WARNING:
CHOKING HAZARD—Small parts. Not for children under three (3) years.
This kit will take you on a fun, educational journey to help you understand the hows and whys of the often mysterious phenomena that occur daily in our world.

The kit includes a fully equipped laboratory of tools and instruments and this step-by-step guide to more than 100 experiments, activities, and scientific reports.

In addition, you will need some easily obtainable common household items to complete your experiments. Let’s explore.

**KEY:**

Look for these symbols.

- **SCIENTIFIC REPORT**
  Includes information about and explanations of the world around us.

- **EXPERIMENT**
  Indicates hands-on experiments or interesting observations.

- **THE ENVIRONMENT UNDER THREAT**
  Explains environmental danger.

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What is light?

Light is a sort of energy that can move in waves and is made up of a flow of particles of energy called photons. A ray of light is so fast it can go back and forth from San Francisco to San Diego about 300 times a second (speed of light = 186,000 miles/second (300,000 km/second)).

Why do hot bodies give off light?

Because they have a lot of energy they can spare.

WHEN LIGHT IS SPECTACULAR

Polar Auroras

Polar auroras, also called Northern Lights, happen when vast areas of the sky light up with colors.

These phenomena occur when there is a clash in the upper areas of the atmosphere between very fast particles that come from the sun and particles in the atmosphere.

“Sprites” and “elves” are other colored shapes in the sky.

Sprites are shaped like hot air balloons. Elves are ring shaped. Both are formed when there is a particularly powerful bolt of lightning. They create areas of the sky that are teeming with negative and positive electric charges that give out red and blue lights and last less than a second.
LIGHT AND MIRRORS

Reflection happens when a ray of light bounces off the surface of a mirror like a ball.

A flat mirror is a sheet of glass covered with a very thin layer of silver.

1 IMAGE IN A FLAT MIRROR

Stand in front of a mirror and touch your right ear.

In the mirror, the image is touching its left ear.

The mirror reflects a reversed image, giving a faithful reproduction of what it has in front of it.

2 IMAGE WITH TWO MIRRORS AT AN ANGLE

Set two flat mirrors up together at an angle so that they give a single image in the area where the mirrors are joined.

If you use your right hand, the image in the mirror will use its right hand.

This time the image isn’t reversed.

One mirror, by reflecting the image in the other, rectifies it.

3 MULTIPLYING COINS

Put a coin between two mirrors set up at an angle, like in the picture. Set the mirrors at different angles to see how you can get more, or fewer, coins. The angle formed by the mirrors determines the number of images you see reflected. The formula is:

\[
\text{Number of coins} = \frac{360°}{\text{angle in degrees}} - 1
\]

4 IF LIGHT PASSES THROUGH A SINGLE MEDIUM, IT TRAVELS IN A STRAIGHT LINE.

Check this with a flashlight and some pieces of cardboard with a hole in the middle, as in the picture.

5 SHADOW GAME

Shine a light onto a white wall and then add a shape (your hand or a cardboard shape) between the light and the wall.

The silhouette will appear on the wall because light rays travel in a straight line and can’t go round the object.
**IF LIGHT PASSES FROM ONE MEDIUM TO ANOTHER, IT DOESN’T TRAVEL IN A STRAIGHT LINE.**

Put a spoon or a straw into a glass of water (so that it’s at a bit of an angle).

When the object is lit, it looks as if it’s split in two because when light passes from air to water or from water to air it is diverted. This is caused by a change in the speed of propagation of the light ray.

This phenomenon is called **refraction**.

**HOW TO BEND LIGHT**

Ask an adult to help you.

1. Make two slits, about 2\(\frac{1}{2}\) (6 to 7 cm) long, \(\frac{3}{4}\) (2 cm) apart and about \(\frac{3}{4}\) (2 mm) wide, in the short side of a shoebox. Glue a white sheet of paper to the opposite short side of the box, as in the illustration.

2. Place a glass of water in the middle of the box. In a dark room, shine a flashlight carefully through the two slits.

Look very carefully during the experiment at the positions of the lines of light on the bottom and on the side of the box with the white paper.

Note: The two lines of light that come through the slits bend and cross over after going through the glass. You can check which line is which by covering one of the slits with your finger. The glass and the water are acting as a lens.

**LIGHT AND COLORS**

The white light of the sun is made up of the seven colors of the rainbow: red, orange, yellow, green, blue, indigo, and violet.

**BREAK UP WHITE LIGHT WITH A PRISM.**

**CAUTION:** Never look at the sun with the naked eye or through any instrument.

1. Hold the plastic prism in two fingers and move it around a little so that the rays of the sun catch one of the three equal sides at an angle and shine out through another side.

2. Try a few times and you will find that the colors of the rainbow appear on a shady spot on the floor or on the walls of the room you are in, about 20\(°\) (50 cm) away. Adjust the prism slightly to get a better rainbow. It won’t take you long to get really good at showing the spectrum of white light, as scientists call it.
THE SPECTRUM OF WHITE LIGHT EXPLAINED

Newton’s Experiment

The seven colors of the rainbow that make up white light all hit the face of the prism at the same angle and are then diverted (refracted) inside at different angles. The red has less energy and is diverted less, while the violet has more energy and undergoes the greatest diversion. All the other colors divert somewhere between the red and the violet.

FROM ALL THE COLORS OF THE RAINBOW TO WHITE

Make a cardboard circle about 4" (10 cm) in diameter and color it with the colors of the rainbow, as in the picture.

Put a stick or pin into the central hole and then spin the circle. It will appear to be white because white light is made up of all colors put together.

Even if we can’t see them, all the colors are present in white light. About 300 years ago, the English scientist, Isaac Newton, answered many questions about light and colors.

THE RAINBOW AFTER THE STORM

After a heavy shower, with the sun behind you, you should be able to see the colors of the rainbow forming in the sky. This is caused by the refraction of the sunlight in the droplets of water that are suspended in the air (just as if the droplets were prisms).

We really only see the arc of a rainbow because the horizon cuts through it. If you were at the right altitude, you’d be able to see a fully circular rainbow, like you can see from a plane. Sometimes, two rainbows form.
WHY WE SEE COLORS IN WHITE LIGHT

You can’t see colors in the dark. You need white light, which is made up of all colors, in order to see colored objects.

When light hits the surface of an object, some colors are absorbed and others are reflected. The color of the object depends on the color it reflects to your eyes.

WHY THE SKY IS BLUE.

Earth’s atmosphere is made up of a mixture of gases. When the light from the sun strikes the atmosphere, the color blue is reflected across the sky and reaches our eyes.

If there were no atmosphere, the sky would be black and stars would be visible just as they are to astronauts in space.

SUNSET IN THE LAB OR AT HOME

Add two drops of milk to a glass of water and stir well with a teaspoon. Now put up a sheet of white paper as a background, shine a flashlight through the glass, and you will see an orange color on the paper just like at sunset.

A solution of water and milk filters out colors other than orange.
What is air?
Air (atmosphere) is a transparent mixture of gases: nitrogen, oxygen, small quantities of carbon dioxide, hydrogen, and rare gases.

