WONDERY KIDS

SCIENCE JOURNAL

This science journal belongs to: ________________

____

WARNING — This set contains chemicals that may be harmful if misused. Read cautions on individual containers [and in manual] carefully. Not to be used by children except under adult supervision.

WOW IN THE WORLD

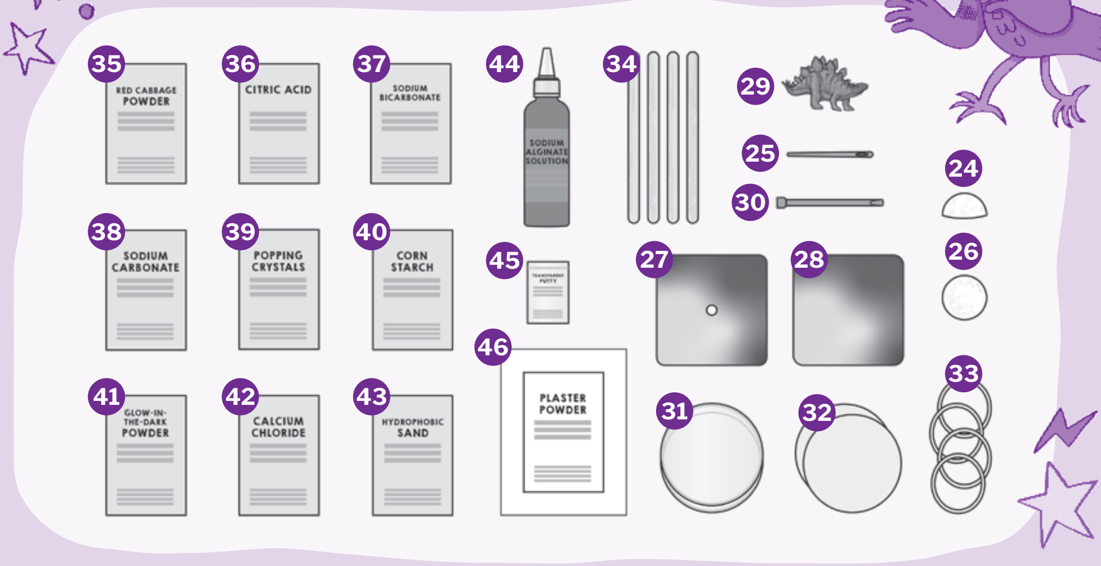
THAMES & KOSMOS

KIT CONTENTS

Part No.	Description	Quantity
1	Safety goggles	1
2	Clip (for holding tools)	1
3	Die-cut cardboard sheets (set of 2)	1
4	Progress poster	1
5	Sticker sheet for poster	1
6	Pen	1
7	Test tube	2
8	Test tube stand	2
9	Scoop (with large, 3-ml bowl and small, 1-ml bowl)	1
10	Pipette	1
11	Beaker	1

Part No.	Description	Quantity
12	Syringe	1
13	Rubber stopper (with hole)	1
14	Balloon	4
15	Foam rocket	1
16	String	1
17	Drinking straw	4
18	Plastic ruler	1
19	Magnifying glass	1
20	Vortex connector	1
21	Flexible tube	1
22	Crepe paper strips (red, yellow, blue)	3
23	Ring magnet	2

KIT CONTENTS



Part No.	Description	Quantity
24	Polystyrene hemisphere	1
25	Needle	1
26	Polystyrene ball	1
27	Mirror with hole	1
28	Mirror without hole	1
29	Dino figurine (species of dino will vary)	1
30	Chisel	1
31	Petri dish	1
32	Filter paper disk	2
33	Rubber band	4
34	Craft stick	4

Part No.	Description	Quantity
35	Red cabbage powder (5 g)	1
36	Citric acid (30 g)	1
37	Sodium bicarbonate (16 g)	1
38	Sodium carbonate (5 g)	1
39	Popping crystals (6 g)	1
40	Corn starch (35 g)	1
41	Glow-in-the-dark powder (4 g)	1
42	Calcium chloride (10 g)	1
43	Hydrophobic sand (15 g)	1
44	Sodium alginate solution (90 ml)	1
45	Transparent putty (20 g)	1
46	Plaster powder (100 g)	1

SAFETY INFORMATION

⚠ WARNING:

CHOKING HAZARD — Small parts.
Toy contains a small ball. Not for children under 3 yrs.
Children under 8 yrs. can choke or suffocate on uninflated or broken balloons. Adult supervision required. Keep uninflated balloons from children. Discard broken balloons at once.

Made of natural rubber latex, which can cause allergies. Use a pump to inflate the balloons.

Warning! Not suitable for children under 3 years. Choking hazard — small parts may be swallowed or inhaled. Strangulation hazard — long string may become wrapped around the neck.

Keep the packaging and instructions as they contain important information.

Warning. Not suitable for children under 6 years. For use under adult supervision. Contains some chemicals which present a hazard to health. Read the instructions before use, follow them and keep them for reference. Do not allow chemicals to come into contact with any part of the body, particularly the mouth and eyes. Keep small children and animals away from experiments. Keep the experimental set out of reach of children under 6 years old. Eye protection for supervising adults is not included.

WARNING! This product contains small magnets. Swallowed magnets can stick together across intestines causing serious injuries. Seek immediate medical attention if magnets are swallowed.

WARNING! This kit contains functional sharp edges or points. Do not injure yourself!

WARNING! Never look directly into the sun — whether with your naked eye, or with the magnifying glass or other lenses! You could blind yourself! Never inadvertently leave the magnifying glass or other lenses in the sun — it could start a fire!

Poison Control Centers (United States)
In case of emergency, your nearest poison control center can be reached everywhere in the United States by dialing the number:

1-800-222-1222

Local Hospital or Poison Centre
Record the telephone number of your local hospital or poison centre below. Write the number down now so you do not have to search for it in an emergency.

Have any questions? Missing any parts? Need help with an experiment? Our tech support team will be glad to help you!

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Email: support@thamesandkosmos.com
Web: thamesandkosmos.com
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SAFETY INFORMATION

Information about Hazardous Substances
None of the substances in this kit are classified as hazardous substances in the quantities included and the applications presented in this kit. However, you must read these safety instructions before use, follow them, and keep them for reference.

The following applies to all chemicals:
CAUTION:
Do not get in eyes or in mouth. Do not ingest.
Adult supervision required.
Read cautions on individual containers and in this manual carefully. Use only as instructed.
Keep out of reach of children. This primarily applies to young children, but also to older children who — unlike the experimenter — have not been appropriately instructed by adults.

The following applies to all powdered chemicals:
Do not inhale dust or powder.

Waste Disposal
Leftover chemicals can be poured down the drain with plenty of water. Please dispose of leftover solids in the household garbage.

First Aid Information
1) In case of eye contact: Wash out eye with plenty of water, holding eye open if necessary. Seek immediate medical advice.
2) If swallowed: Wash out mouth with water, drink some fresh water. Do not induce vomiting. Seek immediate medical advice.
3) In case of inhalation: Remove person to fresh air.
4) In case of skin contact and burns: Wash affected area with plenty of water for at least 10 minutes.
5) In case of doubt, seek medical advice without delay. Take the chemical and its container with you.
6) In case of injury always seek medical advice.

Safety Rules
1. Read these instructions before use, follow them and keep them for reference.
2. Keep young children, animals and those not wearing eye protection away from the experimental area.
3. Always wear eye protection.
4. Store this experimental set out of reach of children under 6 years of age.
5. Clean all equipment after use.
6. Make sure that all containers are fully closed and properly stored after use.
7. Ensure that all empty containers are disposed of properly.
8. Wash hands after carrying out experiments.
9. Do not use any equipment which has not been supplied with the set or recommended in the instructions for use.
10. Do not eat or drink in the experimental area.
11. Do not allow chemicals to come into contact with the eyes or mouth.
12. Do not replace foodstuffs in original container. Dispose of immediately.
13. Do not apply any substances or solutions to the body.
14. Carefully prepare your work area for the experiments. Clear off the table and gather everything you will need.
15. Always leave your work area in clean condition. Always pay attention to proper disposal of any residues.
16. Always work slowly and carefully.
17. When experimenting, wear old clothes that can get messy, or wear something over your clothes (such as an apron or old shirt).
18. Take care while handling hot water or hot solutions.
19. Pay special attention to the quantities specified and the sequence of the individual steps. Only perform experiments that are described in this instruction manual.
20. Do not use any eating, drinking, or other kitchen utensils for your experiments. Any containers or equipment used in your experiments should not be used in the kitchen afterward.
21. Immediately wipe up any spills with a paper towel.

INTRODUCTION

GUY RAZ
(*WOW IN THE WORLD* HOST)

WELCOME TO YOUR *100 EXPERIMENTS THAT WOW!* SCIENCE JOURNAL!

MINDY THOMAS
(*WOW IN THE WORLD* HOST)

THIS JOURNAL HAS ALL THE INSTRUCTIONS YOU NEED TO DO ALL **ONE HUNDRED** EXPERIMENTS IN THIS KIT.

THERE ARE ALSO LOTS OF SPACES FOR YOU TO RECORD YOUR WONDERS AND OBSERVATIONS, SO GET YOUR PENS READY.

AND WE KICK OFF EACH GROUP OF EXPERIMENTS WITH WONDERIFIC AUDIO INTRODUCTIONS. JUST USE THE QR CODE BELOW TO LISTEN!

NOW GO FORTH, AND FIND YOUR WOWS ... ALL ONE HUNDRED OF THEM!

WOW IN THE WORLD

Wow in the World is the #1 kids' science podcast, hosted by Guy Raz and Mindy Thomas!

Start here!

1 Grown-ups! Scan this QR code to start your **audio journey.**

2 Listen to **Track 1,** a *Wow in the World* Bonus Episode!

3 Listen to Guy and Mindy introduce each new group of experiments when you see this symbol in the journal!

Listen!

#1

NOTES TO GROWN-UPS

Dear parents, teachers, and other adult supervisors,

An adult must supervise and assist in the use of this science experiment kit. This includes helping to set up a suitable workplace for the experiments, making sure all experimenters wear eye protection, helping your child read and understand the instructions, and assisting them in actually performing the experiments.

Please also help your child listen to the audio tracks that introduce each group of experiments, help them to record their wonders and observations in the spaces provided in this science journal, and read the scientific explanations that follow the experiments to them.

You must also help your child gather the additionally required materials for the experiments, which are printed in italics in the "You will need" sections found before the instructions for each experiment.

Please read the standard safety information for chemistry sets below. Then, proceed to the next page for an overview on how to use this kit, including this science journal, the audio content, and the progress poster. And most importantly, enjoy these fascinating and fun experiments!

Advice for Supervising Adults

A. Read and follow these instructions, the safety rules and the first aid information and keep them for reference.

B. The incorrect use of chemicals can cause injury and damage to health. Only carry out those experiments which are listed in the instructions.

C. This experimental set is for use only by children over 6 years.

D. Because children's abilities vary so much, even within age groups, supervising adults should exercise discretion as to which experiments are suitable and safe for them. The instructions should enable supervisors to assess any experiment to establish its suitability for a particular child.

E. The supervising adult should discuss the warnings and safety information with the child or children before commencing the experiments. Particular attention should be paid to the safe handling of acids and alkalis.

F. The area surrounding the experiment should be kept clear of any obstructions and away from the storage of food. It should be well lit and ventilated and close to a water supply. A solid table with a heat resistant top should be provided.

HOW TO USE THIS KIT

The following is an overview of how to use this kit, covering how to use this science journal, the audio content, and the progress poster, as well as some helpful tips for the experiments.

1. In this science journal, there are instructions for performing **100 experiments,** which are divided into **17 chapters.**

2. It works best if you do the experiments **in order from 1 to 100,** or at least in order within each chapter. Many of the experiments within the same chapter are meant to be done in a series, sometimes **using the same materials.** Before discarding any parts or chemicals, check the remaining experiments in the chapter to see if the materials from one experiment must be **reused** in another.

3. Many of the kit contents are used for multiple experiments. If a part or material is not destroyed or consumed in an experiment, you should **save it** for later experiments. Keep parts like the string, rubber bands, unbroken balloons, drinking straws, polystyrene shapes, dry crepe paper, and unused chemicals for future use.

4. This book is called a science journal because it includes spaces for you to **write and draw** your wonders, questions, and observations for most of the experiments. We even included a special ***Wow in the World* pen** for this purpose.

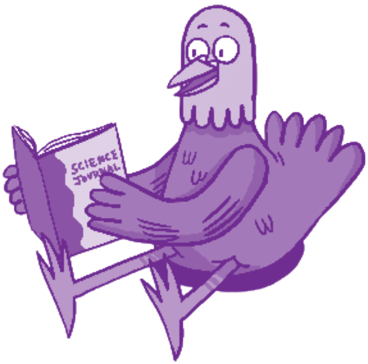
5. If an experiment starts with a **"Listen!"** symbol, first listen to the **audio track** of that number (see **page 4** for info on how to access the audio content).

6. Then, write down what the audio track makes you think of or wonder about in the **"What do you wonder?"** box.

7. Each experiment (or in a few cases, each group of experiments) has a "**You will need"** section, which lists the materials you will need for the experiment(s). Materials not included in the kit are printed in *italics.*

8. The instructions for each experiment are printed under the **"Tinker"** headers.

9. After the instructions, there are usually places to record observations or findings and also a **"What in the wow?"** section explaining what you may have observed.

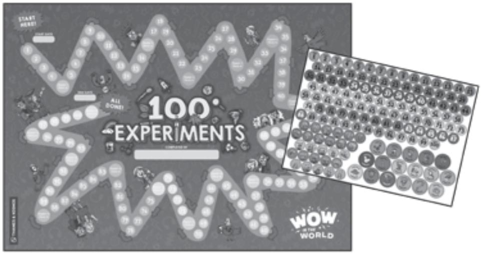


HOW TO USE THIS KIT

10. Before you start experimenting, hang up the **progress poster.** After finishing each experiment, take the **number sticker** for the experiment from the **sticker sheet** and put it on the corresponding **number space** on the poster.

If an experiment was really cool or went very well, you can mark it with one of the stickers with the phrases like **“So cool!”** on them. If an experiment didn’t go as expected, you can mark it with one of the stickers with the phrases like **“Flop!”** on them.

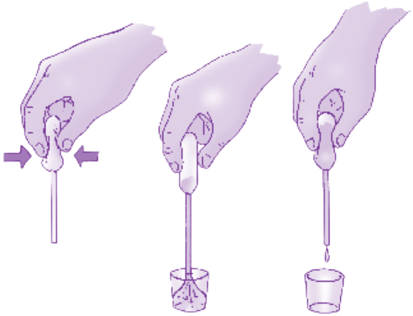
When you finish all the experiments in one chapter, put the **“Complete!”** sticker for that chapter on the poster, in the matching spot.



11. At the end of each chapter you will find a **“Chapter check-in”** page for summarizing your experience in each chapter: Under **“Wow!”,** write and draw what you found cool and interesting about the chapter. Under **“Whoops!”** write and draw what did not work as you expected or what you found challenging. Also write down the **date** you completed the chapter and your **favorite experiment.**

Helpful Tips for Experimenting

1. When measuring with the scoop, always use **level scoops,** not heaping scoops.
2. If the instructions say “water,” you can simply use **tap water.**
3. **“Small scoop”** means the small bowl, which holds 1 ml. **“Large scoop”** means the large bowl, which holds 3 ml.
4. Use **exactly the amounts** of chemicals indicated and **save unused amounts** for later use. Seal the packets with tape in between uses.
5. **Clean equipment** between uses unless otherwise instructed.
6. Remember to **wash your hands** and **clean up your workspace** after every experiment.
7. Here’s how to use the **pipette:**
   - Squeeze the upper part of the pipette between your thumb and forefinger and dip the pipette tip into the liquid.
   - As soon as you release the pressure, the liquid will rise up the pipette.
   - By squeezing carefully, you can make the liquid drip slowly out again.



1. FROZEN GLOBE

Listen! #2

"What is ice?"

See **page 4** for instructions on accessing the audio content.

WHAT DO YOU **Wonder?**

You will need:

- **Balloon**
- **Dino figure**
- *Water*
- *Scissors*

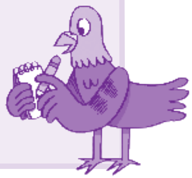
Note: Whenever "water" is called for, you can use tap water.

Tinker:

1. Have someone hold the end of the balloon open wide enough for you to put the plastic dinosaur inside.
2. Fill the balloon with water until it's approximately sphere-shaped.
3. Tie the end of the balloon.
4. Put the balloon full of water into your freezer for at least eight hours, or overnight.
5. When the balloon is completely solid, take it out of the freezer and put it into a bowl.
6. Carefully puncture the balloon with a pair of scissors. What do you see?

MAKE AN OBSERVATION

Draw or describe the results of your experiment. How do they compare to your prediction?



WHAT IN THE WOW?

