Result

The string does not burn, even after ___ minutes, although the screwdriver is heated.

Analysis

The candle flame touches both the string and the metallic part of the screwdriver. Most of the flame's heat energy is absorbed by the screwdriver's metallic part, which is then transferred to the cooler parts of the metal. This process continues, resulting in the metallic part becoming increasingly hot and thus preventing the string from burning. The candle flame contains carbon, which gives a black color to the metallic part as well as to the string.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Metals are good conductors of heat.
2. Heat is transferred by conduction from one end (the warmer end) to the other end (the cooler end) in metals.

Thinking Cap

1. How do optical fibers work?
2. What is a mirage? Why do we observe a mirage during the summer?

Game of Waves

Ask a Question

How are waves formed? Why are waves formed in seas and oceans?

Background Research

Sea waves and ocean waves fascinate almost everyone. When we see the ocean, we are attracted first by the waves: high waves, low waves, and waves bringing shells to the shore.

Waves are formed by the process of convection. Convection is a process of the transfer of heat energy. Heat is transferred in gases and liquids through convection. How does heat reach us when we sit around a bonfire? It is through convection. Air around the bonfire is heated, moves upward, and is replaced by cool air. This movement of heated air particles transfers the heat. Similarly, when water is heated in a pan, hot water particles move upward and are replaced by cooler water particles.

When hot water mixes with cold water, sea waves are formed. Through this experiment, we will learn about convection and how waves are formed. In fluids (liquids/gases), the transfer of heat takes place through tiny particles and this process is also called convection. Convection is not possible in solids but it is the main mode of heat transfer in liquids. In our experiment, let's create waves in a tub of water!

Hypothesis

If there is a difference in temperature, then waves are formed in water.

Materials Required

1. 2 paper cups of equal size
2. Nail or a pin

3. Hot water
4. Cold water
5. Red poster paint
6. 1 paintbrush
7. 1 tub or large container
8. Room-temperature tap water (to fill the tub/container)

Experimental Procedure

1. Fill the tub/container with room-temperature water. Do not fill it up to the top.
2. Take one paper cup. With the help of a teacher or an adult, make a small hole in the bottom of the cup using a pin or a nail. Let the nail remain in the hole. Do not remove it.
3. Pour hot water in the paper cup (with the nail in place). Mix some red paint with room-temperature water in the paper cup using a paintbrush. The water will become red.
4. With the help of a teacher or an adult, carefully hold the paper cup with red-colored hot water in the tub or container. Do not place the whole cup inside the tub. Remove the nail from the hole (where you placed it earlier) and observe what happens. Note your observations.
5. Change the water in the tub. Refill it with room-temperature tap water.
6. Repeat the experiment with the second paper cup using cold water this time.
7. Observe what happens. Note your observations.

Result

Waves are formed in both cases. It is only the height of the waves that is different: The paper cup filled with hot water produces water waves that rise up, while the paper cup filled with cold water produces smaller waves.

Analysis

Water is made up of many tiny particles. When it is heated, water becomes hot because of the movement of these tiny particles. Unlike with conduction, heat is not transferred from one particle to another. Instead, the hot water particles move and are replaced by cooler particles. In other words, heat goes from one end to another with the help of the movement of these tiny particles. This process is known as convection.

Waves in seas/oceans also form because of the process of convection. There is a temperature difference between the water on the surface and the water that is deep under the surface. When the hot water particles move and are replaced by cooler particles, waves are formed in the seas/oceans.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that in fluids like water, heat is transferred from one place to another through convection and in this process, water molecules form waves.

Thinking Cap

1. What causes whirlpools in water bodies?
2. How does a convection oven work?

Sweating Plants

Ask a Question

We sweat when it is hot or when we exercise. Do plants also perspire? Does this water also evaporate? Can we see how much water evaporates through plants?

Background Research

Plants draw water from the soil through their roots. They use this water to make their food through a process called photosynthesis. This process takes place in the presence of sunlight and air. Plants use carbon dioxide (present in air), water (present in soil), and sunlight to make their food with the help of a green-colored substance in the leaves called chlorophyll. During photosynthesis, plants release oxygen gas, which is essential for human beings to survive. Whatever water is left after photosynthesis is lost through the process of transpiration. This excess water is lost from the plants through small openings in the underside of the leaves that are called stomata.