Why does air stay all around the planet Earth?
Because there is sufficient force of gravity to hold even tiny gaseous particles around it, air remains around Earth.

The force of gravity is the force that pulls you down after you jump up.

13  GALILEO GALILEI PERFORMED GRAVITY EXPERIMENTS.
If you drop a ball and a feather, the feather reaches the ground second because it is slowed down by the air. In a vacuum, they would arrive at the ground at the same time because the force of gravity attracts them equally.

14  PROOF THAT AIR EXISTS
The air in the pump blows up your bicycle tires.

15  AIR IS TRANSPARENT.
Ask your parents for a dollar bill. Roll it up and put it all the way down into the test tube. Turn the test tube upside down and, keeping it vertical, put it into a glass of water. Take the test tube out of the water. Remove the dollar bill. Is it wet or dry?
What happened? The air in the test tube prevented the water from entering it.

What is air made of?
78 parts are nitrogen.
21 parts are oxygen.
1 part is other gases.
16 PLAYING WITH AIR IN THE SYRINGES

1. Set the plunger of one syringe to 0 and the plunger of the other to 10. Connect the plungers together with the clear plastic tubing.
2. Press on the level 10 plunger. The plunger that is at level 0 will move out because the air being pushed through the tubing by the other plunger will push it up.

You can move either plunger up or down, and the other plunger will move in the opposite direction. The numbers on the syringe walls show you how much air is passing from one plunger to the other.

17 SHOW THERE IS OXYGEN IN THE AIR.

Iron reacts with oxygen in the air.

1. Wet the walls of the test tube with a little water. Sprinkle a few iron filings into the test tube so they stick to the inside.
2. Make a test tube holder by cutting a hole in a piece of card stock to hold the test tube. Turn the test tube upside down and push it into the hole in the card stock.
3. Immerse the test tube in a glass of water as shown in the diagram. Note the water level. Note the water level after you have left the test tube in this position for a few hours. After a few hours, the water in the test tube will have risen by 3/8" (1 cm) because some of the gaseous oxygen in the air reacts with the iron filings to form iron oxide or rust reducing the amount of gaseous oxygen in the test tube.

18 PLANTS AND ALGAE PRODUCE OXYGEN.

You can carry out lots of experiments with Elodea (waterweed), an inexpensive aquatic plant you will find in aquarium shops.

Fill a jam jar or similar container with mineral water (slightly sparkling water is fine). Add a stone or two and then your Elodea waterweed plant, using the tweezers to help you.

Use the magnifying glass to observe the oxygen bubbles produced by the leaves when exposed to sunlight. Change the water occasionally (do not use tap water) and add a little sparkling mineral water or a sprinkling of bicarbonate of soda to replenish the plant’s carbon dioxide supply.

19 SHOW THERE IS HYDROGEN IN THE AIR.

An iron nail in vinegar produces hydrogen bubbles.

Put a little vinegar into a test tube and add an iron nail that you have sanded off with sandpaper. After a few minutes you’ll see bubbles of hydrogen appear.

20 SHOW THERE IS CARBON DIOXIDE IN THE AIR.

Leave a glass of water exposed to the air.

After a few days, check it and you’ll see that a light film has formed on the surface.
**THE ATMOSPHERE IS A “COVER” WITH A HOLE.**

The atmosphere is the cover that keeps Earth warm just like a down comforter. Some time ago, scientists discovered a “tear” above the South Pole that they called a hole in the ozone layer. Ozone is an atmospheric gas that is formed by the action of solar rays on oxygen: it can be found all around the planet at a height of about 18 miles (30 km). Its job is to block out the invisible ultraviolet rays that come from the sun.

**ENVIRONMENT UNDER THREAT**

Ultraviolet rays are harmful to living organisms and can reach the surface of the earth through the hole in the ozone layer.

**What put the hole in the ozone layer?** The hole happened because gaseous substances known as CFCs (chloro-fluorocarbons) that are found in some aerosol sprays, inside refrigerators, and are used by some industries, escaped into the atmosphere. These substances destroy ozone.

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**AIR PARTICLES HAVE WEIGHT.**

Carefully spread a sheet of plastic wrap over a ruler as shown in the illustration.

Smooth the plastic wrap out with the palm of your hand so that you get rid of any air bubbles between it and the table.

Press on the bit of the ruler that is sticking out, and you’ll see that there is resistance to the weight of your hand. This is because the air particles are keeping the plastic wrap in place.

The air pressure on the sea is greater than the air pressure on the top of a mountain.

At sea level: 14.69 pounds per square inch (psi) = 1,013 millibar = 1 atmosphere.

At the top of Mount McKinley: 6.61 psi = 456 millibar = approx. 0.45 atmosphere.

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**THE BAROMETER IS THE INSTRUMENT THAT MEASURES ATMOSPHERIC PRESSURE.**
24 **MEASURING AIR PRESSURE**

1. Push both syringes down to the 0 position. Then connect them with the plastic tubing.
2. Pull the plungers individually or together almost completely from their syringes. As soon as you let go, the plungers will return to the 0 position.
What happened? Atmospheric pressure forced the plungers to return to the 0 position.

25 **AIR PRESSES IN ALL DIRECTIONS.**

BE CAREFUL NOT TO BREAK THE GLASS!

1. Put some water in a glass, wet the rim, and then apply a piece of paper to the rim and smooth it out.
2. Quickly turn the glass upside down, holding on to the glass tightly while it’s in mid air.

Air pressure keeps the cover on the glass.

26 **THE EFFECT OF AIR PRESSURE ON A PLASTIC BOTTLE**

Fill a plastic soda or water bottle with hot tap water then empty it. Quickly screw the top back on the bottle. Soon the bottle will collapse because the external air pressure is greater than the internal air pressure.

27 **MEASURE AIR PRESSURE WITH A PLUNGER AND A SMALL PAIL.**

1. With its plunger set to 0, put the end of a syringe into a container of water. Pull the plunger out to draw some water into the syringe. Turn the syringe to a vertical position with the hole facing up and push the plunger to expel almost all of the water from the syringe. While it is still upright, seal the hole in the syringe with a little bit of modeling clay or putty.
2. Tie a small pail to the plunger of the syringe.
3. Slowly pour sand or water into the pail a very little at a time. Watch the plunger. As soon as the plunger starts to move, stop adding water or sand to the pail. At this point the weight of the pail has become greater than the air pressure exerted on the bottom of the plunger.

The weight that has moved the plunger is equal to the air pressure. Weigh the pail on a scale. Its weight is one measure of the air pressure acting on the plunger.
28 HOW AIR PRESSURE ALLOWS US TO FLY

Put a sheet of paper just below your mouth and blow hard over the top of it as you see in the illustration.

When you do this, the air pressure above the paper becomes less than the air pressure under it, so the paper rises.

Wings on an airplane create this same pressure difference allowing the airplane to fly.

29 USE A HOUSEHOLD THERMOMETER TO MEASURE AIR TEMPERATURE.

A thermometer is an instrument that measures the quantity of heat in any given body. It’s made with a liquid that expands and contracts inside its small glass tube; alongside the tube is a scale, divided into degrees, that provides a value to the temperature.