The water froze into a round globe shape. You probably see a bloom of tiny bubbles, some forming long thin lines, inside this globe of ice. These bubbles formed because the water had **dissolved air** in it. When water **freezes,** it cannot hold the air, so the air is forced to escape from the water and forms bubbles. But, when you put your balloon in the freezer, the water froze from the outside inward, so the air bubbles got caught inside the ice, with nowhere to go.

2. SALT ICE ART

You will need:

- **Frozen globe from previous experiment**
- *Salt*
- *Watercolor paints or food coloring*

Tinker:

1. Sprinkle salt on the ice and observe what happens.
2. Now drip a few drops of food coloring in various colors on top of the globe, or paint it with swirls of water colors. What do you see?
3. Allow your ice globe to sit somewhere warm for about half an hour (in the light from a sunny window is a good spot). Check on it again. What has happened?

Wonder: PREDICT WHAT WILL HAPPEN

What effect do you think the salt will have while the ice melts?

MAKE AN OBSERVATION

Describe the results of your experiment. How do they compare to your prediction?

WHAT IN THE WOW?

Salt is an **ionic compound,** which means it is made up of multiple types of **ions** — particles with an electrical charge. When the salt is sprinkled on ice, it starts to dissolve, and these ions break apart. The ions lower the **freezing point** of water by disrupting the bonds between water molecules and causing them to break apart more easily. The salt sinks into the ice as it pushes the water molecules aside. When you add the color, you can see it drip down in to the channels left by the salt.
(To learn more about bonds between water molecules, see experiment 34: Surface Tension on page 37.)

3. LIFTING AN ICE CUBE

You will need:

- String
- Beaker
- *Salt*
- *Ice cube*
- *Water*
- *Cup*

Tinker:

1. First, you'll need an ice cube. Fill the beaker a quarter full of water and put it in the freezer for a few hours. If you already have ice cubes, you can skip this step and go to step 3.
2. Take the beaker out of the freezer when the water is frozen all the way through. Run warm water over it for about 20 seconds to remove the ice cube.
3. Place the ice cube in a cup of water. Drape the string across the glass so that as much of it touches the ice cube as possible.
4. Sprinkle some salt on the ice cube. Try to make sure that the area with the string is lightly and evenly coated with salt.

Wonder: PREDICT WHAT WILL HAPPEN

What effect do you think the salt will have while the ice melts?

5. Wait three to four minutes, and then try to lift the ice cube with the string.

MAKE A CONNECTION

How could the effect of salt on ice be useful in daily life?

WHAT IN THE WOW?

As you just learned, salt lowers the freezing point of the water and causes the surface of the ice cube to begin melting. A small puddle is formed, which the string sinks into. But as more water melts, the salt spreads further in the puddle. It becomes more and more diluted. This slows the melting process until it stops. The puddle is cooled by the rest of the ice cube and freezes again. Now the thread is frozen into the ice cube and you can lift it with the other end!

4. MAKING OOBLECK

WHAT DO YOU **Wonder?**

You will need:

- » Corn starch
- » Water
- » Bowl
- » Beaker
- » Teaspoon
- » Food coloring

Tinker:

1. Measure 30 ml of room temperature water in the beaker and then pour it into the bowl. You can also add a few drops of food coloring to change the color.
2. Add about ten teaspoons of the cornstarch, a little at a time, stirring slowly as you go. The consistency should look like white glue when it's at rest. You may need to add a little more water or a little more cornstarch.
3. You've made oobleck! Experiment with your oobleck. Here are some things to try:
   - Pour a puddle of oobleck onto a plate and try to quickly drag your finger through it.
   - Try to jab the surface of the oobleck with your finger, then slowly poke it.
   - Squeeze a handful of oobleck.
4. When you are done playing with your oobleck, throw it into the trash. Do not pour it down any drains.

MAKE AN OBSERVATION

How does oobleck behave differently from other fluids?

WHAT IN THE WOW?

Oobleck is a type of fluid known as a **non-newtonian fluid.** This means it behaves differently from other fluids, like water. Non-newtonian fluids change their **viscosity** — how thick or thin the fluid is — depending on how much stress they are exposed to. When oobleck is exposed to stress (being struck, squeezed, stirred, etc.) it becomes thicker the stronger the stress is. Some non-newtonian fluids behave in an opposite way. For example, ketchup is a non-newtonian fluid that becomes thinner when it's exposed to stress. That's why shaking a ketchup bottle makes it much easier to pour or squeeze out.

CHAPTER 1 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _____________

WOW!

WHOOPS!

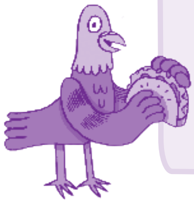
MY FAVORITE EXPERIMENT:

____

5. COLORFUL CLUES

Listen! #4

"Acid or base?"



WHAT DO YOU Wonder?

You will need:

- Beaker
- Scoop
- Red cabbage powder
- Sodium bicarbonate
- Citric acid
- Craft stick
- *Water*

Tinker:

1. Measure 30 ml of water in the beaker and add a small scoop (1 g) of cabbage powder.
2. If the water turns purple, your water is neutral. Move on to the next experiment.
3. If the water turns pink when only cabbage powder is added, your water is slightly **acidic.** With the small scoop, slowly sprinkle sodium bicarbonate into the water while stirring with the craft stick until it turns purple.
4. If the water turns blue when only cabbage powder is added, your water is slightly **basic.** With the small scoop, slowly sprinkle citric acid into the water until it turns purple.

MAKE A CONCLUSION:

My water is (circle one):

Basic **Neutral** **Acidic**

WHAT IN THE WOW?

Red cabbage is a **pH indicator** that can show whether a substance is an **acid** or a **base,** because it contains a water-soluble pigment called **flavin,** which changes color when it comes into contact with an acid or a base. What's pH anyway? pH stands for "potential of hydrogen" and is a measure of the concentration of hydrogen ions in an aqueous — or watery — solution. Many chemicals, including liquids, do not have pH values. If there's no water, there's no pH. For example, there is no pH value for oil, gasoline, or pure alcohol. Sodium bicarbonate (also known as baking soda) is a base. Citric acid, which is found in citrus fruits, is an acid. When red cabbage comes in contact with an acid, it turns pink. When it comes in contact with a base, it turns blue. And when it comes in contact with something with a **neutral** pH (neither acid nor base), it stays purple. What other substances could you test?

Wonder: PREDICT WHAT WILL HAPPEN

Read the next two experiments, then fill in the blank:

IN EXPERIMENT 6 THE SOLUTION WILL TURN _________.

IN EXPERIMENT 7 THE SOLUTION WILL TURN _________.

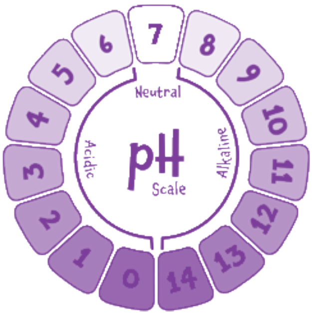
6. IT'S AN ACID

You will need:

- 2 Test tubes
- 2 Test tube stands
- Scoop
- Red cabbage powder
- Citric acid
- *Water*

Tinker:

1. Place the test tubes in the test tube stands.
2. Add water to both test tubes, so they are about half full.
3. Add one small scoop of red cabbage powder to each test tube and stir.
4. Add one small scoop of citric acid to one of the test tubes and stir.



The pH scale measures how acidic or alkaline a liquid is.

7. GETTING BASIC

You will need:

- Setup and materials from experiment 6
- Sodium bicarbonate

Tinker:

1. Add one small scoop of sodium bicarbonate to the other test tube and stir.

MAKE YOUR OWN PH TEST STRIPS

The most common form of pH tests are paper test strips. You can make your own using red cabbage by following the steps below:

1. Tear red cabbage leaves into small pieces until you have about two cups of red cabbage.
2. Put the cabbage into a pot and pour in enough water to cover the cabbage.
3. Ask an adult to boil the cabbage until the water turns a dark blue-purple color.
4. Allow the solution to cool completely, and then ask an adult to pour it into another container while straining out the leaves.
5. Put several coffee filters into the liquid and allow them to soak until they are fully saturated.
6. Remove the coffee filters from the liquid and place them on a baking sheet to dry. Once they are dried, cut them into strips.
7. Pour a drop of liquid onto the test strip to measure pH. The strip will turn red if the liquid is acidic or blue-green if it's basic.

8. MAKING PURPLE FIZZ

You will need:

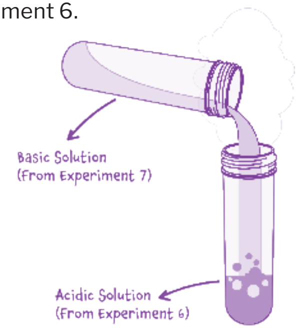
- The acidic solution from experiment 6
- The basic solution from experiment 7

Wonder: PREDICT WHAT WILL HAPPEN

What do you think will happen when you combine these two solutions?

Tinker:

1. Hold the test tube with the acidic solution from experiment 6 over a sink.
2. Slowly pour the basic solution from experiment 7 into the test tube from experiment 6.



MAKE AN OBSERVATION

Draw a picture of what you see. What wowed you?

WHAT IN THE WOW?

You're seeing a **chemical reaction!** When sodium bicarbonate and citric acid mix, they form sodium ions, citric acid ions, carbon dioxide gas, and water. This causes the mixture to bubble up. You'll learn more about chemical reactions in the next few experiments.

You may also notice the color of the mixture is closer to the original purple of the cabbage powder. That's because your acidic solution and basic solution cancel each other out, so the solution is neutral again!

9. HOT VS. COLD

Listen! #5 "very variable"

WHAT DO YOU **Wonder?**

You will need:

- 2 Test tubes
- 2 Stands
- Beaker
- Scoop
- Sodium bicarbonate
- Citric acid
- Craft stick
- *Water*
- *Dinner plate*
- *Glass*
- *Measuring cup*

Tinker:

1. Rinse and dry both test tubes and place them in the stands on a dinner plate.
2. Add one large scoop of sodium bicarbonate to each test tube and stir using the craft stick.
3. Measure 50 ml of cold water with the beaker and pour it into a glass. Add one large scoop of citric acid and stir. (Optional: Add food coloring.)
4. Measure 50 ml of water with the beaker and pour it into a microwave-safe measuring cup. Add one large scoop of citric acid. (Optional: Add food coloring of a different color.)
5. A grown-up should handle all hot objects! Microwave the measuring cup for 30 seconds.

Wonder: PREDICT WHAT WILL HAPPEN

What effect do you think the different temperatures will have?

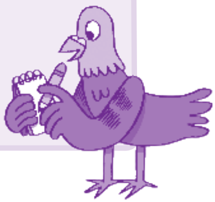
6. Pour the hot solution into one test tube and the cold solution into the other test tube at the same time.

WHAT IN THE WOW?

Science is all about **variables** and variables are all about change. In this experiment, you found out what happens in a chemical reaction if you change one of the properties of matter: temperature. What did you see?

MAKE AN OBSERVATION

What was the difference between the cold and hot reactions? Was your prediction correct?



10. COLORFUL REACTION

You will need:

- Test tube
- Test tube stand
- Beaker
- Scoop
- Citric acid
- Sodium carbonate
- Craft stick
- *Water*
- *Dish soap*
- *Dinner plate*

Tinker:

1. Add one large scoop of citric acid and one large scoop of sodium carbonate to one test tube, and stir to mix the ingredients. Then add a drop of dish soap on top of the mixture. Set up the test tube on a dinner plate.
2. Measure 30 ml of water in the beaker, then add one small scoop of red cabbage powder and stir. This is your chemical indicator.
3. Pour the solution from the beaker into the test tube.

11. SUNKEN ERUPTION

You will need:

- Test tube
- Test tube stand
- Beaker
- Scoop
- Citric acid
- Sodium bicarbonate
- Red cabbage powder
- Craft stick
- *Vegetable oil*
- *Water*

Tinker:

1. Add one large scoop of citric acid and one small scoop of red cabbage powder to another test tube.
2. Use the beaker to measure 25 ml of water and add it to the test tube. Stir to combine. This is a model for liquid magma.
3. Measure 25 ml of vegetable oil in the beaker, then pour it down the inside wall of the test tube so no bubbles are created. (The oil should sit on top of the "magma".)
4. Add one large scoop of sodium bicarbonate to the test tube.

WHAT IN THE WOW?

The bubbles you're seeing in both experiments are caused by the **carbon dioxide** that's a byproduct of these acid-base chemical reactions.

In experiment 10, you saw a mix of colors during the reaction because the citric acid turns the indicator pink and the sodium carbonate turns the indicator blue. Eventually the test tube will calm down (find equilibrium) and be purple.

In experiment 11, just like the pressure under the Earth's crust causes real magma to push up under the ocean floor, the carbon dioxide "magma" in your experiment makes its way up through the oil and erupts at the top. You may also notice that the bubbles of "magma" are different colors. This is because some of them have more sodium bicarbonate trapped in them than others, so they have different pH levels.

12. INFLATION STATION

WHAT DO YOU **Wonder?**

You will need:

- » Test tube
- » Test tube stand
- » Beaker
- » Scoop
- » Citric acid
- » Sodium bicarbonate
- » Balloon
- » *Water*

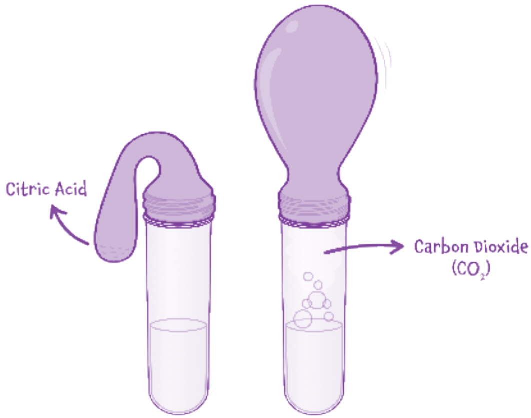
Tinker:

1. Add one large scoop of sodium bicarbonate to one test tube.
2. Pour 25 ml of water into the test tube (use the beaker to measure), then stir until it is mostly dissolved.
3. Add nine small scoops of citric acid to the balloon.
4. Stretch the end of the balloon over the opening of the test tube, while the powder hangs down by the side of the test tube.
5. Lift the balloon to let the powder fall into the test tube. Tip: If the bubbles stop, try swirling the test tube gently.

MAKE A CONNECTION

Think about the experiments you've done so far. What do you think caused the balloon to expand?

Now read the What in the Wow fact on the next page to check your answer.



13. GEYSER TIME

You will need:

- Test tube
- Beaker
- Scoop
- Rubber stopper
- Syringe
- Citric acid
- Sodium bicarbonate
- *Water*
- *Dish soap*

Tinker:

Note: Do this experiment outdoors or over a sink; it can get messy!

1. Add a drop of dish soap to a test tube with 30 ml of water and a large scoop of sodium bicarbonate.
2. Firmly push the rubber stopper into the mouth of the test tube.
3. Measure 25 ml of water in the beaker, add one large scoop of citric acid to it, and stir until dissolved.
4. Fill the syringe with the acidic water from the beaker.
5. Push the tip of the syringe into the hole in the rubber stopper.
6. Hold the rubber stopper in with one hand, while you push the plunger of the syringe with the other hand. Do not stand over the stopper.
7. When you feel pressure building, remove the syringe from the rubber stopper.

14. REACTION ROCKET

You will need:

- Test tube
- Syringe
- Scoop
- Citric acid
- Sodium bicarbonate
- Foam rocket
- *Water*
- *Toilet paper*

Tinker:

1. Measure 10 ml of water with the syringe and squirt it into the test tube.
2. Add one large scoop of citric acid to the test tube and stir well.
3. Add one large scoop of sodium bicarbonate to the middle of a piece of toilet paper and fold the edges up.
4. Place the toilet paper in the test tube, but don't let the powder touch the water.
5. Push the foam rocket into the mouth of the test tube.
6. Shake the tube and: Blast off! (Tip: If the solution in the tube is still bubbling after the launch, you may be able to place the foam rocket back on the tube for another launch.)

WHAT IN THE WOW?

In experiments 12, 13, and 14, the carbon dioxide (CO_2) formed during the reactions expands and builds up **pressure.** In experiment 12, the pressure inflates the balloon. In 13, it builds until it's strong enough to shoot a stream of bubbles out of the stopper. In 14, it propels the rocket off the test tube.

15. POP-ROCK POTION

WHAT DO YOU Wonder?

You will need:

- Beaker
- Scoop
- Popping crystals
- *Lemon juice*

Tinker:

1. Fill your beaker about halfway full of lemon juice.
2. Pour a large scoop of popping crystals in, and carefully swirl the beaker. Do you hear something?

16. POPPING FIREWORKS

You will need:

- Beaker
- Scoop
- Popping crystals
- *Water*
- *Glass*

Tinker:

1. Microwave a glass of water in 15-second increments until it is hot, but not boiling.
2. Fill your beaker about two-thirds full with the warm water.
3. Fill the large scoop with popping crystals and slowly pour them into the water.

MAKE AN OBSERVATION

Compare the results of these two experiments. Which one was more impressive?

WHAT IN THE WOW?