Hypothesis

If we tie a transparent plastic bag for some time around the green leaves of a plant, drops of water will be seen on the bag.

Materials Required

1. Plant
2. Plastic bag
3. Flowerpot and soil
4. Water

Experimental Procedure

1. Locate a green plant in your home garden or school garden. You can use a potted plant, too.
2. Tie the transparent plastic bag around some of the leaves of the plant.

3. While tying the plastic bag, take care that the leaves don't get detached from the plant.
4. Note what you observe inside the bag.
5. Leave the plant with the bag.
6. Check after a few hours or on the following day. What do you observe inside the plastic bag?
7. Note your observations.

Result

Drops of water are found on the inner side of the plastic bag.

Analysis

Evaporation of water from the plant occurs through a process called transpiration. Plants lose water through small pores called stomata, which are found on the undersurface of the leaves. The process of transpiration is important for the movement of water and minerals from the roots of the plant to the leaves; it also helps in cooling the plant.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that plants lose water by the process of transpiration.

Thinking Cap

1. Why are leaves of desert plants reduced to spines? What about leaves of plants in regions with heavy rainfall?
2. How is evaporation of water possible even at low temperatures?

Magno-Magic

Ask a Question

How can we make a magnet?

Background Research

Materials that attract iron are known as magnets. Magnets are of two types: permanent magnets and electromagnets. We can make electromagnets using electricity.

Magnets have various uses. You might have seen magnets inside speakers and motors. Natural magnets have less attracting power, so we use electromagnets for most of our work nowadays.

In this experiment, we will make an electromagnet with help of the electrical energy of a battery.

Hypotheses

Primary Hypothesis: If we wrap copper wire around a nail and supply electricity to this wire, then the nail will work like a magnet.

Secondary Hypothesis: If the electricity supply stops, the nail will stop working like a magnet.

Materials Required

1. Copper wire
2. 6-volt battery
3. Large nail
4. Paper clips
5. Blank sheet of paper

Experimental Procedure

1. Take a large nail and wrap copper wire around it.
2. Does it attract paper clips? Note your observations.

3. Now connect both ends of this wire with the terminal end of the 6-volt battery.
4. Place small paper clips on a piece of paper.
5. Are the paper clips attracted by the nail? Note your observations.
6. Disconnect the supply of electricity (the battery). Note what happens.

Result

The large nail gets magnetized when electricity passes through the copper wire, so it attracts paper clips. When the momentary supply of electricity is stopped, the nail no longer acts as a magnet.

Analysis

As electricity is passed through the wire, the nail becomes an electromagnet and a magnetic field is formed around the nail. The magnetic field attracts paper clips. As soon as the supply of electricity is removed, the nail loses its magnetic power as the magnetic field disappears.

Conclusion

Our primary and secondary hypotheses are supported by the experimental results. From this experiment we conclude that we can magnetize a nail using electric current, but once the supply of electricity is cut off, the nail stops being a magnet.

Thinking Cap

1. Note the readings from the electric meter in your house and calculate how much electricity you consume in a week.
2. How does a television work?

Mother Earth

Ask a Question

Is soil necessary for a seed to germinate and grow into a plant?

Background Research

Have you ever wondered what a plant grows from? Yes, it grows from a seed. If this is true, then why don't the seeds kept in our kitchen grow into plants? Germination is the first step in the development of a plant that typically begins with a seed sprouting into a seedling. Further growth depends on continued nourishment in the form of various nutrients and other factors. This naturally makes us ask a few questions: Is soil required? Can the seeds germinate and then grow into a plant without soil?

Let us try to find out whether germination, and subsequent growth, is possible without the presence of soil.

Hypotheses

Primary Hypothesis: If we are able to grow a plant in three pots—one filled with soil, one with water, and one with cotton—we can state that soil is not required for germination.