**Experiment:** *Expose the thermometer to air in a shady place.* After a while, check the temperature. Keep a record over a long period of time of the daily temperature at 7 o’clock in the morning and the daily temperature at 2 o’clock in the afternoon. Calculate an average of these daytime temperatures *(max. temp. + min. temp.)/2*. Keep the information in a table like the one you find below.

30 AIR EXPANDS WHEN IT IS HEATED.

Put a balloon over the top of an empty soda bottle as you see in the illustration.

1. Heat the air in the bottle on a heater or in warm sunlight. The balloon will inflate because the air expands when it is heated, and the expanded air moves into the balloon.

2. Cool the bottle in cold water. The balloon will deflate because the air in the balloon and bottle shrinks and takes up less room.
THE SUN HEATS OUR PLANET.

The sun heats and lights the planet and is also the “moving force” behind many things that happen on Earth.

Different points on Earth’s surface receive different amounts of heat and light, depending on their latitude.

**Latitude**: the distance north or south of a point on the surface of the earth from the equator.

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**THE GREENHOUSE EFFECT**

The air that surrounds Earth doesn’t let heat out to disperse into space; it works like a down comforter. In fact, on the moon, where there is no atmosphere, the temperature ranges from more than 212°F (100°C) above zero when it is lit by the sun to about 302°F (150°C) below zero when it’s dark.

The atmosphere is heated from below because the rays of the sun are reflected upwards after they hit Earth’s surface and the heat stays there, captured, as if it were in a greenhouse.

This is why it’s hotter on low-lying land than it is in the mountains. **When you go up, the air temperature goes down by half a degree every 328’ (100 m.).**

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**ENVIRONMENT UNDER THREAT**

It would be a good thing if carbon dioxide (CO₂) levels didn’t rise any more, because this is one of the causes of the greenhouse effect. It is produced by living beings, by volcanoes, by industry, and by cars, and if it increased much more, the heat would be impossible to live with.

Think what it’s like when you get into a car that’s been parked in the sun all day.

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**THE GREENHOUSE EFFECT MAKES THINGS HOTTER.**

Put a thermometer into full sun for a few minutes and then note the temperature.

Cover the thermometer with a clear plastic bag, leave it for a while, and then check the temperature again.

How many degrees difference is there?
The differences in the heating of Earth’s surface causes areas where particles rise and press less on the ground creating low pressure along with areas where air particles fall and press more on the ground creating high pressure.

The air circulation between these areas is called wind.

**OBSERVE AND ASSESS WIND SPEED.**

The instrument that allows you to measure wind speed is called a wind gauge or anemometer.

1 knot = 1.15 miles = 1.852 km = 1852 meters

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Earth acts just like a huge magnet. To find north and the other points of the compass, put the compass on a flat surface and the magnetic needle will point to magnetic north which is very close to geographical north.

Stand with your back against the wind, then observe the clouds. If they are moving from right to left, good weather is on its way.

In daylight, the sun, at noon, shows you where south is in the Northern Hemisphere only.

At night, the Pole Star shows you north in the Northern Hemisphere only.

This map shows the sky in summer, when Ursa Major (Big Dipper) is towards the west. In winter, it is found in the east.

Where’s the wind coming from?
The direction of the wind is referred to by the compass point from which the air current comes. As a rule, the direction of the wind is shown in degrees from north going clockwise (as in the diagram).
BREEZES

Breezes are light winds that are caused when two nearby areas are heated differently. They change direction in the course of a day.

- **Sea breeze**
  In the day, the land heats up and attracts air from the sea.

- **Land breeze**
  At night, the sea is warmer and attracts air from the land.

- **Valley breeze**
  In the day, the peak heats up and attracts air from the valley.

- **Mountain breeze**
  In the night, the valley holds heat better and attracts air from the peak.

AIR CIRCULATION AT HOME

Because it is heavier, cold air from outside sinks. Then when it is heated, it rises.
What is water made of?

Water is a compound of atoms of hydrogen (chemical symbol H) and oxygen (chemical symbol O).

The chemical symbol of water is H₂O.

Where does the water on the surface of the earth come from?

- From inside the planet, brought to the surface as vapor during volcanic eruptions.
- From outside the planet with the fall of large comets (they’re made of ice).

**CONDENSATION: COOLING OF WATER VAPOR**

**Experiment 1**

Keep a perfectly dry water glass in the refrigerator for a while and then take it out and put it at room temperature. It will mist up quickly because the humidity in the air, that you can’t see, transforms into droplets of water when it comes into contact with the cold glass.

**Experiment 2**

Pour a little lukewarm water onto a plastic plate and put a cold, dry glass upside down in the center of it.

The inside of the glass will mist up very soon, as the outside did in the previous experiment.

In winter, car windows and windshields mist up for the same reason.
When masses of air move upwards their temperature drops. Condensation of humidity occurs, and lots of little droplets are formed. They are so small that they stay in the air forming clouds. Droplets are formed around dust particles and crystals that promote condensation.

**FAIR WEATHER AND BAD WEATHER**

There are clues in the sky as to whether fair or bad weather is on its way. Look at the height, the color, and the direction of the clouds.

- Cirrus (ice crystals)
- Cirrocumulus (ice crystals) mackerel sky
- Cirrostratus (ice crystals)
- Altocumulus (water vapor)
- Altostratus (water vapor and ice crystals)
- Stratocumulus (water vapor)
- Nimbostratus (water vapor and ice crystals)
- Stratus (water vapor)
- Cumulonimbus (water vapor and ice crystals)
- Cumulus (water vapor)

**RAIN**

CAUTION: Wash out the container very well with distilled water as it will be used for later experiments (especially no. 43).

You can measure rainfall with a rain gauge made from a household container and a funnel set outside as in the picture. Use a graduated beaker to measure the amount of rainfall during the day and empty the container every time you measure the water. Enter the data on the record sheet.

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**CREATE GASEOUS HYDROGEN AND OXYGEN FROM WATER.**

**ELECTROLYSIS**

1. Tape three (3) AA batteries securely together in a series as shown in the illustration. This will provide 4.5 volts of electrical energy.
2. Prepare a piece of cardboard so that it can hold the graphite electrodes (two pieces of pencil with both ends sharpened).
3. Connect everything as you see in the diagram.
4. Add half a glass of pure water.

The H+ (one hydrogen atom) ions will gather at the negative pole (-) to get electrons and will form lots of small hydrogen bubbles (H₂). The OH- (one oxygen atom with one hydrogen atom) ions will gather at the positive pole (+) to lose electrons and form small bubbles of oxygen (O₂).

**THE VOLUME OF HYDROGEN IS DOUBLE THE VOLUME OF OXYGEN.**

This process is called electrolysis and transforms electrical energy into chemical energy and separates water molecules out.

*Hydrogen will be a fuel of the future.*
DISTILLED WATER DOESN'T CONDUCT ELECTRICITY BECAUSE IT IS SALT FREE.

1. Thoroughly rinse a plastic cup with distilled water.

2. Bend two pieces of wire so that they will stay in place on the edge of a glass. The end of the wires that hang down in the glass will become electrodes when water is poured into the glass.