Popping crystals consist of **pressurized CO_2** trapped inside a shell of sugar crystals. When the sugar dissolves, the CO_2 is released. Hotter liquids dissolve sugar faster, so when you put the crystals into hot water, all of the pressurized CO_2 is released almost instantly, causing the crystals to jump!

CHAPTER 2 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _______________

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

____

17. THE CIRCLING BALL

Listen! #8 "Newton's laws"

WHAT DO YOU **Wonder?**

You will need:

- Disk from die-cut cardboard sheet
- String
- Polystyrene ball

Tinker:

1. Cut three lengths of string, about two feet each.
2. Make a small knot in each of the three string ends. If you need help, ask an adult.
3. Now push the threads into the three slots in the die-cut disk so that the disk rests on the three knots.
4. Take the other ends of the three strings in your hand and place the ball in the recess in the middle of the disk.
5. Carefully start to swing the disk around in a big circle. Rotate faster and faster until the disk is perpendicular to the ground.

MAKE A PREDICTION

What do you think would happen if you tried swinging the disk like a very fast Ferris wheel? Try it. Was your hypothesis correct?

WHAT IN THE WOW?

You will notice that the ball stays securely in place instead of falling down. This is an example of Newton's first law of motion, the law of **inertia.** This says that an object will not change its **velocity** (the combination of its speed and direction) unless an outside **force** acts on it. When you spin the disk, you are constantly changing the direction of the ball's velocity, and it keeps trying to continue moving in a straight line. The "force" comes from the ball trying to move in a straight line, but because its path is being stopped by the disk, it cannot do this. Instead, it is pressed firmly against the disk. So firmly, that it does not fall down even if it's sideways or upside down. If the disk suddenly disappeared, the ball would go flying in whatever direction it was moving at that moment.

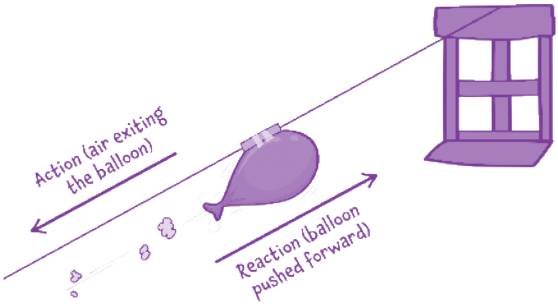
18. ROCKET POWER

You will need:

- Balloon
- Drinking straw
- String
- *Tape*

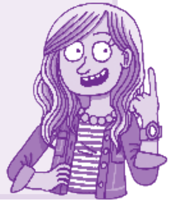
Tinker:

1. Tie one end of the string to a high spot like the top of a window. You may want an adult to help you with that.
2. Blow up a balloon with air, but don't tie the end.
3. While holding the end of the balloon closed, tape the straw (unbent) to the balloon, so that it rests on it. You may want to get someone to help you by holding the end of the balloon while you set everything up.
4. Thread the other end of the string through the straw.
5. While still holding the balloon in one hand and the free end of the string in the other, move as far away as you can from the place where you anchored the string, so that the string is pulled taut. Then let go of the balloon.



MAKE A CONNECTION

Does the way the balloon moves remind you of anything?



WHAT IN THE WOW?

When air is released from the balloon, it is **propelled** forward. This is because of Newton's second law of motion, which is often described as "for every action, there is an equal and opposite reaction." In this case, the action is the force of the air exiting the balloon, the reaction is the balloon being pushed in the opposite direction with equal force.

19. FALLING FAST

You will need:

- Polystyrene ball
- Corn starch
- Transparent putty

Tinker:

1. Remove enough of the transparent putty from the packet to make a sphere about the same size as the polystyrene ball. Roll it between your palms until it forms a sphere. Then roll it in a light layer of corn starch.
2. Hold both the putty ball and the polystyrene ball about two feet above a surface, such as a desk or table. Drop them at the same time. What do you see? If the putty ball is sticking to your fingers, roll it in corn starch again.
3. Repeat the experiment a few times. You'll be able to see what's happening more easily if you film the drops.

WHAT IN THE WOW?

When an object falls on Earth, it gains speed, or **accelerates.** This is because of a force we call **gravity.** Earth's gravity is a **constant,** which means that if there are no other forces involved, all objects take exactly the same amount of time to fall from a given height. The gravity of a planet (or other astronomical body) depends on its mass. That's why astronauts can jump so high on the moon, but they'd be crushed if they tried to walk around on Jupiter!

20. FALLING FAR

You will need:

- The materials from experiment 19

Tinker:

1. Repeat experiment 19, but this time drop both balls from at least four feet off the ground. What changed?

WHAT IN THE WOW?

The polystyrene ball takes longer to hit the ground than the putty ball. But why? Isn't gravity the same for both of them? This is where other forces come into play: namely, **air resistance.** The polystyrene ball reached something called **terminal velocity.** Terminal velocity is the fastest speed that an object can reach when moving through a gas or fluid — in this case, air. It depends on a lot of factors, including the size and shape of an object, but because the two balls are approximately the same size and shape, the most important factor is **mass.** The polystyrene ball has less mass, so its terminal velocity is lower. It reaches its maximum falling speed before the putty ball does, so the putty ball pulls ahead of it in the race toward the ground!

21. BUMPER BALLS

You will need:

» The materials from experiment 19

Wonder: PREDICT WHAT WILL HAPPEN

Read the experiment steps below and form a hypothesis. What do you think will happen to the polystyrene ball?

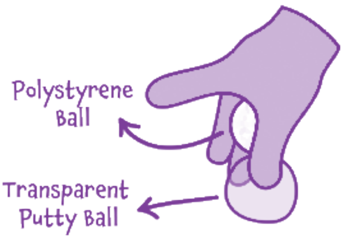
Tinker:

1. Repeat experiment 19, this time paying attention to how high each ball bounces.
2. Hold the putty ball, with the polystyrene ball stacked on top of it, about two feet from the ground.
3. Drop both of the balls at the same time so that the polystyrene ball remains stacked on top of and touching the putty ball. This may take a few attempts.
4. Observe how the two balls bounce. What do you notice?

WHAT IN THE WOW?

When you drop the balls individually, the putty ball bounces back almost as high as the height you dropped it from. This is because the material is **elastic,** so the drop and the bounce are pretty close to being mirror actions. The polystyrene ball doesn't bounce much, because the material isn't very elastic.

This is very different when the balls are stacked. When the putty ball hits the ground, it bounces a little bit, but the polystyrene ball bounces even higher than the point you dropped it from. This is because of something called **transfer of momentum.** You can think of **momentum** as the strength of the movement of an object. It depends on both weight and speed. When the putty ball hits the ground, it bounces and immediately hits the polystyrene ball on top of it. The putty ball was going the same speed as the polystyrene ball, but it has a greater mass, and therefore more momentum. This means that the polystyrene ball bounces upward with more force than it fell with, sending it even higher than its starting point.



22. HITTING HARD

You will need:

- Polystyrene ball
- Transparent putty ball
- Water
- *Plastic bag*
- *Flour*

Wonder: PREDICT WHAT WILL HAPPEN

Read the experiment steps. Which of these do you think will have the most impressive result?

Polystyrene+water:
Polystyrene+flour:
Putty+water:
Putty+flour:

Tinker:

1. Take a large bowl and fill it about halfway with water.
2. Measure a distance one foot above the water and drop the polystyrene ball from that point.
3. Repeat step 2 with the putty ball from the previous experiments. What do you observe?
4. Fill a plastic sandwich bag with enough flour to create a layer about one centimeter (half an inch) thick when the bag is laid flat. Make sure you seal it well.
5. Lay the bag flat on the table, and smooth out the flour so that the surface is as even as possible.
6. Measure a distance one foot above the flour bag and drop the polystyrene ball onto it from that point.
7. Observe and record your result. You may want to take a photograph to record your data. Repeat this step at least five times.
8. Repeat step 7 with the putty ball. What do you observe?

MAKE AN OBSERVATION

Draw an example of each type of drop.

POLYSTYRENE + WATER	PUTTY + WATER
POLYSTYRENE + FLOUR	PUTTY + FLOUR

WHAT IN THE WOW?

Although the balls fall at approximately the same speed, they hit the water and flour with different amounts of **force.** This demonstrates Newton's second law of motion: **Force = Mass x Acceleration.** The greater the mass, the greater the force, and the greater the splash or impact crater!

CHAPTER 3 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

Listen! #9 "Positive and negative"

WHAT DO YOU **Wonder?**

You will need:

» 2 Ring magnets

23. OPPOSITES ATTRACT

Tinker:

1. Hold one magnet in each hand and slowly move their faces toward each other. What happens?
2. Now flip one of the magnets around and try to move them together again. What changed?

24. JUMPING MAGNETS

Tinker:

1. Place one ring magnet on the table.
2. Push the second ring magnet onto the first one with their two repelling sides facing each other. You will notice that it's not so easy to do without making the lower one scoot away.
3. When you finally manage to do it, quickly let go.

25. SPINNING MAGNETS

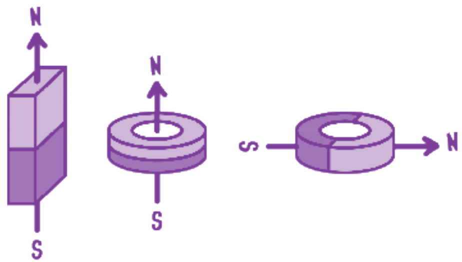
Tinker:

1. Stand one of the ring magnets on its edge on a table surface.
2. Slowly approach it from the top, with the edge of the other ring magnet. How close can you get before the standing magnet starts to spin? Can you steer it with the magnet in your hand?

26. SLOW ATTRACTION

Tinker:

1. Stand one of the ring magnets on its edge on a table surface.
2. Slowly approach it with the edge of the other ring magnet, on the table. How close can you get before the first magnet starts to roll toward you? Can you steer it with the magnet in your hand?



The north and south poles in a magnet are oriented in different ways depending on the shape of the magnet.

27. WHAT'S MAGNETIC?

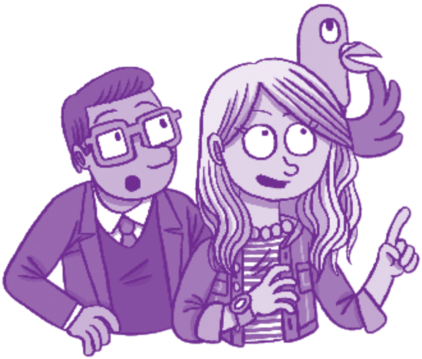
You will need:

- Ring magnet
- *Various household items*

Tinker:

1. Walk around your home with a magnet, holding it up to various objects to see if it attracts them.
2. The following things would be good to investigate as you make your rounds: ceramic, glass, cardboard, paper, plastic, coins, furniture, cutlery, nails, screws, needles, cooking pots, and paper clips.

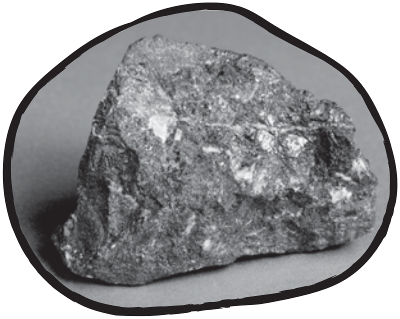
WARNING! Make a wide detour around TVs, computers (especially diskettes and magnetic media), video and music cassettes, and credit and debit cards: The magnet would destroy the data stored on them!



Item tested with the magnet	Did it stick? (Y/N)

WHAT IN THE WOW IS A MAGNET?

Over 2,500 years ago, scientists in **ANCIENT GREECE** made an astonishing discovery: Chunks of certain rocks exert a mysterious power over things made of iron. Since these rock chunks were primarily found near the ancient town of MAGNESIA in Asia Minor, they were called **MAGNETS.** The magnets that people discovered thousands of years ago in nature were made of THE MINERAL MAGNETITE. This mineral, which forms grayish-brown crystals, is composed of iron and oxygen in a very specific ratio. Magnetite is created naturally through volcanic activity.



Today, **PERMANENT MAGNETS** can be produced artificially from compounds of the metals iron, nickel, and aluminum. Permanent magnets possess a magnetic force all on their own — called a magnetic field — and they retain it permanently. Some other metals can be used to create **TEMPORARY MAGNETS,** which are only magnetic when they are around an electrical or magnetic field. This has a lot of useful applications, FROM ELECTRIC DOOR LOCKS TO SPEAKERS.

Whether natural or artificial, permanent or temporary, all magnets have TWO POLES, CALLED THE NORTH AND SOUTH POLES. When a magnet goes near another magnet, and the two poles touching are **OPPOSITE,** the magnets ATTRACT each other. If the two touching poles are **THE SAME,** they REPEL each other.

Materials that react to magnetic fields (whether or not they produce them) are called **FERROMAGNETIC MATERIALS.** The most common ones are iron, nickel, and cobalt. The objects you found around your house that the magnet stuck to most likely contain iron and/or nickel.

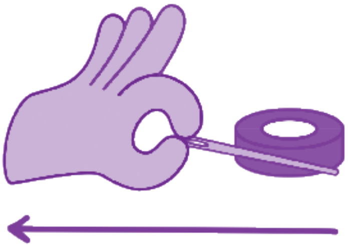
28. MAKING A MAGNET

You will need:

- Needle
- String
- Ring magnet
- *Small magnetic objects (paper clips, iron nails, screws)*

Tinker:

1. Thread about a foot of string through the needle and hold both ends so that the needle hangs from the middle.
2. Slowly move the needle toward the small magnetic objects trying to keep the needle from swinging as much as possible. What happens?
3. Now stroke the needle 50 to 70 times across one of the surfaces of a ring magnet. It's important to always stroke in the same direction.
4. Now repeat step 2. What happens?



Stroke in one direction

MAKE AN OBSERVATION

What wowed you?

WHAT IN THE WOW?

Without the "treatment" with the magnet, the needle won't react much near any of the **ferromagnetic** objects you collected (if it does, the sewing needle must already have had contact with a magnet). After treatment with the magnet, the sewing needle astonishingly retains its **magnetic force** — it is now attracted to the objects. That's because sewing needles are made of steel. Steel has the property of remaining magnetic after being stroked with a magnet.

29. DIY COMPASS

WHAT DO YOU **Wonder?**

You will need:

- Needle
- Ring magnet
- Polystyrene hemisphere
- *Bowl*
- *Water*

Tinker:

1. Stroke the needle 50 to 70 times across one of the surfaces of a ring magnet. It's important to always stroke in the same direction.
2. Push the needle through the center of the polystyrene hemisphere, parallel to the flat side. Fill the bowl with water and float the hemisphere on the water. Be careful not to let the hemisphere touch the sides of the bowl.
3. Now move first one side and then the other side of a ring magnet toward the needle. Note when the pointed tip is attracted to the magnet and when the eye of the needle is attracted to the magnet.
4. Then place the ring magnets far away and pay attention to the direction the needle points after a few minutes.
5. Where does the needle point when it stops moving?

MAKE AN OBSERVATION

What wowed you?

WHAT IN THE WOW?

When a magnet is freely suspended — for instance if you tie a string around it or float it in water — the north pole of the magnet will turn to face the Earth's North Pole, and the south pole will face the Earth's South Pole. By magnetizing the needle and floating it on water, you've built a working **compass!**

CHAPTER 4 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

CHAPTER 5 PHYSICS: STATIC ELECTRICITY

Listen! #11 "Static electricity"

WHAT DO YOU Wonder?

You will need:

- Balloon
- Scoop
- Corn starch
- *Paprika*
- *Plate or bowl*
- *Vegetable oil*

30. JUMPING SPICES

Tinker:

1. Sprinkle a small amount of paprika into the center of a plate or bowl.
2. Fill the balloon with air, and tie the end. Rub it against your hair to charge it. You should notice it clings to your hair, and can even lift strands. You should also be able to feel a light prickling sensation on your fingers when you bring them close to the balloon where you rubbed it.
3. Slowly move the charged balloon toward the paprika. What happens?

31. LIFTING OIL

Tinker:

1. Pour one large scoop of vegetable oil into the center of a plate.
2. Rub the balloon against your hair to charge it.
3. Slowly move the charged balloon toward the puddle of vegetable oil. What happens?

32. MOVING WATER

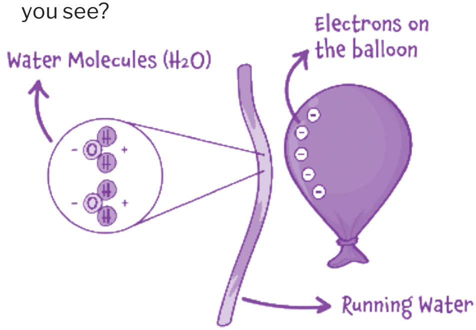
Tinker:

1. Turn on a sink tap a little, so that only a thin stream of water is running out of it.
2. Rub the balloon against your hair to charge it.
3. Slowly move the charged balloon toward the stream of water. What happens?

33. BENDING GOO

Tinker:

1. Mix two large scoops of corn starch with two large scoops of vegetable oil in a bowl and stir until the mixture is smooth.
2. Rub the balloon against your hair to charge it.
3. Scoop a little of the mixture onto the spoon, and drip it back into the bowl while holding the charged balloon very close to it. What do you see?