Secondary Hypothesis: If we observe these sprouted plants for 10 more days, sprouted plants in all the pots will die except the ones sown in the pot filled with soil.

Materials Required

1. 3 glass flowerpots or drinking glasses
2. A few seeds soaked overnight
3. Soil
4. Sawdust
5. Cotton balls
6. Water

Experimental Procedure

1. Fill three pots with soil, water, and cotton balls, one material in each pot.
2. Place soaked seeds in the three pots about 1/3 inch or 1 centimeter below the top surface.
3. Seeds near the walls of the transparent pots will be visible from the outside.
4. Sprinkle water on the contents of each pot (except in the pot filled with water). Make sure that the water is just enough to provide moisture to the seeds.
5. Keep the pots in a safe place.
6. Keep watering the seeds daily.
7. Observe the pots daily for one week.

Result

The seeds germinate in all three pots. However, subsequent growth is seen only in the pot filled with soil.

Analysis

On germination: Germination requires nutrients in addition to water, sunlight, oxygen, and an optimum temperature. Seeds are self-contained for germination, which means that the nutrients are found in each seed. Each seed has one or two cotyledons, which have enough food stored for the seed to germinate. All three pots provide the other requirements: water, sunlight, oxygen, and optimum temperature, and the sprouts in all three pots germinate.

On further growth: Further growth of plants requires continuous nourishment in the form of mineral nutrients like nitrogen, phosphorus, potassium, sulfur, and magnesium, and micronutrients like copper, zinc, and iron. It is the presence of these nutrients, not the soil itself, that ensures the survival and further growth of the seedlings. Seedlings did not die in the pot filled with soil because of the presence of these nourishing nutrients in the soil. Typically, water and cotton do not contain these nourishing nutrients, so the seedlings in the pots filled with water and cotton died. Theoretically, if these nutrients were present in water or cotton, the seedlings grown in the pots filled with water or cotton will also show similar growth to that in the pot filled with soil.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that soil is not necessary for germination. Seeds may germinate in the absence of soil, but for further growth, plants need soil.

Thinking Cap

1. Will seeds germinate on the moon?
2. Initially there was no life on Earth. How did plants come to Earth?

The Vanishing Trick

Ask a Question

Why do some materials disappear when we mix them in water while some do not?

Background Research

When we make sweetened lemonade, the sugar dissolves in water and physically disappears. The same happens when we mix salt in water. Substances that dissolve in water are said to be soluble in water. Try mixing sand in water. The sand will not disappear as it does not dissolve in water. In this experiment, we will find out which substances are soluble in water.

Hypothesis

If we try to dissolve in water a group of substances like salt, sugar, and honey (Group 1) and another group of substances like sand, pieces of mirror, and chalk (Group 2), Group 1 substances will be soluble while Group 2 substances will not be soluble.

Materials Required

1. Spoon
2. Water
3. Drinking glass
4. Salt
5. Sugar
6. Pieces of mirror
7. Sand
8. Honey
9. Chalk

Experimental Procedure

1. Pour water into a glass.

2. Take salt in a spoon, put the salt in the glass and stir well with a spoon.
3. Note your observations. What did you find? Is salt soluble in water?
4. Similarly, check for the solubility of different materials in water.
5. Record your observations in the chart below.

S. No	Substance that dissolved in water	Soluble?
1.	**Salt**	**Yes**
2.		
3.		
4.		
5.		

Result

Group 1 substances are soluble in water, while Group 2 substances are not soluble in water.

Analysis

The materials that dissolve in water are said to be soluble substances, while those that do not dissolve in water are said to be insoluble.

Conclusion

Our hypothesis is supported by the experimental results. From this experiment we conclude that some substances are soluble in water while others are insoluble in water.

Thinking Cap

1. If we compare water from oceans, seas, rivers, and rainwater, in what order will they be ranked in terms of the amount of dissolved substances?
2. Alcohols are used as solvents in medicines and perfumes. What is the possible reason for using alcohol instead of water in these products?

My Country's Soil

Ask a Question

Where do trees and plants get water when there is no rain? Does this water come from the soil? Does soil contain water?