3. Fasten the LED to the test tube with a small rubber band as shown in the illustration. One of the LED’s wires is slightly shorter than the other. It is the negative (−) electrode. The longer LED wire is the positive (+) electrode. Gently bend the two electrodes up and away from the test tube and place it in a holder on your work surface. An upside down foam cup with a hole in the bottom works well as a stand.

4. Connect all the parts of the circuit as shown in the illustration. Connect the negative end of the batteries to the short (negative) wire of the LED. Connect the positive end of the batteries to one of the wires hanging in the cup. Connect the other wire on the cup to the long (positive) wire of the LED.

5. Fill the cup halfway with distilled water. In this experiment the glass of water is going to act as a switch.

The LED doesn’t light up because the distilled water contains no ions. Ions are positively and negatively charged atoms. Since all the atoms in the water are neutral, electricity cannot flow through it.

Use the equipment you have assembled for the next experiment.

DISTILLED WATER WITH SALT CONDUCTS ELECTRICITY.

Add a little cooking salt to the glass from the previous experiment. The LED will light up. Salt provides ions (positive (+) and negative (−) particles).

CAUTION: Never use electrical appliances near water.

SNOWFLAKES

If you observe snowflakes under a microscope, they often look like six-pointed stars. The flakes are formed in very cold areas of the atmosphere where small ice crystals attach to each other, making beautiful geometric shapes.

HAILSTONES ARE LITTLE BALLS MADE OF LAYERS OF ICE.

A hailstone forms from a droplet of water that freezes. It grows by moving up and down through very high clouds (cumulonimbi) shaped like mountains or towers. The more the hailstone moves up and down, the bigger it gets until its weight makes it fall to the ground. Hailstones are almost always small balls of ice, but there are reports of hailstones as big as tennis balls and occasionally, even bigger.

ACID RAIN

Why is rain acid? Smoke from industry and exhaust fumes from vehicles put chemical substances containing sulphur and nitrogen into the atmosphere. They react with water to form the acids that damage plant life and buildings.

Measure the pH of rainwater in different months of the year and note the results.
To express the acidity or basicity (alkalinity) of a solution, for practical reasons, we use a measurement called pH, that shows how acidic or basic (alkaline) a solution is and where it falls on a scale from 0 to 14.

**INDICATORS OF ACIDITY AND BASICITY**

In chemistry, indicators are substances capable of changing color when they come into contact with different compounds (acids and bases). **They are made noticeable by their bright colors.**

### MAKE INDICATOR PAPER FROM RED CABBAGE.

Cut a red cabbage leaf into small pieces and put it in a glass with hot water for 20 minutes. Cut blotting paper or filter paper into 3/8” (1 cm) squares.

Put two drops of the liquid onto each square of indicator paper and leave it to dry. To measure the pH of a solution quickly, as a rough guide, use the paper you soaked as an indicator. From the color the paper takes on, you'll get the following: red if the solution is ACID, blue if it's BASE, and if the color stays the same, the solution is NEUTRAL.

### TRY THE INDICATOR PAPER

Add two drops of lemon juice.

Add two drops of water with baking soda (sodium bicarbonate).

Lemon contains an acid.

Baking soda (sodium bicarbonate) is a base.

If you want, you can buy litmus indicator paper cheaply from the drug store. The pH of rain is usually between 6.5 and 7.

**EXPERIMENT with the acidity of rain.** Take some of the rainwater you collected earlier in a pipette and put a few drops onto the indicator paper you made in the previous experiment. Now compare the color on the pH scale.
THE MENISCUS ON WATER DEMONSTRATES SURFACE TENSION.

Use a glass of water you have already filled to the brim. Put some coins or a small paperclip carefully into the water so that the level of the liquid is over the brim but does not spill.

Look through the magnifying glass and observe the highly curved surface of the water.

The liquid has a curved upper surface or meniscus that forms through surface tension of the water particles.

MEASURING ACIDITY OR PH

Look at experiments 47 and 48.

Some lakes in Northern Europe are deprived of life because their acidity is much too high.

WATER WITH LOTS OF SALT IS A GOOD CONDUCTOR.

Instructions: refer to experiment 43.

TRY ALSO WITH GRAPHITE ELECTRODES (PENCILS).

SALTWATER IS HARMFUL TO PLANTS.

Try watering a tiny patch of grass with saltwater for a few days.

After a while, the grass in that area will begin to die.

In the winter, a huge quantity of salt is spread on the roads to stop ice from forming. Should we look at this policy again and change it?

OILS ARE DANGEROUS POLLUTANTS.

Pour equal quantities of cooking oil and water (chemical formula H₂O) into a test tube, put a cork in it, and shake moderately. After a while, you will notice that the two immiscible (unmixable) liquids separate out almost completely, with the oil, which is lighter, on top.

ENVIRONMENT UNDER THREAT
MAKE FRESH WATER FROM SALT WATER WITH A SOLAR STILL.

1. Pour about an inch of salty water in a glass bowl.
2. Place a water glass in the center of the bowl. The rim of the glass must be below the rim of the bowl as in the illustration.
3. Loosely drape a sheet of plastic wrap over the bowl so that it sags in the middle over the glass. Seal the edges of the wrap to the rim of the bowl.
4. Place the bowl in the hot sun. Leave the bowl in the sun for at least an hour.

The heat of the sun forms water vapor from the salty water. The water vapor condenses on the plastic wrap as it cools and because of the sag in the plastic wrap, the water droplets drip into the glass as fresh water (salt free).

WATER WITH SALTS LIGHTS UP THE LED.

1. Repeat steps 1-3 in experiment 43.
2. Pour a glass of tap water.

The LED lights up because the water contains ions (positive and negative particles) generated by the salts dissolved in it, so it conducts electricity from the battery to the LED. The brightness depends on the type of water in your area.

WATER IN YOUR HOUSE

The water in houses is potable, meaning that you can drink it without any danger to your health. It comes from freshwater springs and water-bearing strata. Try measuring water consumption in your house.

<table>
<thead>
<tr>
<th>AMOUNT</th>
<th>YOUR HOUSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>In the kitchen:</td>
<td></td>
</tr>
<tr>
<td>boiling food</td>
<td></td>
</tr>
<tr>
<td>washing fruits and vegetables</td>
<td></td>
</tr>
<tr>
<td>washing up</td>
<td></td>
</tr>
<tr>
<td>washing clothes in the machine</td>
<td></td>
</tr>
<tr>
<td>In the bathroom:</td>
<td></td>
</tr>
<tr>
<td>for brushing your teeth</td>
<td></td>
</tr>
<tr>
<td>waiting for water to heat up</td>
<td></td>
</tr>
<tr>
<td>flushing the toilet</td>
<td></td>
</tr>
<tr>
<td>taking a shower</td>
<td></td>
</tr>
<tr>
<td>taking a bath</td>
<td></td>
</tr>
<tr>
<td>In the garden or on the balcony:</td>
<td></td>
</tr>
<tr>
<td>watering plants and flowers</td>
<td></td>
</tr>
<tr>
<td>a tap dripping at one drip a second, 2 1/2 gallons</td>
<td></td>
</tr>
<tr>
<td>In the garage:</td>
<td></td>
</tr>
<tr>
<td>washing the car</td>
<td></td>
</tr>
<tr>
<td>Total gallons a day:</td>
<td>___</td>
</tr>
</tbody>
</table>

Change the total of water consumed daily in your house from quarts to gallons. Multiply daily consumption by 30 to get your monthly consumption and check these details on your water bill and water meter.
EXPERIMENTING WITH CONNECTED VESSELS

1. Connect the two syringes without their plungers with the plastic tubing, as in the illustration. Add water so it reaches the halfway mark on the syringes.