WHAT IN THE WOW?

These are all demonstrations of something called **static electricity.** It's the same thing that can make a comb lift your hair strands or give you a shock when you touch a car door on a cold day. As you may already know, all materials are made of **atoms:** tiny pieces of matter made up of a positively charged core of **protons** and **neutrons,** and a negatively charged shell of **electrons.** When certain surfaces are rubbed against each other — for instance, the balloon and your hair, some of those electrons are transferred from one surface to the other, making one of them (e.g., your hair) positive, and the other one (e.g., the balloon) negative. Things with opposite charges attract each other, so your hair sticks to the balloon. Paprika, oil, and cornstarch all have positive charges, so they are attracted to the balloon. Water is neutral as it has an equal number of positive and negative charges. When you bring the negatively charged balloon close to a stream of water, the positive charges in water rearrange themselves to face the balloon, making the water bend toward it! When you rub against certain fabrics, your body can pick up extra electrons. Then, when you touch something made of metal with a slightly positive charge, like a doorknob, those electrons jump from your skin and create a spark of electricity. You can sometimes even see a spark if the light is dim and the transfer is strong enough.

MAKE A CONNECTION

With an adult, choose some more materials to test with the charged balloon. How do they react? What does this tell you about them?

Item tested with the balloon	What happened?

CHAPTER 5 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

Listen! #12 "Surface tension"

WHAT DO YOU **Wonder?**

You will need:

- Pipette
- Test tube
- *Coin*
- *Plate*
- *Water*
- *Dish soap*

34. WATER MOUNTAIN

Tinker:

1. Place the coin in the center of the plate.
2. Pour some water into a test tube.
3. Use the pipette to add water to the top of the coin one drop at a time. How much can you add before it spills over?

Wonder: PREDICT WHAT WILL HAPPEN

Read the experiment steps below and form a hypothesis. What do you think will change?

35. DROP THE TENSION

Tinker:

1. Use the same setup as the previous experiment, but now add a few drops of dish soap to the water and mix it.
2. Use the pipette to add soapy water to the top of the coin one drop at a time. How much can you add now before it spills over?

WHAT IN THE WOW?

The surface of water has a special property called **surface tension** that holds water droplets together. You can imagine it like a type of skin formed by bonds between the molecules. This is because water molecules are **polarized,** meaning they have a positively charged end and a negatively charged end. You learned about opposites attracting in your experiments with magnets. Polarized molecules behave in a similar way. When molecules of the same substance stick together, it's called **cohesion**. This is what makes it possible for water droplets to be pulled across smooth surfaces or be "piled" into a mound.

Soap is a type of substance called a **surfactant**. Surfactant molecules have one end that's **hydrophilic** (which means it likes to bond with water) and one end that's **hydrophobic** (meaning it repels water). Surfactant molecules surround the water molecules and weaken the bonds between them, disrupting their cohesion and lowering the surface tension. This is why the soapy water can't form a mound as well as the pure water can.

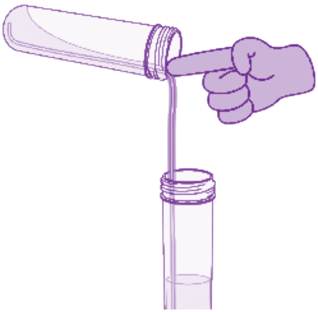
36. STRINGING ALONG

You will need:

- 2 Test tubes
- Test tube stand
- String (2 ft.)
- *Water*

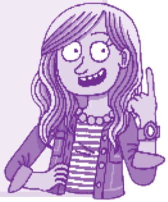
Tinker:

1. Set up your experiment over a basin, sink, or absorbent towels, as some water will likely spill.
2. Soak the string with water. Make sure it is saturated.
3. Fill one test tube about halfway with water. Put the other test tube in the stand.
4. Put one end of the string into the test tube with the water so that it is touching the bottom, and put the other end into the empty test tube. You may double up the string if it feels too long to handle.
5. Holding the test tube with water above and to the side of the empty test tube, slowly pour the water down the string. Use your finger to hold the string against the lower lip of the test tube as you do this.



MAKE A CONNECTION

What does this make you wonder?



WHAT IN THE WOW?

As you just learned, water has **cohesive** properties that cause its molecules to stick together. It also has **adhesive** properties, which allow it to stick to other types of molecules. In this case, the water molecules stick to the string they are being poured down. Soaking the string in water makes the effect stronger because you are taking advantage of both the cohesive and adhesive properties of water.

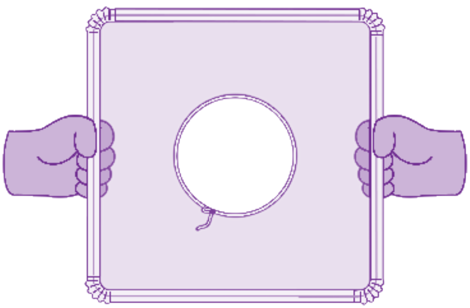
37. A PERFECT CIRCLE

You will need:

- » **Piece of string (about 4 in.)**
- » **Piece of string (about 6 in.)**
- » **4 Drinking straws**
- » *Water*
- » *Dish soap*
- » *Wide bowl or casserole dish*
- » *Scissors*
- » *Plate*
- » *Pencil*

Tinker:

1. Measure three cups of water and a half cup of dish soap into your bowl or casserole dish and mix together.
2. Cut a slit into the short end of each drinking straw so that it can be compressed to a narrower dimension. Form a square frame by pushing the compressed short end of each straw into the long end of the next one.
3. Tie the strings into circles. Ask an adult if you need assistance. Cut off any extra string ends. Soak the strings in the soapy water.



Wonder: PREDICT WHAT WILL HAPPEN

What will happen when the string loops are dropped into the bubble frame?

4. Remove the strings from the soapy water and place them on the plate. Float the straw frame in the soapy water and then slowly remove it, pulling straight upward, so that a bubble stretches across it.
5. Gently place one of the string circles into the frame. If it gets stuck together or folds over, gently open it with the point of your pencil.
6. Now try adding the second string circle.

WHAT IN THE WOW?

One of the other effects of surface tension is that it causes a liquid's surface to shrink to the **minimum surface area** possible. In this case, the string is stretched into a perfect circle — the size of the hole is maximized because the surface area of the liquid is minimized. This property also explains why bubbles and droplets of water are round. A **sphere** has the smallest possible surface area for a given volume.

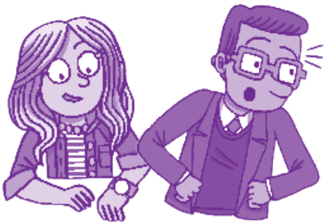
38. CAPILLARY RAINBOW

You will need:

- Crepe paper (red, yellow, blue)
- *Water*
- *5 Drinking glasses*
- *4 Facial tissues*

Tinker:

1. Fill three glasses with water.
2. Add a one-inch strip of red crepe paper to the first glass, yellow to the second glass, and blue to the third glass. Mix each until the color has diffused throughout the water. Then remove the paper.
3. Place the five glasses in a row as follows, leaving a small gap between them: red water, empty, yellow water, empty, blue.
4. Fold one of the tissues into a one-inch-wide strip and fold it in the middle to form a V shape.
5. Put one end in the glass with the red water and the other half in the empty glass next to it. Repeat with the other three tissues to connect all the glasses together:
   red ↔ empty ↔ yellow ↔ empty ↔ blue
6. Leave the glasses like this and check on them in a few hours. What happened?



MAKE A CONNECTION

What color is the water in the glasses that started out empty? What else is going on here?

WHAT IN THE WOW?

This experiment demonstrates **capillary action,** which is the movement of liquids through narrow spaces regardless of gravity. This is made possible because of surface tension and adhesion. You can see a less dramatic demonstration of this phenomenon if you put a clear straw into a glass of water. The water in the straw will form a small crater (called a **concave meniscus**) and will be higher than the water in the glass outside the straw. The pores in materials like a tissue act the same way, but they're small enough to be filled up with water and overflow into the next pore. This forms a chain reaction where the water molecules pull each other from pore to pore, slowly climbing up the tissue and then down into the next glass. This is also how paper towels and sponges work to absorb liquid.

39. BIGGEST DROP

You will need:

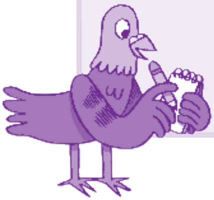
- Hydrophobic sand
- Pipette
- Beaker
- *Water*
- *Plate*

Tinker:

1. Fill the beaker with water. Make a mound of hydrophobic sand on the plate.
2. Use your finger to make a wide crater in the mound.
3. Use the pipette to slowly add drops of water to the sand crater. How big can your water drop get?

MAKE AN OBSERVATION

Draw a picture of what you see.
What wowed you?



40. DRY SAND

You will need:

- Hydrophobic sand
- Beaker
- Scoop
- *Water*

Tinker:

1. Fill the beaker three-quarters full of water.
2. Take a large scoop of hydrophobic sand.
3. Slowly lower the scoop into the water, being careful not to spill it.
4. Lift the scoop out of the water. What do you notice about the sand?

WHAT IN THE WOW?

The word **hydrophobic** comes from the Ancient Greek words **hydro** meaning “water” and **phobia** meaning “fear.” Materials that are hydrophobic are repelled by water, which means water doesn’t stick to them. On the other hand, things that are **hydrophilic** (meaning water-loving) attract water. Sand isn’t naturally hydrophobic, but this sand is coated with a hydrophobic oil. Water can’t bond with the oil. When you submerge the sand underwater, the grains all try to avoid getting wet. This causes them to stick as closely together as possible, and prevents them from falling off the scoop. And when you remove the sand from the water, you can see they were successful — the sand is dry!

CHAPTER 6 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

41. HAZY TO CLEAR

Listen! #13 "Mixing it up"

WHAT DO YOU **Wonder?**

You will need:

- 2 Test tubes
- 2 Test tube stands
- Beaker
- Scoop
- Calcium chloride
- Citric acid
- Sodium carbonate
- Craft stick
- *Water*

Tinker:

1. Measure 20 ml of water and pour it into the first test tube.
2. Add four small scoops of calcium chloride and stir until it's completely dissolved.
3. Measure 50 ml of water and pour it into the second test tube. Add one large scoop of citric acid and stir until it's completely dissolved.
4. Measure 20 ml of water in the beaker and add two small scoops of sodium carbonate. Stir until completely dissolved.
5. Pour the solution from the first test tube (the one with less liquid) into the beaker. What happens?
6. Pour the solution from the second test tube into the beaker. What happens?

MAKE AN OBSERVATION

What wowed you?

WHAT IN THE WOW?

When you add the calcium chloride solution to the sodium carbonate solution, a **chemical reaction** occurs that creates two products: sodium chloride — also known as table salt — and a **precipitate** called calcium carbonate. Calcium carbonate is not **water-soluble,** meaning it doesn't dissolve in water, so it forms tiny solid granules that make the solution look cloudy. This is the same material that eggshells and pearls are made of. Sodium chloride is water-soluble, so you won't see any salt crystals. When you add the acidic solution of citric acid, it breaks down the calcium carbonate and forms new products: calcium citrate, carbon dioxide, and water. Calcium citrate is water soluble, and the carbon dioxide escapes the solution as little bubbles of gas. The solution becomes clear again!

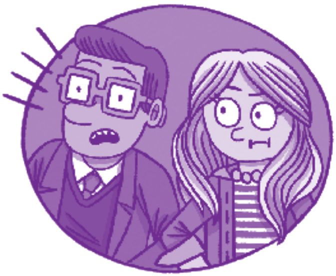
42. GOOEY EGGS

You will need:

- Pipette
- Beaker
- Scoop
- Calcium chloride
- Sodium alginate
- Craft stick
- *Water*
- *Paper towel*
- *Plastic cup*

Tinker:

1. Fill the cup with 150 ml of water, then add two small scoops of calcium chloride and stir until the powder dissolves.
2. Add about ten small drops of sodium alginate to the solution using the pipette.
3. Scoop out a couple of your newly-formed "eggs" and squeeze them. What happens?
4. Take about half the remaining eggs out of the solution and place them on a paper towel to save for the next experiment. Then let the remaining eggs soak for another two minutes.
5. Take the remaining eggs out and squeeze them. Has anything changed?



43. EGG IN AN EGG

You will need:

- Materials from experiment 42, including calcium chloride solution and alginate eggs

Tinker:

1. Fill the large scoop with sodium alginate, then sink one of the eggs from the previous experiment into it.
2. Slowly lower the scoop into the calcium chloride solution and wiggle it around to release the sodium alginate.
3. Let it soak for 30 seconds and then remove it from the solution.
4. Squeeze your big egg to release the little egg inside!

Wonder: TRY CHANGING A VARIABLE

Repeat the experiment with very cold water and then with hot water. Does anything change?

44. GLOW WORMS

You will need:

- Scoop
- Beaker
- Calcium chloride
- Sodium alginate
- Glow-in-the-dark powder
- Petri dish
- *Water*
- *Plastic cup*

Tinker:

1. Using the beaker to measure, fill one cup with 150 ml of water, then add two small scoops of calcium chloride and stir until the powder dissolves.
2. Put two small scoops of the glow-in-the-dark powder into the petri dish and place it in the sun or under a lamp for at least five minutes.
3. Carefully unscrew the lid of the sodium alginate and add the energized glow-in-the-dark powder to it. Screw the cap on tightly and shake well to mix. Shake until you don't see any lumps of the powder in the bottle.
4. Using steady pressure, squeeze a long stream of sodium alginate into the calcium chloride solution. Repeat until you have several strands.
5. Turn off the light and look at your strands. Scoop them out and put them under a lamp again if they stop glowing.

WHAT IN THE WOW?

When the sodium alginate solution comes into contact with calcium chloride, a jelly-like solid precipitate forms around a liquid core. In molecular gastronomy, or scientific cooking, this technique is called **spherification.** When the calcium ions come into contact with the alginate, they insert themselves between the individual alginate strands, forming molecules of calcium alginate. The egg's shell consists entirely of these molecules connected together, creating a giant molecule called a **polymer.** The longer you leave the alginate eggs to soak in the solution, the further the calcium can soak into the alginate, and the thicker the shell becomes. You may be asking, if the calcium and alginate make calcium alginate, what happens to the chloride and the sodium? They combine to make sodium chloride again! When you squeeze the sodium alginate into the calcium chloride solution in a long strand, the exact same process occurs, but the strands are thinner, so the calcium can get all the way to their centers much faster and make them solid all the way through. One of the most useful properties of polymers is their ability to form very long and strong chains. DNA is a polymer, and so is hair and fur. Artificially manufactured polymers are also used to make all kinds of plastics, from polyester fabrics to airplane parts.

You'll learn how things glow in the dark in experiment 68.

CHAPTER 7 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

Listen! #14 "Your building blocks"

WHAT DO YOU Wonder?

You will need:

- **Plastic ruler**
- **String**
- *2 Eggs*
- *2 Clear plastic cups*
- *Corn syrup*
- *White vinegar, apple cider vinegar, or rice vinegar*
- *Soup spoon*
- *Sticky notes or paper and tape*
- *Pen*
- *Paper towels*
- *Water*
- *Distilled water*

45. NAKED EGG OSMOSIS I

Tinker:

1. Copy the table to the right onto two sticky notes and stick one to each cup.
2. Measure the circumference of each egg using the string and the ruler. Gently wrap the string around the middle of the egg, and mark the spot where the string overlaps its own end. Then use the ruler to measure the distance from the end of the string to the mark. Note your results on the label for each egg's cup. If you have a kitchen scale, you can also weigh the eggs when you measure them in this experiment and the following two experiments.
3. Place one egg in each cup and pour enough vinegar into each cup to cover the eggs. You may want to double the number of eggs and cups so you can have backups in case an egg breaks later in the experiment.
4. Leave the eggs in the refrigerator overnight.
5. The next day, carefully remove the eggs from the vinegar with the soup spoon. Pour the vinegar down the drain or keep it to use as plant fertilizer (some plants love the calcium from dissolved eggshells — you should dilute 10 ml of eggshell vinegar with 1 L of water). Then, put the eggs back into the cups. Cover again with fresh vinegar and refrigerate.
6. Check the eggs every morning until the shell has dissolved and they're translucent. You only have to replace the vinegar after the first day.
7. When the eggs are ready, carefully remove them from their vinegar baths and place them on a paper towel. Measure their circumference again and note it on the tables.
8. Rinse out the cups to prepare for the next experiments.

Liquid	Starting circumference	Ending circumference
Vinegar	___ cm	___ cm
Corn syrup	___ cm	___ cm
Distilled water	___ cm	___ cm

46. NAKED EGG OSMOSIS 2

Tinker:

1. Place the naked eggs back into their cups and pour in enough corn syrup to cover the eggs. If you prepared extra eggs, cover those with water instead of corn syrup.
2. Place the eggs in the refrigerator for 24 hours.
3. Carefully remove the eggs from the corn syrup and rinse them off with warm water.
4. Measure their circumference again and note it on the tables.
5. Wash out the cups to prepare for the next experiment.