Background Research

Water enters the soil in various ways, for example, through rain and snow. The presence of water in the soil is very important, as this water is absorbed by plant roots, allowing the plants to grow. It is also important for the survival of the animals living in the soil. Let us prove the presence of water in the soil through an experiment.

Hypothesis

If we cover a soil-filled container with a transparent plastic bag, we will get water drops on the inner surface of the airtight bag, and after a few hours, this will indicate that the soil contains water.

Materials Required

1. Small container of any material
2. Soil
3. Plastic bag

Experimental Procedure

1. Put some garden soil into a container.
2. Cover this container with a plastic bag and tie the mouth of the bag tightly.
3. Keep the container in a warm place (under sunlight) for a few hours.
4. Observe after a few hours. Note your observations.

Result

After a few hours, some water droplets can be seen on the inside surface of the bag.

Analysis

Water present in the soil evaporates, and changes back to water by the process of condensation. We can observe droplets of water on the surface of the plastic bag.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that soil contains water, which is necessary for plants to grow and thrive.

Thinking Cap

1. Do soils of different regions contain the same amount of water?
2. What factors affect water retention in soil?

Making a Thermometer

Ask a Question

How do we measure temperature? Can we measure temperature simply by touch?

Background Research

You might have seen a doctor using a thermometer to measure your body temperature, but sometimes we only need to get a feeling of whether the body is warm without measuring the temperature. In this experiment, we will make an indicative thermometer, which will provide a measure of temperature.

Hypothesis

If we construct a homemade thermometer, we can detect indications of temperature.

Materials Required

1. 1 transparent narrow glass bottle (test tube is preferred)
2. Empty pen refill open at both ends
3. Cork or stopper to close the mouth of the bottle
4. Hammer
5. Nail
6. Scissors
7. Food color

Experimental Procedure

1. Take a transparent bottle or test tube and make gradations on it using a marker ot tape.
2. Fill water up to the 2/3 inch or 2 centimeter mark on the bottle.
3. Mix food color in the water to see the increase in water level inside the pen refill.

4. Now make a hole in the cork using a nail and a hammer (a teacher or an adult will help).
5. Fix the pen refill in the hole of the cork and set it appropriately.
6. Rub your hands together. When you feel that they are warm enough, touch the bottle with your hands.
7. What did you find? Did the water level increase? Note your observations.

Result

As we touch the bottle with our warm hands, the water level inside the pen refill increases.

Analysis

As we hold the bottle with our hands, heat from our hands is transferred to the bottle. This causes air inside the bottle to expand, exerting pressure on the water inside the bottle. This pressure pushes the water up the refill.

Real-life thermometers use mercury instead of water. Mercury is a metal that expands quickly with a slight change in temperature. It is also shiny (and easily visible), in addition to not sticking to the walls of glass.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we have learned:

1. Thermo (heat) + meter (measure) is a device used to measure temperature.
2. The liquid inside the thermometer rises when it is heated, giving us an indication of how hot it is.

Thinking Cap

1. How did humans measure temperature before the thermometer was invented?
2. If a thermometer breaks, the mercury forms small spherical balls and not cubes. Why?

Counting Coins

Ask a Question

What will happen if we add a few lightweight coins to a glass filled to the top with water?

Background Research

You will have noticed that if we place a heavy/dense object in a glass filled to the top with water, the water spills over. What will happen if you slip in a few lightweight coins, one at a time, into a glass filled with water? Will the water spill over as soon as you add a single lightweight coin or will it be possible to add a few coins before the water spills over? Let us find out through an experiment.

Hypothesis

If we add lightweight coins, one at a time, into a glass filled with water, we will be able to add several such coins before the water in the glass spills over.

Materials Required

1. Drinking glass
2. Water and lightweight coins (15–20) used for beam balance in physics lab.

Experimental Procedure

1. Take a glass and fill it up to the top with water.
2. Put a few lightweight coins in your hand.
3. Slip one coin in the glass. Does the water spill over? Carefully observe what happens at the top of the glass. Does a film form at the water surface?
4. Repeat the process of slipping coins in the glass, one by one, pausing after dropping each coin.
5. Continue until the water finally spills over. How many coins were you able to slip in before the water spilled over?