2. Watch the water levels as you raise or lower the syringes.

THE PRINCIPLE OF CONNECTED VESSELS

Liquid contained in several connected vessels or pipes, distributes itself in such a way that it reaches the same level in each of them.

THAT’S HOW DRINKING WATER GETS UP TO THE UPPER FLOORS OF BUILDINGS

In the same way, water from large tanks tends to reach houses through pipes at the same height as the tank. Today, however, we also use pumps to push water up to the top floors.

HOW A SIPHON WORKS

1. Fill the plastic tubing with water and seal off the two ends with your fingers. (There must be no air in the tubing.)

   You can use a plunger to draw water into the tubing.

2. Fill a glass full of water. Place an empty glass on a surface below that of the glass filled with water.

3. Put one end of the tubing in the water in the higher glass. Put the other end of the tubing in the lower glass. Remove your fingers from the ends of the tubing.

   The water in the higher glass begins draining through the tubing into the lower glass because atmospheric pressure pushes down on the water in the higher glass.
ROCKS AND SOIL

60 EXAMINE ROCKS.
1. Wash the sample in water. Check under the light if the rock is made up of mineral particles of different colors. If they glisten, they are crystals. (Check with the magnifying glass.)
2. Try scraping the surface of the rock with a nail to test its hardness.
   
   Hardness: scratch resistance of a mineral. A mineral will scratch any other mineral with a lower level of hardness.

61 PREPARE REPORTS

Sample 1 = pumice (very few crystals, easily marked by the nail, lots of small holes present). Pumice is made up of volcanic glass and is formed by the rapid cooling of lava from volcanoes. The small holes were formed when gas escaped at the moment of solidification.

Sample 2 = granite (many crystals, resistant to scratching by the nail). Granite is a rock formed from volcanic magma and forms deep in the earth from the slow cooling of the magma.

Sample 3 = marble.

Sample 4 = limestone (no crystals, only scratchable with the nail). Lab analysis continues with later experiments.

• The surface of the earth is made up of rocks.
• Rocks are formed from granules of minerals.

MOHS HARDNESS SCALE

1. Talc (very soft)
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar
7. Quartz
8. Topaz
9. Corundum
10. Diamond (very hard)

F. Mohs (1773-1839)
German mineralogist
GET BUBBLES OF GAS FROM THE ROCKS USING VINEGAR.

For this type of experiment, geologists use hydrochloric acid (HCl). You’re going to use vinegar.

Pour a small amount of vinegar into a test tube. Then use the pipette to put a few drops of vinegar onto the rock sample. If bubbles of carbon dioxide (CO₂) are formed (use the magnifying glass so you can see better), the rock is calcareous or carbonized.

PREPARING A REPORT

Sample 3 = white marble (develops gas bubbles)
Marble is a metamorphic rock, a rock that has undergone a transformation from its original state.
Sample 4 = Limestone may be pink due to the presence of iron (develops gas bubbles).
Limestone is a sedimentary rock formed by clustering of particles that accumulate on seabeds or as a result of wind action on Earth’s surface.

FLOATING ROCKS

Pour some water into a plastic food container and then put the rock samples into the water. Some sink because of their weight, but one sample floats.
This is pumice. It’s porous and light because of its many cavities left by gas when the rock was forming.

WATER AND SALT CRYSTALS

Grow your own crystals from cooking salt.
1. Make a solution with three teaspoons of cooking salt and a little water.
2. If you want colored crystals, add a few drops of food coloring.
3. Dip a piece of string tied to a stick into it, as in the illustration, and leave the water for a few days so that it evaporates.

Caution: Don’t let the crystals that have formed get wet.

DETERMINE THE HISTORY OF STONES FROM THEIR SHAPE.

Pebble from the sea
It starts off as a sharp-angled stone from a marine reef. Its flat shape is the result of wave action dragging it along the coast.

Pebble from the river
It starts off as a sharp-angled stone from the mountains and is brought down to the valley by torrents of water in rivers. It’s rounded because it was rolled along the way.
Try the vinegar test to find out what minerals different stones are made of.
**Determine the age of sand from the shape of its grains.**

**Sand:** Determine its age from its shape. If sand is very fine, it’s important to look at the shape of the grains. Use the magnifying glass.

**Observe:** You can tell the difference between sharp-cornered grains of sand from young beaches and short rivers and rounded grains from ancient beaches transported by very long rivers.

**Soil**

Soil comes from the transformation of rocks by the action of water, heat, cold, wind, and living organisms.

**Important components of the soil:**

- 60% sand
- 20% clay
- 10% limestone
- 10% humus

**Soil acidity**

Put a little sample of soil into the glass. Add distilled water or rainwater and mix. Use the pH indicator paper you prepared in experiment 48 or litmus paper from the drug store to measure the acidity of the soil by matching the color to determine the pH.

**Environment under threat**

Soil comes from the transformation of rocks by the action of water, heat, cold, wind, and living organisms.
LAB STUDY ON SOIL POROSITY

The quantity of water in soil depends on how porous it is.

Do this experiment with sand.

For this experiment, it is very useful to have at least one plastic bottle, like a water bottle, that an adult can help you cut in two, as in the diagram. Some rocks can hold water in the spaces between the particles that make them up, and they act just like sponges.

Measure 1/2 cup (100 cc) of sand in the graduated beaker and pour it into the plastic cylinder you have just made for yourself. Measure 1/2 cup (100 cc) of water carefully and pour it slowly onto the sand stopping as soon as water appears at the surface. Check how much water you have poured in. The volume of water you have poured corresponds to the volume of the spaces between the grains of sand.

Sand is very porous. In fact, the underground water bearing strata that are used by water companies to supply us with huge quantities of drinking water are made up of sand and gravel and act just like water tanks.

Record the data and try again with other types of soil.

FIELD ACTIVITY

Choose an area of ground that doesn’t present any dangers and dig a hole to a depth of about twice the size of the palm of your hand.

At this depth you will be able to locate different strata — or layers — below the surface.

Take a small sample from every stratum until you have collected about 1/2 cup (100 cubic centimeters) in your graduated beaker and save it for the next experiment.

LAB STUDY ON SOIL COMPOSITION

This is a study that will allow you to determine the quantity of gravel, sand, clay, and humus.

Add 1/2 cup (100 cc) of water to the soil you collected in the previous experiment. Carefully mix it a little, leave it for a few hours to settle and the strata will separate as in the illustration. Check what you have and in what quantity.