47. NAKED EGG OSMOSIS 3

Tinker:

1. Return the shriveled corn syrup-soaked eggs to their cups and cover with distilled water.
2. Wait 24 hours and then measure and note their circumference again. What happened?
3. If you have extra eggs, you can experiment with different liquids. What happens if you soak them in oobleck, or in salt water with a couple drops of food coloring? What about if they're buried in salt?

WHAT IN THE WOW?

When the egg's shell is dissolved in vinegar, what remains is a thin **semi-permeable membrane** encasing the inside of the egg. This membrane allows liquid to move through it in a process called **osmosis.** Osmosis is the movement of a liquid through a membrane from an area with a higher ratio of water to **solutes** — dissolved particles — to an area with a lower ratio of water to solutes. The process of osmosis is always trying to find a balance where the same ratio of water to solutes exists on either side of the membrane.

The egg has a lot of solutes in it, so when it's floating in vinegar, which is mostly water, some of the water from the vinegar passes into the egg through its membrane, and the egg gets bigger. The opposite happens with the corn syrup. Corn syrup has a lot of dissolved sugars — that's why it's so thick — and so the water from inside the egg moves out of the egg into the sugar. When you put the egg into water, the process reverses again, and the egg plumps up!

48. TURGOR PRESSURE I

You will need:

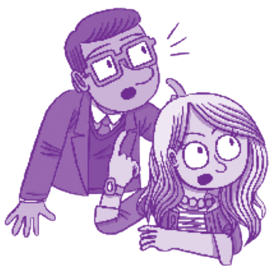
- **Beaker**
- **Scoop**
- **Plastic ruler**
- *Potato*
- *Water*
- *Salt*
- *Knife*
- *Plastic cup*
- *Cutting board*
- *Paper towel*

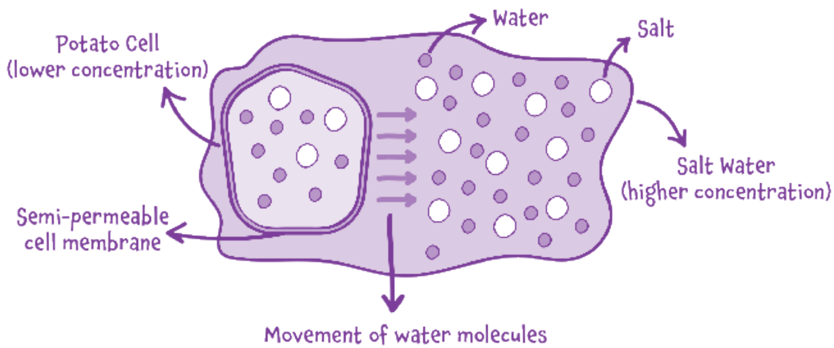
Tinker:

1. Have an adult help you peel the potato and cut it into sticks like french fries. Use the ruler to trim the pieces so they are all the same length. Note your measurement.
2. Using the beaker, measure 100 ml of water and pour it into the cup. Then add four large scoops of salt and stir until the salt dissolves.
3. Pick up the potato slices and note how they feel. How bendy are they? Are they firm or squishy?
4. Put several potato slices into the cup with the salt solution. Leave them for at least half an hour, and then remove them and place them on the paper towel. How do they feel now?
5. Measure the length of the potato pieces again. Has anything changed?

MAKE AN OBSERVATION

How do the potato pieces feel before you put them in the salt solution? What about after?





49. TURGOR PRESSURE 2

You will need:

- Potato sticks from experiment 48
- Crepe paper (red)
- *Water*
- *Paper towel*

Wonder: PREDICT WHAT WILL HAPPEN

What do you think will happen when you soak the potato pieces in fresh water? If you've done experiments 45-47, think back to what happened to the eggs.

Tinker:

1. Pour 100 ml of water into the beaker and add a one-inch piece of the crepe paper. Wait until the color has diffused into the water, then remove the paper, making sure to wring out as much water as possible.
2. Pour the fresh, dyed water into a clean cup.
3. Put your potato pieces from the last experiment into the cup, and wait at least 30 minutes.
4. Remove the potato pieces from the cup. How do they feel? What else do you notice?
5. Measure the potato pieces.

WHAT IN THE WOW?

Eggs are made up of many cells, but for the purposes of the previous experiments, the egg acted as a **model** of a single cell — models allow us to see a clearer, simplified version of complicated processes. Potatoes are also made up of many cells, and their cells have semipermeable membranes that act similarly to how the egg's membrane acted. Unlike animal cells, plant cells have cell walls, which gives their cells a more rigid shape.

When the potato pieces are soaked in salt water, the water inside their cell membranes is drawn out via osmosis, causing the membrane to pull away from the cell wall. This lowers their **turgor pressure** — the pressure inside the plant cell that keeps it firm. When the turgor pressure is low, plants wilt and become floppy, like the pieces of potato. When the potato pieces are put into fresh water, osmosis draws water back into the cells, making the potato pieces more firm and rigid in comparison. You can see how the dye was pulled into the cells along with the water.

Here's a useful culinary tip: if you want vegetables to be more crispy when they're fried or baked, you can salt them to draw water out before cooking. On the other hand, if you have some carrots or celery that's starting to get a little rubbery, you can put them in a cup of water to make them crunchy again. Science and snacks!

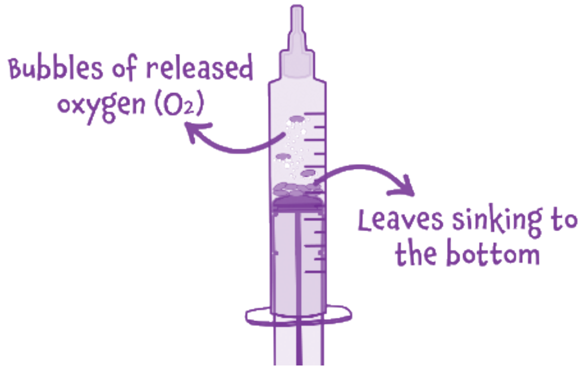
50. FLOATING LEAVES

You will need:

- Beaker
- Scoop
- Syringe
- Drinking straw
- Sodium bicarbonate
- *Spinach leaves*
- *Water*
- *Dish soap*
- *Measuring cup*
- *Plastic cup*
- *Optional: Desk lamp with incandescent or 100-watt equivalent light bulb*
- *Craft stick*

Tinker:

1. Use the drinking straw to stamp out ten circles from your spinach leaves by pressing down with the ends of the straw.
2. Remove the plunger from the syringe, put the end of the straw into the syringe, and blow the leaf disks gently into the syringe.
3. Using a measuring cup, fill the plastic cup with one cup of water and add one small scoop of sodium bicarbonate and a couple of drops of liquid dish soap. Stir gently, trying to avoid making suds.
4. Gently pour 100 ml of the solution into the beaker, trying to avoid making suds.
5. Replace the plunger in the syringe, being careful not to damage any of the leaf disks.
6. Put the end of the syringe into the beaker and carefully draw 6-8 ml of the solution into the syringe. The leaf disks should float.
7. Hold the syringe with the tip up and gently compress the plunger to remove all the air. Stop as soon as you see some liquid escaping.
8. Plug the tip of the syringe with your thumb and gently pull the plunger. Hold for a few seconds and then release the plunger. The plunger will be pulled quickly back by the vacuum you created. When you do this, you should see tiny bubbles coming off the disks when you pull on the plunger, and some of the disks should sink when you release it.
9. Repeat step 8 until all of the disks sink to the bottom of the solution. You may need to tap on the plunger to dislodge some of the bubbles.
10. Carefully remove the plunger and pour the leaf disks and solution into the beaker. They should sink to the bottom of the beaker. If any disks float, remove them.
11. Set your beaker outside in the sun. If there's no sunshine available, set up your desk lamp about a foot from the surface of the table and turn it on. Place your beaker below it. How long does it take for the disks to float again?



Wonder: WHAT HAPPENS NEXT?

When all of the disks are floating, put the beaker somewhere dark. What happens?

WHAT IN THE WOW?

As you may already know, plants transform energy from sunlight into food — sugars they use to fuel their cells — and oxygen through a process called **photosynthesis.** The other important ingredient in this process is carbon dioxide, a gas that animals (including you!) exhale when they breathe. As you've seen in some of your chemistry experiments, carbon dioxide can also be formed by mixing sodium bicarbonate and water. Plant matter usually floats, because there's oxygen between plant cells. However, when you created a vacuum with the syringe, you removed all of that oxygen, so the leaf disks sink. When you put the leaf disks under a lamp, the process of photosynthesis starts again. Slowly, they begin using the carbon dioxide in the solution and the energy from the light to produce sugars and oxygen. The little bubbles of oxygen stick to the plant leaves, causing them to float. While plants are photosynthesizing, they're also **respirating.** This is the process that breaks down the sugars they created to be used as energy for their cells. Respiration uses oxygen, but as long as the plants are photosynthesizing, they're producing more oxygen than they're using. If you put the beaker somewhere dark, the leaf disks can't photosynthesize anymore, so they have to use the oxygen they already have. As the little bubbles of oxygen are used up, the leaf disks sink back down to the bottom of the beaker.

51. STRAWBERRY DNA

You will need:

- **Magnifying glass**
- **Petri dish**
- **Scoop**
- **Beaker**
- **Craft stick**
- *Water*
- *Salt*
- *2 Strawberries (fresh or frozen) with the greens removed*
- *Dish soap*
- *Coffee filter*
- *Rubbing alcohol*
- *2 Plastic cups*
- *Plastic bag*

Tinker:

1. Place the strawberries in the plastic bag and smash them until they're a smooth pulp.
2. Add two large scoops of salt and three large scoops of dish detergent to one of the plastic cups. Then use the beaker to measure and add 120 ml of water and stir gently until salt dissolves.
3. Pour the solution into the bag with the strawberries, and gently massage to mix well. Try not to create too many bubbles.
4. Place the coffee filter over the opening of the second plastic cup and slowly pour your strawberry mixture into it. You may ask a friend for help holding the coffee filter in place. Wait for the liquid to drip through the coffee filter.
5. Remove the coffee filter and pour an amount of rubbing alcohol equal to the strawberry liquid into the cup.
6. Gently swirl the cup until you see pale strands and clumps forming toward the top of the liquid. That's DNA!
7. Use the stirring tool to gently lift the DNA out of the liquid and place it in the petri dish. You can use your magnifying glass to examine it.

WHAT IN THE WOW?

Have you ever wondered why you get only tomatoes from tomato plants, and only potatoes from potato plants? Rabbits have rabbit babies and humans have human babies. Did you ever wonder why tomatoes don't have rabbit babies? It has to do with a gigantic programming code inside all living things. Science has been tracking this code down for over 150 years. Today it is finally clear where it is located. It is even possible to isolate the material that contains this program. If everything has gone according to plan, you should see some pale threads. If you can't see anything, put the cup in the freezer. After a few hours, you will see fine white threads and flakes in the cup. They are none other than the fabled genetic material: **DNA.** You have isolated the code that makes strawberries come from strawberries! In the watery strawberry solution, the genetic material is finely dissolved and thus evenly distributed and invisible to us. But when the material is surrounded by cold alcohol, it balls up and separates from the liquid. This is similar to the way that sour milk curdles when you pour it into hot coffee.

CHAPTER 8 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

WHAT DO YOU **Wonder?**

You will need:

- String
- *Metal spoon*
- *Utensils of different sizes and materials: larger and smaller spoons, forks, wooden or plastic utensils, etc.*

52. RINGING BELL

Tinker:

1. Knot the middle of a two-foot piece of string securely around the handle of the spoon. Ask an adult for help if you need it.
2. Wrap one end of the string around the tip of your left pointer finger and the other end around your right one. Stand in front of a chair or a table, and let the spoon swing against it.
3. Next, place your wrapped fingers in your ear, and let the spoon swing against the surface again. What do you observe?

53. SPOON SYMPHONY

Tinker:

1. Follow the same procedure as the previous experiment with different utensils. What do you notice? Are there any patterns or clues you can use to predict what sound each utensil will make?

MAKE AN OBSERVATION

Which utensil materials make the loudest noises? Which ones are quietest?

WHAT IN THE WOW?

You only heard a soft clinking at first, but when you put your fingers in your ears, the soft clinking became a loud chime. The **vibrations** from the spoon travel faster through the solid string and reach your ears with more energy. When you experimented with other utensils, you probably noticed that metal is louder than wood or plastic. This is because metal conducts sound very well.

54. "TIN CAN" TELEPHONE

You will need:

» String » *2 Plastic cups*

Tinker:

1. Ask an adult to help you punch a small hole in the bottom of each cup that's just big enough to thread the string through. Use the longest length of string you have from this kit, or use your own string. The "tin can" telephone can work at very long distances!
2. Thread each end of the string through each cup and tie enough knots to hold it securely in place.
3. Get a friend to hold one of the cups, and walk far enough away from them with the other cup that the string becomes taut. Have your friend hold their cup to their ear while you speak into yours. You don't have to shout! Then switch roles.

WHAT IN THE WOW?

The sound of your voice travels along the string and can be heard at almost the same volume at the other end of the string. Before electric telephones existed, people used devices that worked on this principle — like speaking tubes and acoustic telephones — to be able to have conversations from up to a quarter mile away.

55. BALLOON MUSIC

You will need:

» Balloon

Tinker:

1. Blow up a balloon with air, but don't tie the end; just pinch it so the air does not escape.
2. Ask someone to hold the balloon. With the air still sealed inside, pull the two sides of the balloon opening outward then let the air leak out.
3. Try pulling the sides by different amounts. What do you notice?

WHAT IN THE WOW?

The size of the balloon's opening changes the sound it makes because it controls how fast the air rushes out. A small opening makes a high-pitched squeal, while a big opening creates a lower, whooshing sound! Your vocal cords work very similarly!

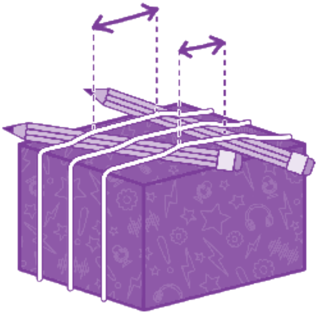
56. DIY GUITAR

You will need:

- Folding box from die-cut sheet
- 3 Rubber bands
- *Tape*
- *2 Pencils*

Tinker:

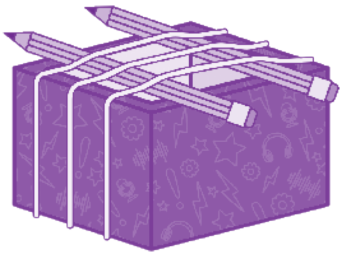
1. Assemble the box from the die-cut cardboard sheet using tape.
2. Stretch the rubber bands around the shorter edges of the box, parallel to the longer edges. With the base of the box facing up, insert one pencil at each end underneath and perpendicular to the rubber bands.
3. Pluck the rubber bands. Do they all make the same note, or are they different?
4. Angle one of the pencils so that the eraser end is closer to the other pencil. Now pluck the strings again. What changed?
5. Keep adjusting the angle of the pencils and testing the notes. What do you notice? What if you place the pencils and pluck the bands on the hollow side of the box?



WHAT IN THE WOW?

As you learned in the balloon music experiment, faster vibrations make **higher-pitched sounds.** Tighter rubber bands vibrate faster and make higher-pitched sounds. But the length of the vibrating part also matters — shorter sections make higher pitches! When the pencils are straight, the vibrating sections of all the rubber bands are the same length making them sound similar. When the pencils are angled, it makes the vibrating section of some rubber bands shorter, changing the pitch. Violins, guitars, harps, and pianos (pianos are full of strings that are hit when you hit the keys) rely on both the amount of tension a string has and the length that's vibrating to change the pitch.

When you stretch the rubber bands over the hole, the sound gets louder, just like a guitar's sound hole helps amplify its music!



CHAPTER 9 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WHOOPS!

WOW!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

CHAPTER 10 PHYSICS: OPTICS

Listen! #16

"Lenses and mirrors"

WHAT DO YOU **Wonder?**

You will need:

- This journal
- Magnifying glass
- Plastic ruler
- Dino figurine

57. READY FOR MY CLOSEUP

Tinker:

1. Place the big lens of the magnifying glass on top of the monkey.
2. Holding the handle, slowly lift the magnifying glass away from the page, keeping it centered over the monkey.

Wonder: TRY CHANGING A VARIABLE

How far away do you get before the monkey becomes blurry? Try closing one eye. How does that change what you see? Try seeing the monkey through the small lens. What changed?

58. WORLD UPSIDE DOWN

Tinker:

1. Place the dino figurine on a table.
2. Holding the magnifying glass at arm's length, position it so that it is about six inches from the dino figurine.
3. Look through the big lens as you slowly back away, keeping the distance between the lens and your eye constant.
4. What does the dino look like when the lens is about one foot away?
5. Now go outside or look out the window at an object in the distance. What does the world look like when you look at it through your magnifying glass?

WHAT IN THE WOW?