Result

___ coins were added to the glass of water before the water spilled over.

Analysis

The water does not immediately spill over because of the formation of a thin water film over the surface of the glass due to surface tension. As we continue to add a few lightweight coins, one by one, water finally spills over once the threshold is crossed.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude:

1. A thin water film forms at the water surface when a glass is filled to the top.
2. We can add a few lightweight coins into the glass before the water actually spills over.

Thinking Cap

1. Why do idols of gods in a Hindu temple sometimes seem to drink milk?
2. How did the water strider get its name?

Soft Skin

Ask a Question

How sensitive is our skin? Are we aware of everything that touches our skin?

Background Research

Our skin is a sensitive organ. It is the largest organ of the human body and covers all of our internal organs, protecting them from external temperature and the environment. Underneath our skin is the nervous system, which is spread throughout our entire body. The nervous system connects the brain to all of the other organs of our body. This network of nerves is dense in certain areas of the body and sparse elsewhere. Wherever there is a dense network of nerves, like at the fingertips, our skin experiences heightened sensitivity. Wherever the network is sparse, like at the back of the neck, the skin experiences less sensitivity. Let's find out more with the help of this experiment.

Hypothesis

If we cover our friend's eyes and touch her or him lightly in a skin area where the network of nerves is sparse, then our friend will be unable to sense the exact outlines of the touch.

Materials Required

1. A hairpin (U-shaped)
2. Handkerchief or blindfold

This experiment cannot be done alone. Please have the help of a friend or classmate.

Experimental Procedure

1. Blindfold your friend and make sure that she or he cannot see anything.
2. Now take the U-shaped hair pin and stretch it about 1/3 inch or 1 centimeter from its end

3. Apply pressure by lightly pressing your friend's fingers by using one end of the hairpin first and then both the ends on the same finger. Ask your friend what she or he feels.
4. Repeat the same procedure on the skin on the back of the neck and ask your friend if she or he felt one end or both ends of the pin pressing on her or his neck.
5. Record what your friend reports.

Result

When your friend's finger is pressed, she or he can clearly sense the pressure of one end of the hairpin and from the pressure of both ends of the hairpin together. However, when the same procedure is repeated on the back of the neck, your friend will not be able to sense so clearly the difference between one or two ends of the pressure points.

Analysis

Wherever there is a dense network of nerves, like at the fingertips, the message of the pin pressure using both ends of the hairpin is carried to the brain by two different nerves, and we can clearly sense the different pressure of one end of the pin from the pressure of both ends together. But wherever the network of nerves is sparse, like at the back of the neck, the skin experiences less sensitivity, and we cannot sense the difference between the two types of pressure.

Conclusion

Our hypothesis is supported by the experimental results. From this experiment we conclude that:

1. Our network of nerves is dense in certain areas of the body and sparse elsewhere.
2. Wherever there is a dense network of nerves, our skin experiences heightened sensitivity.
3. Wherever there is a sparse network of nerves, our skin experiences less sensitivity.

Thinking Cap

1. Do plants have senses?
2. A dog is often seen with its tongue hanging out. Why is that?

Battle Between Air and Water

Ask a Question

How can we put air into a balloon without blowing into it?

Background Research

Air is all around us. Empty spaces that we see are actually filled with air, even though we may not be able to see air with our eyes. We can certainly feel the air around us. In this experiment, we shall see the interplay between air and water. Let us try to fill a balloon without blowing air into it.

Hypothesis

If a bottle with a hole in its base and a balloon fixed around its neck is dipped in water, the balloon will inflate.

Materials Required

1. Balloon
2. Plastic bottle
3. Scissors
4. Tub or bucket
5. Water

Experimental Procedure

1. Take a large plastic bottle.
2. Make a hole at the base of the bottle with the help of a teacher or an adult.
3. Stretch the balloon to loosen it and then fasten it at neck of the bottle on the outside.
4. Push the bottle inside the water. Is this difficult to do? Does air start filling the balloon? Does the balloon inflate? Note your observations.