OBSERVE the soil layers with the magnifying glass.
What is electricity?

It is a form of energy produced by the movement of electrons that pass from some atoms to other atoms. There are two types of electricity: static electricity (an electric charge that doesn’t move), and current electricity (a flow of moving electrons).

The word electricity comes from the Greek “electron,” the name the Greeks gave to amber, a fossil resin.

What is magnetism?

It is the propensity of a mineral, magnetite, to attract ferrous material. Magnetic properties derive from the behavior of atoms and electrons.

WHAT IS STATIC ELECTRICITY?

If you rub plastic, glass, or amber, you electrify them, and they will attract very light objects. This happens because of the way the electrons* in the atoms that make up the material behave.

*very small particles of atoms with a negative electrical charge

How and Why an Object Is Electrified

The energy that develops when you rub the ball against the woolen clothing is taken from the electrons in the wool which separate from it.
THE EFFECTS OF STATIC ELECTRICITY

You can make paper “dance” using a balloon.

Electrify a balloon by rubbing it with a wool cloth. Pieces of paper will stick to it and fall back down, again and again.

The many negative electric charges from the balloon first attract the pieces of paper.

A moment after, the balloon repels them because the pieces of paper have now acquired negative charges as well. Then they jump back up from the table to the balloon and the process starts all over again.

MOVE A STAR WITH STATIC ELECTRICITY.

1. Fold a square of paper over twice and cut it as shown in the illustration.

2. Push a toothpick into an eraser or a cork and balance the unfolded star on it.

3. Rub a plastic comb with wool, hold it above the star, and move it round in a circular motion: the star will rotate. The star will even rotate if you cover it with a glass vase.

This happens because the comb has negative electric charges and the star has positive ones.

LIGHTNING IS AN ELECTRICAL DISCHARGE IN THE SKY.

During a storm, clouds attract negative electric charges because of friction with the air. When a great many have accumulated, bolts of lightning can jump from cloud to cloud or between clouds and the ground (spires, towers, trees etc.).

CAUTION: Never stay out in the open when there’s a lightning storm.

When you get out of the car, you often feel a little shock between you and the car: it’s a little bolt of lightning.

USE THE HAND DYNAMO FLASHLIGHT FOR VERY CLEAN ENERGY.

Use your hand to squeeze the flashlight lever firmly in and out. You will create light, as if by magic. You don’t need batteries and it’s always ready when you are left in the dark.

While you’re squeezing it, look at the mechanism inside the flashlight and you’ll see a wheel turning round inside a circuit of wires. This is the movement that produces instant electrical energy.

Electric current is a flow of electrons that move from one end to another in wires.
MAGNETISM

Ancient peoples already knew all about magnetism, i.e. the power of a mineral, magnetite, to attract iron. We get the word magnet from the material magnetite.

**CAUTION:** Don’t get a magnet too near a clock or a TV set—you might damage them.

*How an artificial magnet is made:*

Ferrous material is worked when it’s hot in an area where there is a strong magnetic field causing all the magnetic particles to face in the same direction.

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**76 TEST THE MAGNETIC RING WITH LOTS OF OBJECTS.**

Put the magnetic ring near lots of objects like spoons, keys, small change, erasers, plastic, pieces of wood, or aluminium.

Only objects made of iron, or steel with nickel and chrome, will be attracted to it, because they are magnetic.

**77 A MAGNETIC FIELD IS AN INVISIBLE FORCE.**

Put a sheet of paper or a light piece of card between a magnet and some ferrous objects.

If the magnet is near the paper, the objects will be attracted to it.

**78 MAKE THE MAGNETIC FIELD VISIBLE WITH IRON FILINGS.**

Put a few iron filings on a piece of paper and put a magnet underneath the paper.

The iron filings reproduce the shape and the direction of the lines of force of the magnetic field.

**79 CREATE A MAGNETIC FIELD WITH AN ELECTRIC CURRENT.**

Wrap a compass with an electrical wire connected to the poles of a battery.

The compass needle moves when the electric current passes through.

H.C. Oersted discovered this phenomenon in 1820.
THE MAGNETIC RING CHANGES DIRECTION ON ITS OWN.

Hang a ring magnet from an 18” (50 cm) piece of fine sewing thread.

It will oscillate a few times, and then the magnet will turn so that the yellow part is towards Earth’s magnetic North Pole.

There is an N stamped in the yellow part to indicate the magnet’s north pole. On the purple half there is an S to show the magnet’s south pole. These are the magnet’s poles.

Use your compass to check where to find north in the place you’re in.

CAUTION: Don’t get the compass too close to the magnet.

Put the compass onto a flat surface and check where the needle points: the arrow always points to Earth’s magnetic north.

The point of the magnetic needle is pointing in the same direction as the yellow half of the magnetic ring with the N stamped on its face.

EARTH’S MAGNETIC FIELD

The previous experiment shows how Earth behaves like a huge magnet, as the Englishman G. Gilbert (1540-1603) discovered. The compass needle lines up with the lines of force of the magnetic field.

The causes of Earth’s magnetism are still unknown; some scientists think that there are large magnetized masses inside the planet, but it is a more commonly held view that there are electric currents inside the planet that create a magnetic field.

INVESTIGATING WITH TWO MAGNETIC RINGS

The two rings are attracted to each other.

There are two magnetic poles in a magnet: the north pole and the south pole.

The two rings repel each other.
What makes a sound?
A flexible body moving rapidly creates vibrations in the air and thus makes a sound.

Why do we perceive sound?
The ear hears sound because the membrane in the eardrum vibrates along with vibrations in the air.

Very Useful Experiment: A Shoebox and Elastic Band
Try plucking household elastic bands of different sizes and thicknesses that you’ve put over an empty shoebox.

Listen to the sound it creates in comparison with how the elastic band and the air around it vibrate. (The elastic band’s oscillations are easy to see.)

When you put the bottom of the box up to your ear, the sound is much louder. Cardboard (a solid) transmits sound much better than air (a gas).
**ECHOES: REPEATING YOUR WORDS**

You’ll be able to hear your own words, if you stand facing a wall that is at least 55’ (17 meters) away from you; walls reflect sound waves.

For an ear to hear two syllables that are distinct from each other, they have to reach the ear at an interval of more than a tenth of a second. If the wall is 110’ (34 m) away, you will hear two syllables; if the wall is 165’ (51 m) away, you will hear three syllables.

**THUNDER IS THE SOUND MADE BY A BOLT OF LIGHTNING.**

When a bolt of lightning is discharged, there is a sudden warming of the air greater than 36,000°F (20,000°C). This violent movement of air particles is heard as thunder.

Light travels at approximately 186,000 miles per second. Sound travels at approximately 1100 ft. per second.

The time it takes the light from the lightning bolt to reach you is negligible because the speed of light is so high. When you first see the lightning flash, immediately start counting at a per second rate. When the thunder is heard, multiply the number of seconds you counted by 1100. This will give you the approximate distance in feet from you to the lightning bolt.

**CAUTION:** Never stay out in the open in a lightning storm.

**CREATE DIFFERENT SOUNDS FROM LONG AND SHORT STRAWS.**

Cut a drinking straw so that you’ve got three different length tubes.