A magnifying glass is **biconvex,** which means both sides bulge out. When a magnifying lens is close to an object of interest, the object is enlarged and in focus. But when the object of interest is further away, the image you see is flipped both vertically and horizontally.

The shape of the lens causes the rays of light that pass through it to **refract** — or bend. But because our brains think all light rays always go straight, our eyes see either **enlarged** or **inverted** images through the lens, depending on the distance of the object from the lens.

59. DIY MAGNIFIER

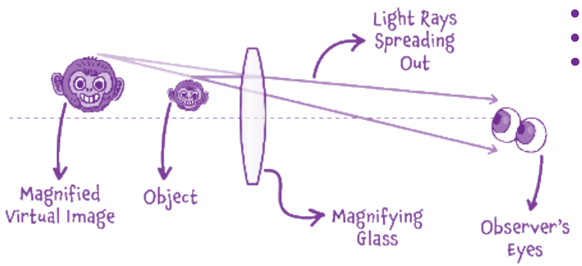
You will need:

- This journal
- Water
- *Clear, round drinking glass (without facets or decorations)*

Tinker:

1. Fill the glass with water.
2. Stand this journal up on the table.
3. Place the glass in front of the journal and look at the monkey on the previous page.

WHAT DO YOU **Wonder?**



A ray diagram showing how a magnifying glass produces enlarged images.

60. DIY LENS

You will need:

- This journal
- Transparent putty
- Petri dish

Tinker:

1. Take a small piece of transparent putty and form it into a ball with a diameter of about one centimeter (half an inch).
2. Place the ball in one side of the petri dish.
3. Wait about ten minutes and watch what happens to the ball.
4. Hold the petri dish over the previous page and look at the monkey through the putty.
5. Pick up an object you want to observe more closely and look at it through the putty.

WHAT IN THE WOW?

The water glass acts like a **convex lens,** bending light rays inward and creating a magnifying effect. The putty also creates a convex lens that works similarly.

Your eyes do the same thing — focusing light on the retina. Far-sightedness and near-sightedness happen when the shape of a person's eye causes light to focus in the wrong place instead of directly on the retina, so contact lenses and glasses are used to correct that focus.

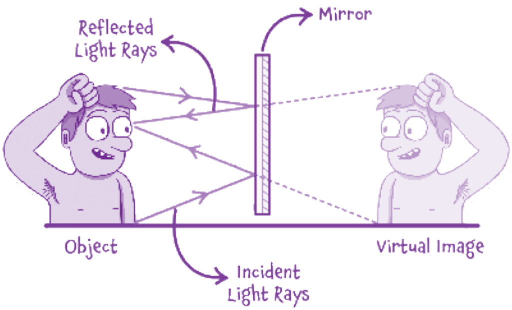
61. INFINITE REFLECTION

You will need:

- » **Mirror with hole**
- » *Household mirror*

Tinker:

1. Remove the protective film from the reflective side of the mirror with the hole and discard the film.
2. Stand in front of a mirror in your house, like the one in your bathroom or in your bedroom. Hold the mirror with the hole in front of one of your eyes so that the reflective side is facing in the direction of your household mirror.
3. In your household mirror, look at the reflection of the mirror with the hole. What do you see? Try moving closer and further away from your household mirror. What changes do you observe in the reflection?

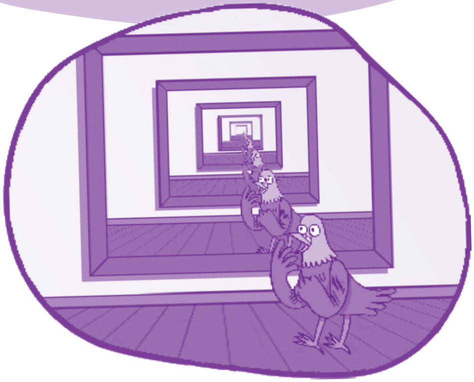


A ray diagram showing how we see reflections in a plane mirror.

WHAT IN THE WOW?

If you hold the mirror so that it is completely parallel to the household one, the light and the image will be reflected again and again. You are looking at infinity!

How is it that we can see ourselves in a mirror at all? **Light** is needed to be able to see. When a beam of light hits something, part of the light is **absorbed** and part is **reflected.** For a surface to be a reflective surface, it must reflect as much light as possible. But a white sheet of paper also reflects a lot of light. However, we are not reflected in it because the paper surface is rough and uneven. The individual rays of light are reflected back in all directions in a disordered manner. A mirror, on the other hand, is very smooth, so it reflects light in an orderly fashion. Each ray of light leaves the mirror at the same angle as it entered and then hits our eye as a reflection.



You will need:
- » Mirror with hole
- » *Household mirror*

62. CONCAVE MIRROR

Tinker:

1. Gently squeeze the sides of the mirror together so that the center curves toward your household mirror. What happens to your reflection?

63. CONVEX MIRROR

Tinker:

1. Gently gently squeeze the sides so that the center curves toward you. What do you see?

WHAT IN THE WOW?

You're probably familiar with the wavy mirrors in a fun house. They distort your reflection. When you look at yourself through a **convex mirror,** you look shorter and wider than you really are. When you look at yourself through a **concave mirror,** you appear taller. Concave and convex images focus and reflect the light that hits them differently from ordinary, flat mirrors.

MAKE AN OBSERVATION

Draw a picture of what you see in each scenario

FLAT MIRROR	CONCAVE MIRROR	CONVEX MIRROR

64. DISAPPEARING COINS

You will need:

- **Mirror without hole**
- **Die-cut box**
- *Coins*

Tinker:

1. If you have not already, assemble the die-cut box, and remove the small and large rectangles from the sides. (Leave the box top open for now.)
2. Remove the protective film from the mirror without the hole.
3. Add the mirror (without hole) to the box on a diagonal with the reflective side facing down.
4. Close the box and place it on a surface so that it is at your eye-level, with the hollow side facing you.
5. Place coins into the slot.

WHAT IN THE WOW?

The inserted coins seem to disappear. The coins fall behind the mirror, but the mirror is positioned in the box in such a way that it reflects the underside of the box, making it practically invisible. This is also how a magician's disappearing cabinet works!

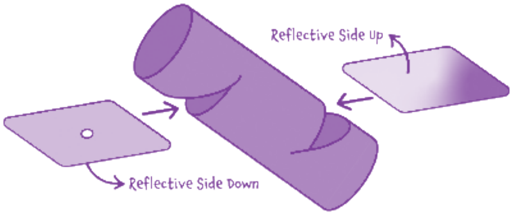
65. PERISCOPE

You will need:

- **Mirror without hole**
- **Mirror with hole**
- *Paper towel roll*
- *Scissors*

Tinker:

1. Have an adult cut slots into a paper towel roll as shown below.
2. Place the two mirrors into the slots.
3. Use your periscope to peer around corners, high places you can't reach or out of the top of a fort.



WHAT IN THE WOW?

The two mirrors in your periscope are positioned at parallel 45° angles. The light from the opening of the tube hits the mirror further from you, which then bounces the light to the mirror closer to you, allowing you to see an image around the corner.

CHAPTER 10 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

Listen! #17

"What makes a rainbow?"

WHAT DO YOU **Wonder?**

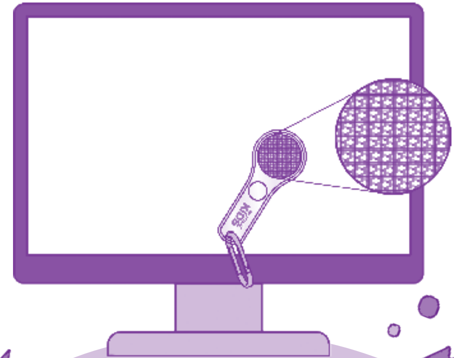
66. PEEP THE PIXELS

You will need:

- Magnifying glass
- *TV screen or computer monitor*

Tinker:

1. Find a white area on a computer monitor or TV screen.
2. Look at the screen through the small lens of your magnifying glass, and adjust the position of the lens until the image is as large as it can be while still being in focus.



WHAT IN THE WOW?

On your computer screen, all the different colors are made by mixing the three basic **colors of light: red, green, and blue.** Study a white section of your screen image with the magnifying glass. Through the magnifying glass, you can see small dots of red, green, and blue. Without the magnifying glass, however, the eye can't separate the colors, and only perceives them as mixed — which is why this part of the screen looks white.

MAKE AN OBSERVATION

Draw what you see.

67. REVEAL A RAINBOW

You will need:

- Petri dish
- Filter paper
- Pipette
- *Black water-soluble marker*
- *Water*

Tinker:

1. Take one of the sheets of filter paper and draw a circle in the middle about 2 cm (less than 1 inch) in diameter. Be sure to use a water-soluble marker. Then place the filter paper on the petri dish.
2. Use the pipette to add three to four drops of water to the middle of the circle, and observe what happens.
3. You can use the other two filter papers to repeat the experiment or to try it with other markers.

WHAT IN THE WOW?

The process you used to separate the ink is called **chromatography.** That word comes from Greek and means "to write with colors." This process is used to determine what ingredients are in a mixture, and to separate them from each other. The "black" ink in your marker is actually a mixture of many colors. Water acts as a dissolving agent and draws the different colors out to different distances, "writing" with them on the filter paper.

68. HIGH ENERGY LIGHT

You will need:

- Petri dish
- Glow-in-the-dark powder
- *Flashlight*
- *Sunlight*

Tinker:

1. Put one small scoop of glow-in-the-dark powder in the bottom of the petri dish.
2. Shine a regular flashlight (from home) on the powder for one minute to charge it, then bring it into a dark room. How well does the powder glow?
3. Put the powder in direct sunlight for one minute, then bring it into a dark room. How well does the powder glow? Save the powder for the next experiments.

Wonder: TRY CHANGING A VARIABLE

What happens if you use different kinds of lights? What about different amounts of charging time for the powder? Copy this table to record your findings.

Light source	Charging time	Results

69. TUBE OF LIGHT

You will need:

- Test tube
- Glow-in-the-dark powder
- Scoop
- Petri dish
- *Water*

Tinker:

1. Fill the test tube about halfway with water.
2. Add half of a small scoop of glow-in-the-dark powder to the petri dish and spread the powder out evenly.
3. Put the petri dish in the sun or shine a lamp on the powder for a few minutes.
4. Add the powder to the test tube.
5. Bring the tube into a dark closet or room.

WHAT IN THE WOW?

Ultraviolet (UV) light from the sun has shorter wavelengths and higher frequency than visible light, which means it carries more energy per **photon,** or particle of light. The glow powder is a **phosphorescent** material. This means, when you shine light onto it, its electrons absorb the energy of photons, and as they relax back down to their prior energy state, they emit light in the form of a green glow. The UV light makes the powder glow much brighter and longer because it has more energy than visible (white) light.

70. GLOWING BALL

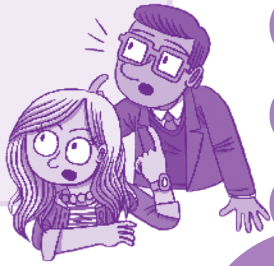
You will need:

- Transparent putty
- Glow-in-the-dark powder

Tinker:

1. Mix half of a small scoop of glow-in-the-dark powder into a small chunk of transparent putty with a diameter about the size of a dime.
2. Squish the powder into the putty until it is fully incorporated and roll it into a ball.
3. Now you've made a glow-in-the-dark ball that can be recharged with light any time.
4. Store the ball in a plastic bag. If you leave the ball alone, it will ooze out into a puddle. Don't worry! You can shape it into a ball again.

WHAT DOES THIS MAKE YOU **Wonder?**



CHAPTER 11 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

WHAT DO YOU **Wonder?**

71. MAKE AN IMPRESSION

You will need:

- Transparent putty
- Dino figurine
- Beaker
- Plaster powder
- Petri dish
- Scoop
- *Plastic cup*
- *Plastic wrap*
- *Water*

Tinker:

1. Line the petri dish with two or three layers of plastic wrap (cling film). Then, using some of the putty, form a thin even sheet in the bottom of petri dish.
2. Pour 12 large scoops of the plaster slowly into the plastic cup without creating dust. Add six large scoops of water. Stir the mixture until it is smooth and free of lumps.
3. Press the dino figurine into the putty in the petri dish until it makes an impression, then remove the dino figurine.
4. Pour the plaster mixture to the rim of the petri dish. Wash your hands and let the plaster harden for at least an hour.
5. Remove the plaster and plastic wrap from the petri dish, remove the plastic wrap, and carefully peel the putty off of the plaster.

MAKE AN OBSERVATION

Draw what you see.

WHAT IN THE WOW?

Because the layer of putty in your dish wasn't very thick, the impression of your dino is also pretty flat. This type of mold is called a **relief**. The plaster flowed into the impression of the dino in the putty and hardened there, forming a relief cast of your dino.

Real dinosaur fossils are also often very flat because they were under high pressure during their formation process, which pressed them flat. By the way, did you know that what you see as bones were actually never part of the living creature? In reality, they're minerals that replaced bones and other body parts over thousands of years.

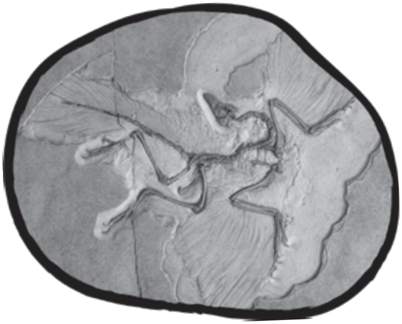
72. BURY YOUR DINO

You will need:

- Dino figurine
- Plaster powder
- Beaker
- Craft stick
- *Water*
- *Plastic cup*

Tinker:

1. Fill the beaker up to the 50-ml mark with the plaster, then pour it into the plastic cup.
2. Use the beaker to measure 25 ml of water and pour it into the cup. Stir the mixture until it is smooth and free of lumps.
3. Put the dino figurine in the cup and use the stirring tool to press it into the plaster until it's completely covered, for about three minutes. Wash your hands.
4. Check on the cup after 10, 20, and 30 minutes and feel the outside of it. What do you notice?
5. Leave the dino in its plaster block overnight.



Fossil imprint of archaeopteryx showing bones and feathers.

WHAT DOES THIS MAKE YOU **Wonder?**

WHAT IN THE WOW?

The thick plaster-water mixture begins to solidify quickly into a stone-like consistency. It's like your dino was buried under a solid layer of sediment. You will also notice that the mixture begins to warm up after a few minutes. Why does plaster get warm when it hardens? Plaster contains water in its natural form. When plaster is heated, it loses some of its water. If you then mix the plaster with water again, you transform it back into its original form. This creates very small needle-shaped crystals that interlock with each other. The plaster becomes solid. During this process, it releases energy. Chemical reactions that release energy are called **exothermic** (from the ancient Greek exo = outside; thermós = warm). One example of an exothermic reaction you're definitely familiar with is fire.

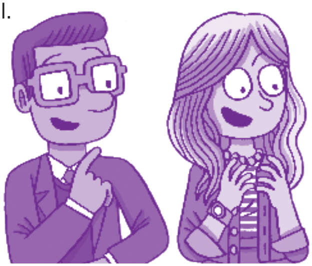
73. DINO DIG

You will need:

- » Dino in plaster from experiment 72
- » Chisel
- » Beaker
- » Pipette
- » *Water*
- » *Scissors*
- » *Plastic or paper plate*
- » *Newspaper*
- » *Paper towels*

Tinker:

1. Cover your work surface with the old newspapers. Cut open the cup containing the dino figurine in its plaster block and remove the plaster block. Ask an adult for assistance with this.
2. Place the plaster block on the plate or on two layers of paper towels. Fill the beaker with water and use the pipette to thoroughly dampen the exterior of the plaster block with water.
3. Wait until the water has sunk into the plaster, and then begin chipping at the surface with the chisel. Add more water when the plaster hardens again. Only chip away plaster that is damp.
4. Continue until the dino is freed from the plaster. Remove it and rinse off any remaining plaster with running water. Wash your hands as well.



WHAT DOES THIS MAKE YOU **Wonder?**

WHAT IN THE WOW?

You dug up the dino again. You did so in a very similar way to **paleontologists** who dig up real prehistoric fossils. **Paleontology** is the science that studies creatures that lived on our Earth hundreds of thousands or even millions of years ago. There is absolutely nothing left of most dinosaurs today. Their remains have completely decomposed. However, if a dinosaur was covered in sand or mud shortly after its death, it was sometimes protected from decay. Then, over the course of thousands of years, the bones recrystallized, meaning the bones were replaced by calcium, silica, or other minerals. The shape of the bone was retained, but the material of the bone was not. This is **fossilization.** If it weren't for this process, we wouldn't even know dinosaurs ever existed!

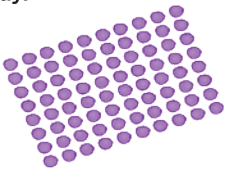
74. HOW OLD IS THAT?