Result

The balloon begins to inflate as water fills the bottle. Gradually, more force has to be exerted to push the bottle in the water, as if there is an ongoing battle between the water trying to enter the bottle and the air inside the balloon.

Analysis

Air fills empty spaces. An empty bottle contains air. As the water starts filling the bottle, air inside the bottle gets compressed. Since it has no other way to exit, air starts filling the balloon and inflating it. During this experiment, there is a need to exert force to fill water in the bottle because the air inside the bottle resists the water.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that air is all around us. When force is applied, air finds its way into empty spaces (like it did in the balloon in this experiment).

Thinking Cap

1. If our atmosphere were made up of water instead of air, how would air pressure differ?
2. Is there air pressure on any other planet?

Secret of Breathing

Ask a Question

All living things breathe. What happens inside our body when we breathe? Which parts of the body are involved in the process of breathing?

Background Research

The physical movement associated with exchange of gases in our lungs is called breathing. Taking the air into our body while we breathe is called inhalation. Our lungs expand in this process and need more space. When we breathe out, our lungs contract and release air out of our body. This is called exhalation.

There is a large sheet of muscles under the lungs that helps in the process of breathing. It is called the diaphragm. During inhalation, the diaphragm moves downward into the abdomen, creating an empty space. This makes fresh air rush into the lungs. During exhalation, the diaphragm moves upward into the chest cavity. This contracts the lungs, which pushes air out of the lungs. Let us make a model to understand the breathing process.

Hypotheses

1. During inhalation, lungs expand, pushing the diaphragm downward.
2. During exhalation, lungs contract, pushing the diaphragm upward.

Materials Required

1. Plastic bottle (2 quarts or 2 liters) with cork inserted in top
2. Scissors
3. Knife (should not be very sharp)
4. 3 large balloons
5. 2 rubber bands
6. Good-quality adhesive tape

7. Flexible plastic tube (8 inches long)
8. Y-shaped pipe connector

Experimental Procedure

1. Take a bottle and push the eight-inch-long tube inside the jar by making a hole in the cork that seals the mouth of the jar. Make a Y-shaped structure.
2. Attach the tail of the Y-shaped connector to the end of the tube.
3. Fix two balloons on either side of the Y-shaped structure; these balloons will function as our lungs.
4. Cut out the bottom of the bottle. Cut the third balloon in two pieces and fix the bottom part of the balloon at the bottom of the jar using a rubber band. This will work as the diaphragm. (The two balloons attached to the Y-shaped connector represent the lungs, while the part of the third balloon fixed on the bottle represents the diaphragm. The diaphragm is actually just below our lungs and continuously moves upward and downward.)
5. As we push the diaphragm downward (in the bottle), both balloons attached to the bottle expand. This reflects what happens during inhalation.
6. Allow the diaphragm balloon to come back to its original position. The balloons contract and the air in the balloons rushes back to fill the bottle. This reflects what happens during exhalation.

Note

We can also make a simple structure of one balloon to understand this concept.

Result

When we blow air inside the balloons that represent the lungs, the other balloon (representing the diaphragm) will also expand and move downward. When air moves out of the balloons representing lungs, the balloon representing our diaphragm comes back to its original position.

Analysis

Our lungs and diaphragm work together during the process of breathing. When air enters our lungs, the lungs expand, thus lowering the diaphragm. When air is exhaled, the lungs contract and the diaphragm returns to its original position. The air that is exhaled is rich in carbon dioxide.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. During inhalation, our lungs expand to allow air to fill the lungs and the diaphragm moves down to make place for the expanded lungs.
2. During exhalation, the air moves out of the lungs, reducing the volume of the lungs, which allows the diaphragm to return to its original position.

Thinking Cap

1. Why do aquatic animals have gills instead of lungs?
2. How does cigarette smoking affect the functioning of our lungs?

Black Is Hot

Ask a Question

Why do we feel more comfortable wearing light-colored clothes in summer and dark colors in winter?