Close off the bottom with your finger and blow across the top of the straw.

Your puffing into it sets the air in the straw vibrating. You get three different sounds from three different length tubes.

High sounds (children’s voices) have lots of air vibration from the short straw.

Bass sounds (adult male voice) have little air vibration from the long straw.

Wind instruments work in this way.
**Algae, Plants, and Flowers**

**Why are algae and plants so important to the planet?**
Algae and plants produce oxygen and sugars via the chemical process of chlorophyll photosynthesis.
Plants originated from algae around 500 million years ago.

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**86 ALGAE LOOK FOR LIGHT.**

Ask a gardener for some of the greenish film of algae that grows on the damp walls of greenhouses or on pond water.

Tip a little of this greenish water into a jam jar and cover it up with tin foil. Make a small hole in the tin foil.

Put the jar into the light and after a few hours you’ll see that the algae are all in the lighted area.

---

**87 SEAWEED: GREEN, BROWN, AND RED**

Algae need light to live, and light is made up of colored radiation just like the colors of the rainbow.

Green seaweed, which only uses red radiation from light, lives in the areas near the surface because that type of radiation doesn’t go down very deep.

Red seaweed can live in deep areas because it uses the green-blue radiation which can get down deep below the surface.
FROM SEED TO BEAN PLANT

Soak two beans in water overnight.
The next day, put the beans into test tubes full of soil.
Put them in a light, warm place and water them every day.
You’ll be able to see how a plant grows by looking through the clear plastic of the test tube.

THE LIGHT MAZE

1. Make a maze in a shoebox with bits of cardboard as shown in the illustration. Make a 2” (5 cm) hole in the lid.
2. Put a bean or potato seedling in the opposite side from the hole and cover it with the lid.
3. Water every day.
4. After a week, the seedling will have gotten through the maze and will be poking out of the hole, in search of light.

WATER RISES IN A PLANT.

Get some white flowers or some celery with 6” to 8” (15 – 20 cm) stalks. Place the flowers or vegetables in a solution of water and add a few drops of food coloring or ink.

Observe how the color of the plant changes as the colored water passes through the cells.

HOW POTATOES AND STRAWBERRIES CAN REPRODUCE

On the surface of a potato you’ll see several buds called “eyes” from which roots can form. One single bud is able to make a whole potato plant. This type of reproduction is called vegetative because there is only one parent and the children, i.e. the potatoes, are all identical to the parent.

Plant a potato in a hole in the ground with an eye facing up. Cover with soil and water periodically. What happens after a few months?

Strawberries can also reproduce vegetatively. Some branches bend towards the soil, developing leaves on one side and roots on the other. New strawberry plants grow from these branches, which are called offshoots or runners.

Cut between one root and another to get lots of independent plants.
DIFFERENT LEAF SHAPES

Leaves can have different shapes, edges, colors, and thicknesses. Study them, then keep them in plastic bags if you like.

- **COMPOUND LEAVES**
  - pinnate
  - palmate

- **SIMPLE LEAVES**
  - toothed edge
  - smooth-edged, non-lobed
  - smooth-edged, lobed

LEAF RUBBING

Cover the leaf you want to do a rubbing of with a sheet of white paper and color over with a soft colored pencil.

THE HEIGHT OF TREES

1. Find a stick as long as your arm.
2. Hold the stick at arm’s length in such a way that the ends of the stick align with the top and the base of the tree.
3. The distance between you and the tree is equal to the height of the tree.

The tallest tree in the world is the sequoia (conifer), over 328' (100 meters), the same height as a 40-floor skyscraper.
RECOGNIZE TREES AND THEIR LEAVES

Pinus sylvestris (Scots Pine) 115' (35 m)

Pinus pinea (Stone Pine) 65' (20 m)

Larix decidua (European Larch) 98' (30 m)

Abies alba (Silver Fir) 131' (40 m)

Cupressus sempervirens (Cypress) 115' (35 m)

Aesculus hippocastanum (Horse Chestnut) 65' (20 m)

Acer pseudoplatanus (Sycamore) 32' (10 m)

Tilia cordata (Small-leaved Lime) 82' (25 m)

Populus alba (White Poplar) 98' (30 m)

Quercus robur (English Oak) 82' (25 m)
How to extract chlorophyll from leaves

1. Pound three spinach leaves to a pulp with a hammer. Then add a few drops of rubbing alcohol or acetone to the pulp.
2. Cut a piece of blotting paper or coffee filter paper to the right size to fit vertically into a plastic glass.
3. Draw one or two drops of the green liquid extracted from the leaves in a pipette and make a small colored stain at about a 1/4” (1 centimeter) from the bottom of the paper, as in the illustration.
4. Fold the strip of paper over a toothpick with the stain downwards, and then rest the toothpick on the rim of the glass.
5. Use a pipette to put a tiny bit of alcohol or acetone in the glass so that the liquid just touches the paper but is nowhere near the stain.

After a few minutes, the liquid will transport different amounts of the substances that make up the mixture as it rises up the paper, separating them into bands of color.
FLOWERS
Why are flowers important for planet Earth?
The flowers of a plant have a very important function in reproduction. One part, the **ovary**, turns into **fruit**.

**THE HISTORY OF FLOWERS**
Flowers appeared on Earth during the Cretaceous Period, at the time when the dinosaurs were dying out.
There are two parts to this piece of equipment:

- The clear plastic container
- The lid that both closes the container and has a lens capable of magnifying things considerably.

The lid with the lens can also be used separately.

**How to transfer a living animal into the viewer.**

Trap a fly or spider under the container and slide a piece of paper under the container to act as a lid.

**CAUTION:** Turn the container over and put on the lid. You may need to use a bit of force to click it into place.
OBSERVE LIVING INSECTS

Be very careful when studying insects so you can restore them safely to the environment. Your study must last only a short time. Compare your specimens to the drawings below.

Pine Processionary Moth
nocturnal
antenna: 2 furry
wings: 4
legs: 6

Clothes Moth
nocturnal
antenna: 2 filiform
wings: 4
legs: 6

Cabbage White
diurnal
antenna: 2 clubbed
wings: 4
legs: 6

Silverfish
antenna: 2
wings: none
legs: 6
appendages: filiform on the abdomen

Wasp
antenna: 2
wings: 4. The front wings are attached to the rear wings.
legs: 6
stinger: 1 at the end of the abdomen can cause a painful sting.

Black Ant
antenna: 2
wings: 4. Males and fertile females have wings; worker and soldier ants do not have wings. The front wings are attached to the rear wings.
legs: 6

Fruit Fly
antenna: 2 short
wings: 2 front
balancers: 2 transform the front wings into authentic balancing instruments.
legs: 6

Bee
antenna: 2
wings: 4. The front wings are attached to the rear wings.
legs: 6
stinger: 1 at the end of the abdomen can cause a painful sting.