You will need:

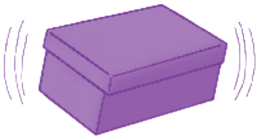
» *80 Pennies* » *Shoebox*

How do we know how old dinosaur fossils are? Scientists use a combination of **relative and absolute dating methods,** analyzing the rock layers the fossils are found in and using **radiometric dating** techniques to determine the age of surrounding volcanic rocks. To understand how radiometric dating works, you must understand the concept of **half-life.** The half-life of a radioactive substance is the time it takes for half of the substance to change into another substance, or **decay.**

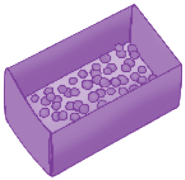
Tinker:



1. Count out 80 pennies.
2. Put the pennies in a shoebox and shake it up.



3. Open the shoebox and remove the pennies that are facing heads up. Count the remaining pennies. Record the number in the table.



4. Repeat steps 2 and 3 with the pennies remaining each time, until only one penny remains.

RECORD YOUR DATA HERE:

HALF-LIVES	PENNIES REMAINING	EXAMPLE DATA: PENNIES REMAINING
0	80	80
1		39
2		24
3		11
4		5
5		2
6		1
7		1

WHAT IN THE WOW?

This example models the probability of decay of a **radioactive** substance. **Radiometric dating** calculates an age in years for geologic materials by measuring the amount of a short-life radioactive element, like **carbon-14,** or a long-life radioactive element plus its decay product, like potassium-14 and argon-40. If you pretend the pennies represent carbon-14 atoms, then after each half-life, or each time you shake the box, the probability is that half of the carbon-14 atoms will have decayed, or that half the pennies will land heads up. The half-life for carbon-14 is approximately 5,730 years. Every 5,730 years, the amount of carbon-14 in a sample decreases by half.

CHAPTER 12 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

CHAPTER 13 PHYSICS: PRESSURE

Listen! #19 "Under pressure"

WHAT DO YOU **Wonder?**

75. STRONG AIR

You will need:

- **Plastic ruler**
- *Table*
- *Sheet of printer paper*
- *Large sheet of paper (such as newspaper)*

Tinker:

1. Place the plastic ruler on the edge of the table so that about two inches of the ruler are hanging off of the edge.
2. With two fingers outstretched, swiftly hit the edge of the ruler. What happens?
3. Replace the ruler in the same position on the table.
4. Place a large sheet of newspaper on top of the ruler.
5. With two fingers outstretched, swiftly hit the edge of the ruler. What happens?

Wonder: TRY CHANGING A VARIABLE

Try the experiment again with different paper sizes. What do you notice?

WHAT IN THE WOW?

Even though the newspaper feels light, you were probably not able to fling the ruler in the same way. There are about 15 pounds of **atmospheric pressure** per square inch pressing on the newspaper. That's a lot! If the area of your newspaper sheet is about 500 square inches, that's more than 7,000 pounds of pressure pushing down.

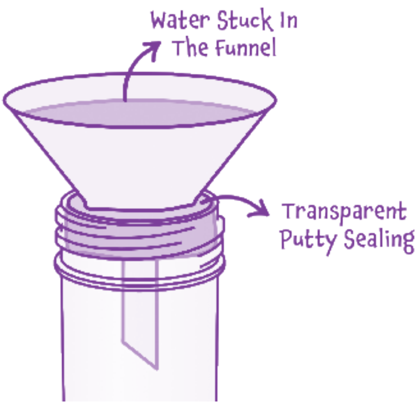
76. NOTHING BUT AIR

You will need:

- Transparent putty
- Test tube
- *Funnel*
- *Water*

Tinker:

1. Take enough putty to make a ball with a diameter of about 2 cm (1/2 inch).
2. Roll the ball of putty on a table with your fingers until it makes a rope 7 cm (about two and a half inches) long. Wrap the rope of putty around the inside of the mouth of the test tube, and press it firmly against the walls. You may use more or less putty to make sure the putty is evenly thick all around.
3. Now place the funnel in the test tube, pressing it in as far as possible to make sure everything is sealed together with the putty.



4. Hold your assembly beneath a water tap and turn the water on carefully. If the water keeps flowing easily through the funnel into the test tube, repeat the previous steps and make sure there are no air gaps where the funnel meets the test tube.

WHAT IN THE WOW?

At some point, the water stops flowing from the funnel into the test tube even though it is empty. Why? Because the test tube isn't empty — it's full of **air!** Because you sealed any gaps with the putty, the air can't escape and the water can't take its place. What exactly is air? Air is a combination of a lot of different gases, but it's mostly composed of the gases **nitrogen** and **oxygen,** which we need to survive. Carbon dioxide (CO_2) is also an important ingredient, even though it only makes up about 0.04 percent of air, because plants require CO_2 to survive. Air also contains countless **aerosols** — tiny particles like pollen, bacteria, ash, and fine particles of sand, as well as man-made pollutants like smog. And don't forget: there is also a lot of water vapor in air, which is responsible for forming clouds and creating rain.

You will need:
- » Syringe
- » Beaker
- » *Water*

77. CREATING A VACUUM

Tinker:

1. Pull back the plunger on the syringe; it's easy!
2. Now cover the nozzle with your finger and try pulling back the plunger again. It is much harder to pull it back. Why do you think that happens?

78. TRAPPED BY PRESSURE

Tinker:

1. Fill the beaker with water.
2. Put the tip of the syringe in the water and pull up the plunger to draw water into the syringe.
3. Remove the syringe from the water with the tip down. Does any water drip out?

79. VACUUM BOILING

Tinker:

1. Fill the cup with warm water. The warmer the water is, the better this experiment will work, but be careful not to scald yourself.
2. Hold the syringe with the tip in the water and pull the plunger up about halfway.
3. Remove the syringe from the cup and cover the opening at the tip with your thumb while pulling the plunger up the rest of the way. Be careful not to pull it all the way out.

WHAT IN THE WOW?

As you pull the plunger of the empty syringe, you increase the volume inside the syringe, but no air can enter to fill the space since the nozzle is covered by your finger. This creates a low-pressure (partial **vacuum**) inside the syringe. A vacuum is an area with no matter at all, including air. We can't create a perfect vacuum in real life, but even a partial vacuum has impressive properties. The vacuum created by the syringe also holds the water in, even if the tip is open. When most of the air is removed from a container, it lowers the **air pressure** inside to almost nothing. This creates a powerful suction force as the air pressure inside the container tries to become equal to the air pressure outside the container by pulling in more air. This stops you from being able to pull the plunger out all the way. It's also how vacuum cleaners work.

When you fill the syringe with warm water and pull up the plunger, it starts to boil. But how does the water boil without getting warmer? It's because the **boiling temperature** of water depends on the surrounding air pressure — the lower the air pressure, the lower the boiling point. By pulling up the plunger, you also are creating a vacuum in the syringe. If there's no air, there's no air pressure, and water boils at a very low temperature.

You will need:

- Syringe
- Tube
- *Tall glass*
- *Short glass*
- *Water*

80. LEVEL WATER

Tinker:

1. Attach the tube to the syringe and push the plunger down all the way.
2. Fill the tall glass about two-thirds full of water and put the end of the tube into the water.
3. Slowly pull the plunger up until the syringe is filled with water. Now slowly move the syringe next to the glass, so the tube makes a bendy “N” shape. Remove the plunger from the syringe, making sure the tube stays in the water and the syringe stays level. What happens? Leave the setup for the next experiment.

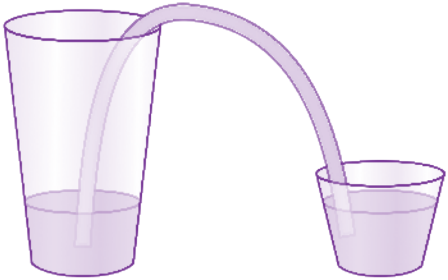
WHAT IN THE WOW?

When a set of containers holding a liquid are connected below the level of the liquid, they’re called **communicating vessels.** When liquid settles in two communicating vessels, it is always at the same level, no matter the size and shape of the two vessels. This is very useful for simple things like checking the water level in a large tank or more complex things like using a water tower to push water into the plumbing system of a city.

81. RESERVOIR PIPE

Tinker:

1. Carefully bring the syringe close to the empty short glass. Then remove the syringe, making sure that one end of the hose stays in the water in the tall glass and the other end is in the empty short glass.



MAKE AN OBSERVATION

What wowed you?

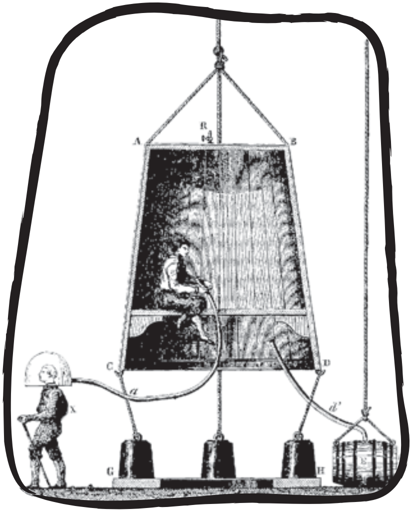
82. DIVING BELL

You will need:

- » **Dino figurine**
- » **Petri dish**
- » *Drinking glass*
- » *Clear bowl*
- » *Water*

Tinker:

1. Fill the bowl halfway with water.
2. Place the dinosaur figurine on the petri dish and place the dish on the surface of the water in the bowl.
3. Now place an empty glass over the dinosaur and the petri dish and press it down toward the bottom of the bowl. Be careful not to tip over the dinosaur. If you are experimenting using breakable household dishes, be careful to avoid breaking anything.



A diagram of an early diving bell. On the ground to the right, you can see a barrel of air that could be released into the bell as needed.

WHAT IN THE WOW?

The dinosaur sinks to the bottom of the bowl with the glass and stays completely dry. This is because air is lighter than water, and is actually trying to escape upward. However, because the glass is closed on top, the air stays trapped inside. The effect was probably too small for you to notice, but when you pressed down, some water got into the glass. This is because the opposing pressure from the water slightly compressed the air.

People have been using **diving bells** for hundreds of years. The ancient Greeks were familiar with simple versions, like the one you just made. They were used by pearl divers, for example, so they didn't have to go all the way back to the ocean's surface to breathe. Instead, they could quickly get some air from under the bell. Over the centuries, this technology has been consistently improved, for example by introducing ways to add fresh air. Modern versions of the diving bell are still used, especially in the under-sea stages of building bridges and tunnels.

CHAPTER 13 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

CHAPTER 14 PHYSICS: DENSITY

Listen! #20 "What is density?"

WHAT DO YOU **Wonder?**

83. MARBLED MILK

You will need:

- **Pipette**
- *Whole or almond milk*
- *Shallow bowl or plate*
- *Food coloring*
- *Dish soap*

Tinker:

1. Pour a small amount of milk into a shallow bowl. You only need a thin layer of milk.
2. Drop some food coloring into the milk. You can add a few different colors.
3. Fill the pipette with some dish soap, then place a few drops of it over the food coloring. What do you observe?

WHAT IN THE WOW?

Milk is **denser** than the food coloring you added to it, so the color stays on the surface. Milk also contains fat molecules which don't dissolve into the liquid around it. When you place a drop of dish soap into the milk, it merges with the fat molecules, so the food coloring in the milk will move around in interesting ways.

84. WATER AND OIL

You will need:

- **Crepe paper (any color)**
- **Test tube**
- **Test tube stand**
- *Cooking oil*
- *Water*
- *Glass jar with lid*

Tinker:

1. Pour about an inch of cooking oil into the jar.
2. Make colorful water by placing water and an inch of the crepe paper into the test tube. Remove the crepe paper when the color has transferred.
3. Slowly pour the colorful water into the jar.
4. Put the lid onto the jar and shake it up.

WHAT IN THE WOW?

As you will see again in the next experiment, water and oil do not mix, so the water breaks up into little bubbles. Because **water molecules** are much denser than **oil molecules,** the water bubbles will slowly sink through the oil and pool at the bottom.

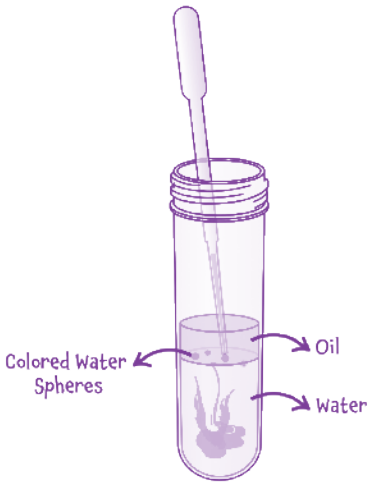
85. JELLYFISH FACTORY

You will need:

- Crepe paper (red, blue)
- Pipette
- Test tube
- Test tube stand
- *Vegetable oil*
- *Water*
- *2 Plastic cups*

Tinker:

1. Put an inch of the red crepe paper into one of the cups and an inch of the blue crepe paper into the other. Fill each of them about halfway with water.
2. Stir until both papers have transferred their color to the water. Squeeze the papers out well and dispose of them.
3. Fill the test tube halfway with water and then slowly add about an inch of vegetable oil to it. Wait until the liquids have fully separated.



4. Using the pipette, add small drops of the red or blue water on top of or just below the surface of the oil.
5. Watch for a few minutes to see what happens.

WHAT IN THE WOW?

As soon as the colored drops of water touch the oil, they begin sinking toward the border between the lighter oil and the heavier water. They linger there for a while until they pass the boundary between oil and water. When that happens, they burst open, and the colored water flows into the clear water. For a moment, it looks like you've created little jellyfish. There are two reasons why oil and water don't mix. The first is that oil is lighter than water, so it floats on top. The other reason the liquids stay separated is because water molecules are **polar** — they have a positive and a negative side. Oil, on the other hand, has neither a positive nor a negative charge. Therefore, the water molecules attract each other and push the oil out. When you add a drop of colored water to the oil, it tries to separate itself from the oil by creating a shape with the smallest possible surface area: a sphere. Then when it comes into contact with water, the sphere breaks apart and the color spreads into the rest of the water.

86. TEMPERATURE DENSITY

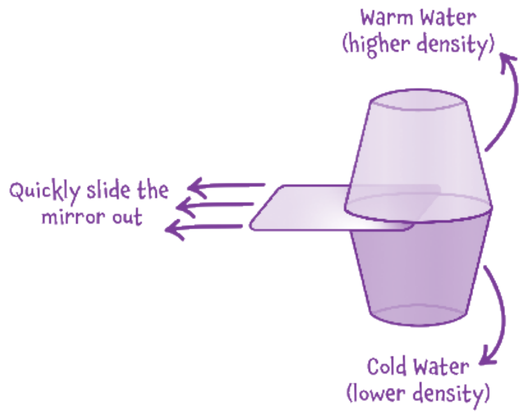
You will need:

- Crepe paper (red, blue)
- Mirror without hole
- *Water*
- *2 Small clear plastic cups*

Tinker:

Note: You may want to do this experiment over a sink or a surface covered with plastic as it may involve some water spilling.

1. Put a one-inch strip of the blue crepe paper into one of the cups and a one-inch strip of the red paper into the other. Then, pour cold water into the cup with the blue paper and warm water into the cup with the red paper.
2. Stir until both papers have transferred their color to the water. Squeeze the papers out well and dispose of them.
3. Cover the mouth of the cup full of red water with the mirror. Now carefully hold the mirror in place and turn the cup upside down quickly, making sure not to spill the water.
4. Place this cup and mirror over the other cup with the blue water. Now quickly slide the mirror from between the two cups without letting the top one fall or spill. The top cup should rest on the bottom one with their mouths perfectly aligned. Ask an adult to help with this.



WHAT IN THE WOW?

Instead of mixing into the cold blue water below, the warm red water stays floating on top. This is because warm water is **less dense,** and therefore **lighter,** than cold water. The reason: warm water molecules move **faster** than cold water molecules and therefore take up more space with fewer molecules. That doesn't just go for water, but for practically every material. For example, air works the same way. This principle is how hot air balloons work: because the hot air in the balloon is lighter than the colder air surrounding it, the balloon rises.

87. RAINBOW IN A TUBE

You will need:

- **Crepe paper (red, blue, yellow)**
- **Beaker**
- **Syringe**
- **Test tube**
- **Test tube stand**
- *Granular white sugar*
- *Tablespoon*
- *Water*
- *3 Plastic cups*

Tinker:

1. Using the beaker, pour 50 ml of water into each of the plastic cups. Then add a one-inch strip of the red paper to the first, yellow to the second, and blue to the third.
2. Stir until the papers have transferred their color to the water. Squeeze the papers out well and dispose of them.
3. Add two tablespoons of sugar to the yellow water and stir until it dissolves.
4. Add four tablespoons of sugar to the blue water and stir until it dissolves.
5. Place the test tube in the stand. Take 10 ml of the blue sugar water in the syringe and empty it into the test tube.
6. Take 10 ml of the yellow sugar water in the syringe. Make sure the nozzle of the syringe is touching the inside wall of the test tube. Now slowly empty the syringe. You should see a layer forming of the yellow sugar water.
7. Repeat step 6 with the red sugar-free water.

MAKE AN OBSERVATION

Draw what you see.

WHAT IN THE WOW?