Background Research

If you wear dark-colored or black clothes during the summer, you feel uncomfortable. However, if you wear black clothes in the winter, you feel warm. Ever wondered why this is so? Black absorbs heat and light. This causes a body wrapped in black to become warm faster. White reflects or sends back heat and light, making the body wrapped in it feel comparatively cooler.

Hypothesis

If we place two identical water-filled plastic bottles (one painted black and one painted white) in sunlight, the water in the black bottle will be warmer than water in the white bottle.

Materials Required

1. 2 plastic bottles with caps
2. Black paint and white paint
3. Paint brushes
4. Water

Experimental Procedure

1. Pour water in both bottles and close the bottles.
2. Paint one bottle white on the outside.
3. Paint the other bottle black on the outside.
4. Leave the two bottles in the sun for a few hours.
5. Before sunset, feel the water inside each bottle with your fingers.
6. Which one is warmer?

Result

The water inside the black bottle will be warmer than the water in the white one.

Analysis

Black absorbs more heat compared to white. Therefore, the water in the black bottle becomes warmer than the water inside the white bottle. Applying this principle to real life, the pipes of water heaters are blackened so that water gets heated up faster. Similarly, solar cookers or outdoor grills are also blackened to absorb heat faster and thus help in speedier cooking. Which color would you use to paint the outer walls of your house? Why?

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that:

1. Black facilitates faster heating as it absorbs heat and light.
2. White facilitates slower heating as it reflects heat and light.

Thinking Cap

1. Some animals are able to vary their body temperature. How does that happen?
2. Can you think of a method to trap the heat of the sun and use it when it is needed?

Paper Recycling

Ask a Question

We use paper in the classroom almost every day. How is paper made?

Background Research

Paper is generally made from wood, though nowadays we can make paper from chemical fibers, too. With an increase in the world's population, deforestation has also increased. Deforestation means the cutting of trees on a large scale. One of the reasons for deforestation is an ever-increasing requirement for wood for making paper. However, if we can recycle paper, that will help reduce deforestation. Recycling of paper in industries involves many steps, but we can create handmade paper using old newspapers at home with simple equipment. Let us do this through an experiment.

Hypothesis

If we make a pulp of sheets of old notebooks using water, flatten and then dry it, we will get good-quality handmade paper.

Materials Required

For the pulp:

1. A few sheets of old notebook paper
2. Hot water
3. 1–2 spoonfuls of starch syrup
4. 1 bowl
5. Mortar and pestle
6. Color and silk strands (optional)

For frame and paper:

1. 1 rectangular A-4 size sieve
2. 1 rectangular tub or large container

3. Room-temperature water
4. Rolling pin
5. 2 small pieces of silk fabric

Experimental Procedure

1. Tear sheets of old notebooks into small pieces.
2. Soak them in a big bowl of hot water for 40 minutes.
3. Then using a mortar and pestle, grind the soaked paper pieces into a creamy pulp.
4. Add two spoonfuls of starch syrup to the pulp and mix well. This will help you to write on your handmade paper. You can even add color and a few strands of silk thread.
5. Pour the creamy pulp into an empty tub or large container, spread it evenly on the surface of the tub, and fill the tub with water. The water should be filled so that the pulp is completely submerged (do not fill with too much or too little water).
6. Now take the sieve and collect the pulp water of the tub in it. Level it with your hands and then remove the sieve very carefully. This will drain the water while the pulp that is spread will remain on the sieve. Hold the sieve over the tub and allow more water to drain out.
7. Place a clean silk cloth on a flat surface and carefully flip the sieve on the cloth so that the concentrated pulp falls on the cloth. Cover the paper with another silk cloth and slowly and carefully press it using a rolling pin to remove excess water. If you don't have silk cloth available, then just flip the sieve on any flat surface so that the paper falls on it and then press very gently with a sponge to remove excess water.
8. Let the paper dry for 24 hours and your recycled paper is ready to use.

Result

Recycled paper is made using sheets of old notebooks and easily available materials.