Fly
antenna: 2
wings: 2 front
balancers: 2 transform the front wings into authentic balancing instruments.
legs: 6

Common Mosquito
antenna: 2 furry
wings: 2 front
balancers: 2 transform the front wings into authentic balancing instruments.
legs: 6

Crane Fly
antenna: 2 short
wings: 2 front
balancers: 2 transform the front wings into authentic balancing instruments.
legs: 6

Woodworm
antenna: 2
elytrum: 2 transform the front wings into a casing for the rear wings.
wings: 2 back
legs: 6
Animals with two pairs of wings, the upper pair of which forms a hard, scleritic casing (elytrum) while the lower pair is transparent:

- **Antenna:** 2
- **Elytrum:** 2
- **Wings:** 2
- **Legs:** 6

Animals with a body formed of one or two parts with eight legs and no wings are called arachnids.

- **Very small with very short legs:**
  - **Red spider**
- **Medium legs:**
  - **Spider**
- **Long legs:**
  - **Daddy long legs**

Wingless animal with a body made up of less than 15 rings (segments), with legs:

- **Woodlouse (Oniscus)**

Wingless animal with a long body made up of more than 15 rings with two pairs of legs:

- **Millipede (Diplopoda)**

Wingless animal with a long body made up of more than 15 rings with two pairs of legs per ring:

- **Centipede (Chilopoda)**
1. Why are termite nests so tall and large?
If they weren’t, they couldn’t survive the great heat where they live. They build themselves nests that allow the air to circulate in the most efficient way possible and to keep the right levels of humidity inside. Some nests are even shaped like mushrooms, with a roof to keep out the rain.

2. Why do beavers build large dams across rivers?
Damming the course of a river with trees and branches raises the water level. At this point, beavers build their lodges inside the dam, with an underwater entrance in the area with the most water. From the outside it’s impossible to tell where the entrance is, which keeps away unwanted visitors.

3. Why don’t spiders get caught in their webs?
There are both dry and sticky threads in a silk spider’s web. The spider watches out for the sticky threads, but also has a lubricant on its feet to keep it from getting stuck.

4. Why are the cells in a beehive hexagonal in shape?
The hexagon is the geometric shape that is strongest for the hive, and it also uses space most efficiently. Bees can get the greatest number of cells this way.

ADVANTAGEOUS ARRANGEMENTS

Tiger: Its coat is an advantage.
In an area with long grass, the stripes on the tiger’s coat camouflage it, breaking up its shape, and making it less visible to the animals it preys on.

Zebra: Its stripes are useful.
The vertical black and white stripes disorientate predators especially when the zebra is moving. Predators only have a very short time to tell the front from the back of their prey before moving in for the kill.

Hare: It has a brown coat in summer and a light one in winter.
Changing its coat makes it easier for the hare to escape its predators.
CAMOUFLAGE: DRESSING UP AND TRANSFORMATIONS

In the wild, there are lots of different ways for animals to transform themselves in order to hide from or trick their adversaries.

1. The chameleon takes its color from the environment it finds itself in.

From time to time, the color the reptile takes on is the result of a mix of three colors: yellow, red, and black.

The change is caused by nerve and chemical stimuli after the animal has made a visual exploration of the area.

2. A fly dressed up as a wasp

The fly, which copies the yellow and black of wasps, is in less danger from aggressors because it looks like an animal that can defend itself with a sting.

The predator must have had a previous bad encounter with a wasp (Batesian camouflage).

3. A snake that copies another snake

The Lampropeltis avoids attack by aggressors because its skin is similar to that of the coral snake, which is a poisonous species.

The bright colors of the coral snake warn others that it is dangerous.

The Lampropeltis copies the model and so it is also thought to be dangerous (Batesian camouflage).

4. A butterfly that pretends to be a dead leaf

In certain environments, the Kallima butterfly takes the appearance of a leaf to escape from aggressors.

This makes it difficult to see.

5. Stick insects change color at night.

In the daytime they are lighter. At nighttime they turn darker because the color pigments come to the surface of the skin making them darker.

In the morning, the pigments sink back making the skin lighter.
CHEMICAL WARFARE IN THE ANIMAL WORLD

Why do many animals use chemical substances?
They use chemicals to stun their prey or defend themselves.

1. *The jellyfish has little balls that sting.*
It uses irritant cells (little balls) to capture prey or defend itself.

2. *The hornet uses a big sting and poison.*
It's a big wasp, about 1¼" (3 cm) long, with a hefty stinger in its abdomen that injects a strong poison.

3. *The cuttlefish shoots out black ink.*
To escape from difficulty or aggression, it sprays black ink. The ink was once used for writing and drawing.

MORE FUN FACTS

1. *Why does the fur on a cat's back stand on end when it meets an enemy?*
Because it makes the cat look bigger than it is.

2. *Why do wolves prefer to attack in a pack?*
A group attack strategy is more effective both in terms of the number of kills and because they can hunt bigger prey.

3. *Why do bees do a type of dance?*
Bees dance to show their companions the location and distance of food or flowers.

4. *Why does a firefly give off light?*
The bright light it gives off is used to attract others of the same species.
BIRDWATCHING THROUGH THE TELESCOPE

Looking at the silhouettes of the birds, try assessing the dimensions and the shape of the wings and the tail.

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THE TELESCOPE

CAUTION: Never look at the sun with the naked eye or through an instrument.

The telescope is an optical instrument used to view distant objects. It has a main tube through which a slightly smaller secondary tube slides.

The telescope in this set uses refraction with an objective lens that directs light rays into a focus point and another lens called an ocular lens (where you put your eye) that is used for enlarging the object you have in focus.

The instrument can make things five times larger. This is written 5x.

Instructions
1. Hold the main tube in your hand.
2. Put your eye to the eyepiece and shorten or lengthen the telescope by moving the secondary tube until the image of the object appears clearly (is focused on the image).

Warnings: Don’t touch the lens with your finger.
- Use a brush to remove dust from the lens.
- Keep the instrument in the box when you are not using it.
1. In the Galapagos Islands in the Pacific Ocean, there are giant turtles that weigh 440lb. (200 kg) and are as long as a scooter.

2. Some lizards that live in the Andes are so fast that they can run up to 18 mph (30 km) over short distances. That means they could compete with man.

3. The albatross, a seabird, has a wingspan of about 13’ (4 m), the length of a car.

4. The smallest bird is the hummingbird. It’s 2 1/2” (6 cm) long, weighs .07 oz. (2 grams), and beats its wings 90 times a second.

5. One of the highest flying birds you’ll find is the swan. Swans have even been spotted by pilots 5 miles (8,000 meters) high, where it’s difficult to breathe.

6. Some condors in the Andes, a mountain range in South America, have lived to be 70 years old.

7. The biggest reptile is the crocodile. They have been known to be around 26’ (8 meters) long, the size of a small bus.

8. The dolphin is able to stay underwater for about 7-8 minutes and to dive to a depth of around 1,500’ to 1,600’ (400 or 500 meters). Remember, the dolphin isn’t a fish; it’s a mammal like man.
What is ecology?
Ecology is the study of living organisms and their relationship with the environment.

Why do we study ecology?
It helps us realize the effects of the actions carried out by living creatures, including man, on the environment. These include industrial, agricultural, and urbanization activities.