You already know liquids with higher density sink to the bottom. The more sugar you dissolve in the water, the denser it becomes. Because the red, yellow, and blue liquids have different densities, they layer on top of each other.

However, because they're all mostly made of water, and the densities are only a little bit different, the liquids mix together where they touch. Between red and yellow, there's an orange layer, and between yellow and blue there's a green layer. You can use this trick to layer different types of juice to make a rainbow drink!

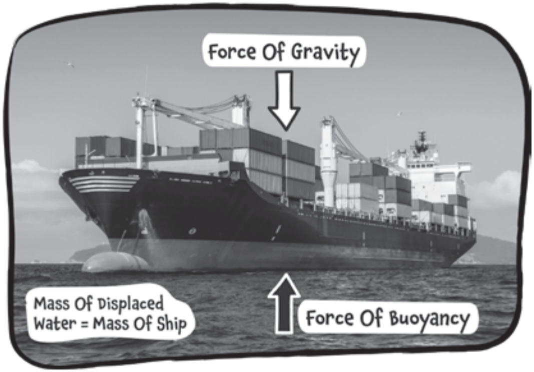
88. SINK OR FLOAT

You will need:

- Transparent putty
- *Plastic cup*
- *Water*
- *Coin*

Tinker:

1. Fill the cup two-thirds full of water.
2. Make a ball of putty, about an inch in diameter, and wrap the coin inside it. Now gently drop it into the cup. What happens?
3. Take the ball out of the cup and reshape it into a small bowl. Place the coin in the center of this bowl.
4. Now take the bowl with the coin and place it on the water in the cup, making sure to not tilt the bowl or get any water into it. What do you observe?



MAKE A BOAT

Try making some boats out of aluminum foil. You can place other objects, like metal coins, on the boat until it sinks. Draw a picture of your favorite boat.

WHAT IN THE WOW?

When you wrapped the coin in the putty, it sank immediately because of the weight of the coin. However, when you placed the coin in the putty bowl (or boat), it floated. Material and mass are not the only factors in whether something will sink or float. Shape is also a key component of **buoyancy** — the upward force on objects in liquids. Buoyancy is related to the amount of water that is **displaced,** or moved out of the way. The boat displaces more water, therefore increasing the buoyancy, so the boat floats. This is what keeps massive steel ships afloat!

CHAPTER 14 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

Listen! #21 "What is weather?"

WHAT DO YOU **Wonder?**

89. MAKE A TORNADO!

You will need:
- Vortex connector
- *2 Empty two-liter bottles with screw caps*

Tinker:

1. Fill one of the bottles with water until it is two-thirds full. Twist on the vortex connector.
2. Hold the empty bottle upside down and twist it onto the other end of the vortex connector.
3. Flip the two bottles so that the empty one is at the bottom. Then, holding it by the bottle on the bottom, swirl the bottle as though you are stirring a pot. What do you observe?

WHAT IN THE WOW?

Real **tornadoes** happen during severe thunderstorms, and are caused by a number of factors, including temperature differences, atmospheric pressure, wind direction, and centrifugal force. Your bottle tornado is created by the spin you gave it and gravity.

90. WHICH DIRECTION

You will need:
- Setup from previous experiment

Tinker:

1. Flip the two bottles so the empty one is at the bottom.
2. Swirl the bottles in the opposite direction of your first experiment. What happens?
3. Try swirling faster or slower, at different angles, or using any other variables you can think of. Write down what you tried in your notebook and what the results were.
4. Plug your bathroom sink and fill it part-way with water, and then unplug it. What direction does the water swirl?

Wonder: TRY CHANGING A VARIABLE

Variable	Results

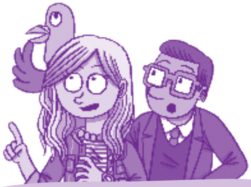
91. BEST BOTTLES

You will need:

- Vortex connector
- *Various bottles with standard screw caps*

Tinker:

1. Try replacing the two-liter bottles with ones in different shapes and sizes. Which one makes the best vortex? Which one makes the worst?



Wonder: TRY CHANGING A VARIABLE

Type of bottle	Results

WHAT IN THE WOW?

Did you notice that, at first, the water was flowing from the top bottle to the bottom bottle very slowly, but when you swirled the bottle, the water flowed more quickly?

While the bottle without water in it looks empty, in reality, it is full of air. If the bottle is full of air, there is no room for water. However, if you swirl the bottles while the one full of water is on top, a **vortex** is created, which pushes water to the outside of the bottle and creates a channel in the middle. This allows air to escape upward into the upper bottle, which creates the space needed for the water to flow into the lower bottle.

You may have heard that water always swirls clockwise in the Northern Hemisphere and counterclockwise in the Southern Hemisphere because of the something called the **Coriolis effect,** caused by the Earth's rotation. In reality, the Coriolis effect only applies to very large systems, like hurricanes. Even tornadoes are too small to be affected by it! The water in drains and bottles is much more strongly affected by other factors, such as the shape of the container or your hands swirling it.

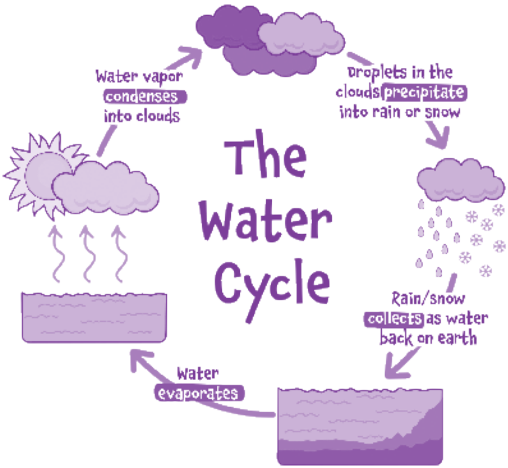
92. WATER CYCLE

You will need:

» **Beaker**
» *Water*
» *Large plastic sandwich bag*

Tinker:

1. Pour about 30 ml of water into the beaker.
2. Put the beaker inside the sandwich bag, being careful not to spill any water, and seal the bag. Then, place it on a sunny windowsill.
3. Leave the beaker in the sun for several hours, checking on it periodically. What happens after an hour? Two hours?



WHAT DO YOU **Wonder?**

WHAT IN THE WOW?

You've created a model of the **water cycle!** When the sun hits the water, it heats up and begins to **evaporate.** The evaporated water cools on the sides of the bag and **condenses** into droplets. These droplets eventually become too heavy and fall to the bottom of the bag.

This is exactly what happens on a larger scale in the environment. The sun's heat evaporates surface water, which rises into the air and condenses into clouds of water vapor. When the droplets in these clouds become too heavy, they fall as rain or snow.

CHAPTER 15 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

CHAPTER 16 ENGINEERING

Listen! #22 "Bridging the gap"

WHAT DO YOU **Wonder?**

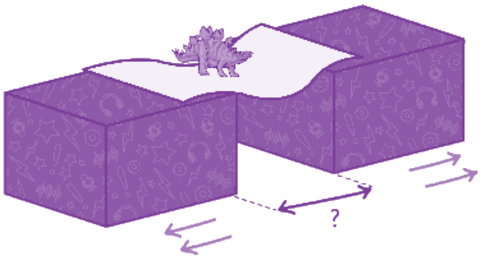
You will need:

- **Dino figurine**
- *Plain copy paper or printer paper*
- *Tape*
- *Bridge supports (two tissue boxes or two books of the same thickness, or similar)*

93. A BRIDGE FOR DINOS

Tinker:

1. Place the long ends of your two tissue boxes next to each other so they are touching and place the sheet of paper on top. Put your dino figurine in the center, above where the two boxes meet.
2. Slowly move the boxes apart from each other. Try to keep the paper and the dino centered between the two boxes.



3. When your paper bridge starts to collapse, measure the distance between the two boxes. How far could your bridge stretch?

94. A BETTER BRIDGE

Tinker:

1. Fold the paper like a fan or an accordion, lengthwise.
2. Set up the experiment the same way as the last one. Make sure the paper is oriented so that the folds are perpendicular to the boxes at either end.
3. Slowly move the boxes apart from each other. Try to keep the paper and the dinosaur centered between the two boxes. When does the paper start to collapse this time?
4. Try making a longer bridge by taping some sheets of paper together end to end. How long can you make your bridge?

MAKE AN OBSERVATION

How long can you make the first bridge?

How long can you make the second bridge?

Is the bridge stronger if the folds are wide or narrow?

95. THE BEST BRIDGE

Tinker:

1. Using what you learned from experiments 93 and 94, make the longest bridge you can with paper and tape.

MAKE AN OBSERVATION

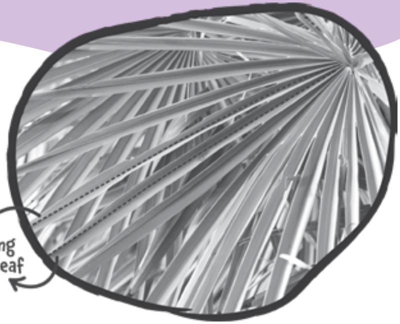
Draw a picture of your best bridge.

MY BEST BRIDGE

WHAT IN THE WOW?

In the first experiment, the paper will bend and the dino will fall pretty quickly. Its weight presses on the paper at a right angle — so all the pressure from the weight is going straight down. The **accordion bridge,** on the other hand, is strong enough to bring the dino safely to the other side. Because the paper is folded, it is at a sharper angle to the dino's weight, and the weight is distributed. With the right folding, a very light material can become very strong.

Like you, civil engineers often have the challenge of achieving a high level of stability with very light building materials, for example when building bridges. In doing so, they are often inspired by models from nature (this branch of science is called **bionics**). For example, we copied the accordion bridge from a fan palm leaf. Thanks to the fold along the leaf's long axis, it's very stable.



Folds along the palm leaf

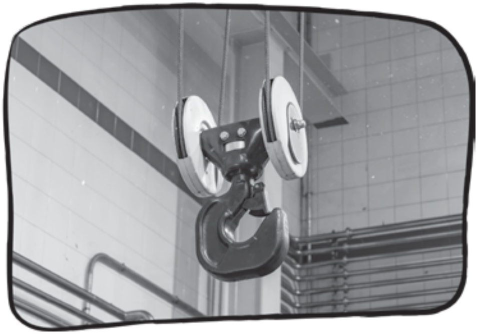
96. GOING UP

You will need:

- » **String**
- » *Chair*
- » *Bottle of water*

Tinker:

1. Make sure the cap of the bottle is screwed on tightly. Then tie one end of the string around the neck of the bottle.
2. Holding the other end of the string, try to lift the bottle off the ground. Notice how difficult it is.
3. Now drape the string over the back of a chair. Have an adult hold the chair steady. Depending on how long your string is and how tall the chair is, you may need to put the bottle on a higher surface to make this work (see the illustration below).
4. Pull down on the string to lift the bottle. What do you notice?



A compound pulley with a hook on it

WHAT IN THE WOW?

You have created a very simple version of a **pulley.** A pulley is a type of **simple machine,** which are the most basic types of mechanical devices. Complex machines, like cars, combine many simple machines. The function of a simple machine is to make **work** easier. In physics, work is the force needed to move an object over a given distance.

A simple pulley, like the one you just made, makes work easier by changing the direction of the force. It's easier for people to pull down than it is to lift. If you're trying to lift really big objects, it's also easier to have a lot of people pulling on the end of a rope than it is to have them all try to lift an object at the same time. The other simple machines are: **levers, wheels, inclined planes, screws, and wedges.**

CHAPTER 16 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _____________

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

____

Listen! #23
"Seeing is believing"

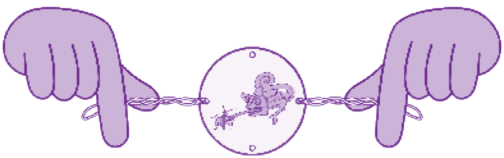
WHAT DO YOU **Wonder?**

97. SLOW EYES

You will need:
- Disk from die-cut sheet
- 2 Rubber bands
- *Tape or glue*

Tinker:

1. Fold the two sides of the disk together so the chameleon is on one side of the disk and the mosquito is on the other, and secure it with tape or glue.
2. Pull the two rubber bands through the two holes in the disk.
3. Hold the rubber bands on both sides with your thumb and index finger (as shown below). Spin the disk by rolling the rubber bands between your thumbs and index fingers. Watch the disk while you do this.



WHAT IN THE WOW?

If the disk spins fast enough, you can see the chameleon catch the mosquito! This **optical illusion** relies on the so-called **afterimage effect.** Every image we see has an effect on our retina for a brief moment. This effect lasts only for a fraction of a second. You can test this even without the disk. Stare at an object for a while and then close your eyes quickly. You will still see the object for a split second, despite your eyes being closed.

This type of contraption made of a disk and strings is called a **thaumatrope.** This name is from Ancient Greek and means something like "wonder turner." Thaumatropes were first described in the 19th century and quickly became very popular, but archaeologists have discovered a possible thaumatrope — made from a small disk of bone — that was created as far back as 15,000 years ago. There's a picture of a sitting reindeer on one side and a picture of a standing one on the other side. If the disk is spun at the right speed, it looks like the animal is sitting down and standing up. This disk is the oldest known animation.

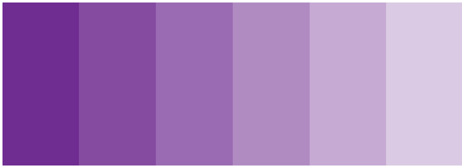
98. CHANGING COLORS

You will need:

- **Illustration below**
- *Pencil*

Tinker:

1. Sit down, relax, and take a look at the illustration below. What do you see?
2. Now take your pencil and place it along the lines between each of the adjacent strips of color, one after the other. What do you see?



WHAT IN THE WOW?

Your brain processes colors differently based on what other colors are next to them. Each rectangle is a different solid shade of purple, but if you focus on the borders, you might notice that each rectangle seems to be a gradient from light to dark. Even weirder, if you place the pencil along the border between two colored columns, they look like they are both the same color! This illusion is named after Michael Eugene Chevreul — an artist who did a lot of experiments with color.

99. DISAPPEARING SMELLS

You will need:

- **2 Test tubes**
- **Beaker**
- *Cocoa powder*
- *Cinnamon*
- *Timer*

Tinker:

1. Put some cinnamon powder in one test tube and cocoa powder in the other one. In the beaker, mix equal parts cocoa powder and cinnamon.
2. Set the timer for 30 seconds and sniff the test tube with the cinnamon powder until the timer rings. Then, quickly sniff the beaker. What do you smell in the beaker?
3. Repeat step 2, but sniff the test tube with cocoa powder and then the beaker.

WHAT IN THE WOW?

Your brain has **smell receptors** which receive and process information from your nose. When you smell the same scent for a long time, the smell receptors stop registering it. That's why you might not notice the smell of your own home, but you can smell your friends' homes when you visit them!

100. AMES WINDOW

You will need:

- **Ames window from die-cut sheet**
- **String**
- *Small binder clip*
- *Tape and glue*
- *Optional: black construction paper*

Tinker:

1. Remove the Ames window from the die-cut sheet, fold the two halves together, and secure it with glue or tape.
2. Thread a two-foot piece of string through the holes at either end. Tie the string ends so they don't slip out.
3. Hang the window so that it can spin freely. For best results, set up a solid, dark backdrop behind it, such as a piece of black construction paper.
4. Wind up the string by spinning the window, so that when you release the window it rotates on its own.
5. Let go and watch the window spin. It is best for the window to be at eye level at least four feet from you.
6. Now attach a binder clip to the center of the shortest edge of the window and repeat steps 3 and 4.

Tip: If you're having trouble seeing the illusion, try filming it.

WHAT IN THE WOW?

Your brain is used to seeing windows that are rectangular. When you look at the trapezoid shape of this window, your brain assumes that the smaller side is further away from you and the larger side is closer, even when that's not true. This makes it look like it's waving back and forth instead of rotating. The illusion is so strong, that it can even make a binder clip appear to pass through the window frame.

MAKE AN OBSERVATION

What wowed you?

CHAPTER 17 CHECK-IN

I FINISHED THIS CHAPTER ON

(DATE) _ _ _ _ _ _ _ _ _ _ _ _

WOW!

WHOOPS!

MY FAVORITE EXPERIMENT:

_ _ _ _ _ _ _ _ _ _ _ _

NEXT-LEVEL CHALLENGES

Try these experiments on your own!

1. Reflect on what you've learned about air pressure and tinker: Can you stab a raw potato with a plastic straw?
2. Experiment 38 wowed you with the wonders of capillary action. Can that help you change the color of a few cabbage leaves?
3. If you tinker with a test tube filled with warm, red water, could you create an underwater volcano with it?

Scan this QR code to KEEP THE WOW ROLLING with additional **educational resources** related to this item.

This kit was completed by:

Write your name(s) in the spaces below.

X _ _ _ _ _ _ _ _ _ _ _ _ _ _

X _ _ _ _ _ _ _ _ _ _ _ _ _ _

X _ _ _ _ _ _ _ _ _ _ _ _ _ _

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PLAY IT FORWARD!

When you are done playing and learning with this toy, we encourage you to pass it on to another curious kid!

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