Analysis

As we spread the pulp on the floor and drain the water from it, the pulp slowly forms a solid structure. Starch provides it strength, besides allowing us to write on this paper with pens. The paper made from this method is highly absorbent, which means that if you write on it with a fountain pen, ink will spread on the paper. Adding corn starch syrup solves this problem. To make colorful paper, you can add a vegetable dye or food color to the pulp and then flatten it.

Conclusion

Our hypothesis is supported by the experimental result. From this experiment we conclude that we have learned to produce handmade paper from sheets of old notebooks. We can also use old letters or magazines instead of sheets of old notebooks.

Thinking Cap

1. How was paper invented?
2. Can you think of ideas to save paper in school? How much paper can you save by implementing these ideas? How many trees can you save?

FROM THE DIRECTOR

Lakshya and I would like to dedicate this book to Gary Shrager for his thirty years of passionate teaching and dedication to the growth of The Saturday Course. Gary and Lakshya worked closely on curriculum development before the course was piloted. I've been with The Saturday Course since 1994, and I'm still thrilled to welcome hundreds of students who come through the door with a mission! The program buzzes with eager, talented students. In *Science Magic*, students study inertia and static electricity, while in *Make Your Own City,* students "bid" thousands of dollars to develop their own parcel of land. Wood is cut and shaped in *Woodworking;* mysteries are solved in *A Series of Mysterious Classes;* cases are tried in *Trial Court;* and sheep brains and hearts are dissected in the popular *Blood and Guts* class. There are more than forty courses, including *The Learning of Science Begins with Why*? that whet students' appetite for discovery. Based on input from parents and students, we're always developing new courses to keep things fresh. I'd like to thank the stellar faculty and staff that make The Saturday Course an educational utopia.

Kristan Burke – Director • Saturday@milton.edu

NOTES

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The Saturday Course

In 1975, former Lower School principal Elizabeth "Betty" Greenleaf Buck had a vision: to harness the physical and intellectual resources of Milton Academy to benefit surrounding communities and families. The result of that vision, Milton Academy's Saturday Course, was born in 1978. Today 1,000 academically talented students participate in the program, representing about 100 schools in the Greater Boston area. The program offers students the opportunity to study traditional and non-traditional subjects. Courses range from computer programming to woodworking and are taught by professional teachers and industry leaders. The partnership between The Saturday Course and local public schools is a significant factor in the program's success and longevity. Ninety percent of Saturday Course admission decisions are made by teachers and administrators who know which students would enjoy and excel in an advanced educational environment. With more than 50 years of combined leadership, Kristan Burke and Gary Shrager are proud of The Saturday Course's impact on young scholars.

www.milton.edu/k8/lower-school/saturday-course

Co-Directors Gary Shrager and Kristan Burke

THE LEARNING OF SCIENCE BEGINS WITH WHY?

Born in India in 1999, **Lakshya Pawan Shyam Kaura** travelled to USA and studied at The Martin Luther King School in Cambridge, Massachusetts. At an early age, Lakshya showed a keen interest and proficiency in science. Currently residing in Old Faridabad, Haryana, India, Lakshya founded i-Cube Science Club in 2011 and since 2012 has been conducting experiments in nearly one hundred underserved schools in Faridabad and Ballabgarh blocks. He has developed official curricula for Haryana state government (2014) and Afghan schools (2015), conducted teacher training for Haryana, Karnataka, Tibet government-in-exile and Afghanistan teachers, and developed a novel method of learning science for students of low socioeconomic status. His interest in science and science education led him to devise a pedagogical explanation for the Doppler Effect which was published in The Physics Teacher, a journal of the American Association of Physics Teachers (2017).

When he is not learning or teaching, Lakshya is a committed inventor solving everyday problems. Australia Patent Office granted his first patent at age 16, placing him amongst the world's 50 youngest patent holders. Honored as National Innovator by two Presidents of India (2012, 2016), he was placed amongst top 10 innovators in Australia and Asia by Google Science Fair (2013) and third globally in both IDEAS and PROJECTS categories in a UNESCO partnered innovators' entrepreneurship contest (2016).

His other interests include exploring Sanskrit classics and sculpting artifacts. Indian Patent Office has registered Lakshya's thirteen artifact designs (2015).