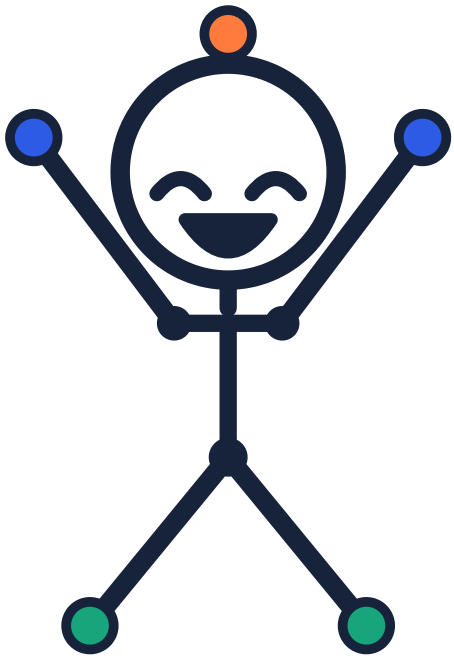
Young Innovators
FOR CHANGE
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A FULL-YEAR SCIENCE PROGRAM · GRADE 6

Inside the System

36 weekly investigations into how things work together: cells, bodies, heat, weather, climate and design.



This book belongs to

_____

A system I took apart _____

What flows through it _____

Teacher _____

School year _____

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START HERE HOW THIS BOOK WORKS

Everything is a system of smaller systems.

Two pages a week, front and back. About thirty-five minutes.

The shape of a week

Page 1 teaches one idea, and in 16 weeks it gives you a small investigation to try. **Page 2** has a table to think about, two questions to talk about, and a harder challenge, and in 17 weeks a page for your System File. No computer needed.

Part 1 takes apart a pen, a body, a cell and the water cycle. Part 2 is heat, and how uneven heating makes the weather. Part 3 is climate, and the living things it shapes. Part 4 is a warming world, and a design project to measure and reduce one human impact close to school.

The boxes on the page

SITS BESIDE	The California science standard the week teaches. This book sits beside your science lessons, not instead of them.
NOTICE FIRST	Two minutes of looking before any explaining. Every scientist starts by noticing.
TRY IT	What you need for the week's investigation. Most of it is already in a classroom or a kitchen, and the teacher guide lists the few things to gather.
WORDS TO KEEP	One or two words pinned down properly.
PRACTICE DATA	Results made up for the page so everyone can answer the same questions. Your own results will be different, and yours are the real ones.
SYSTEM FILE	The one thing you build all year, in a notebook your teacher gives you: 17 pages, each one a system taken apart: its parts, what flows between them, and what changes when one part does.
TALK ABOUT IT	Two questions to talk over with someone at home or at school.
STUCK? TRY THIS	A way in when the page stops making sense.
CHALLENGE ZONE	Harder, and usually open. For whoever finishes early.

The one question of the whole year

What are the parts, and what flows between them? Every week takes one system apart and asks what happens when one part changes. And every test changes one thing at a time, so you know what caused what. Temperatures in this book are in degrees Celsius.

WEEK	TITLE	TOPIC	STANDARD
PART 1 · WEEKS 1–9 · SYSTEMS AND SUBSYSTEMS			
1	**What Is a System?**	Systems	MS-LS1-3
2	**Made of Cells**	Systems	MS-LS1-1
3	**Inside a Cell**	Systems	MS-LS1-2
4	**Cells, Tissues, Organs**	Systems	MS-LS1-3
5	**Systems Working Together**	Systems	MS-LS1-3
6	**Signal to the Brain**	Systems	MS-LS1-8
7	**Water Through Everything**	Water	MS-ESS2-4
8	**Sunlight and Gravity**	Water	MS-ESS2-4
9	**Systems Inside Systems**	Review	MS-LS1-3
PART 2 · WEEKS 10–18 · HEAT, AND WHY WEATHER HAPPENS			
10	**Heat Moves**	Heat	MS-PS3-4
11	**Same Heat, Different Change**	Heat	MS-PS3-4
12	**Keep It Warm**	Heat	MS-PS3-3
13	**Test the Insulator**	Heat	MS-PS3-3
14	**Motion and Energy**	Heat	MS-PS3-5
15	**Uneven Heating**	Weather	MS-ESS2-6
16	**Air Masses Meet**	Weather	MS-ESS2-5
17	**Reading a Forecast**	Weather	MS-ESS2-5
18	**Why Weather Happens**	Review	MS-ESS2-6

WEEK	TITLE	TOPIC	STANDARD
PART 3 · WEEKS 19–27 · CLIMATES AND THE LIFE THEY SHAPE			
19	**Weather Is Not Climate**	Climate	MS-ESS2-6
20	**Why Coasts Are Mild**	Climate	MS-ESS2-6
21	**Rivers in the Ocean**	Climate	MS-ESS2-6
22	**The Dry Side of a Mountain**	Climate	MS-ESS2-6
23	**Grown in a Climate**	Life	MS-LS1-5
24	**Behavior and Offspring**	Life	MS-LS1-4
25	**Flowers and Pollinators**	Life	MS-LS1-4
26	**One Parent or Two**	Life	MS-LS3-2
27	**A Place and What Lives There**	Review	MS-LS1-5
PART 4 · WEEKS 28–36 · A WARMING WORLD			
28	**A Century of Temperatures**	Warming	MS-ESS3-5
29	**Good Questions About the Rise**	Warming	MS-ESS3-5
30	**What Changes for Living Things**	Warming	MS-LS1-5
31	**Measure a Human Impact**	Warming	MS-ESS3-3
32	**Design a Monitor**	Warming	MS-ESS3-3
33	**Criteria and Constraints**	Design	MS-ETS1-1
34	**Compare the Designs**	Design	MS-ETS1-2
35	**Test and Improve**	Design	MS-ETS1-4
36	**Inside the System**	Review	MS-ESS3-3

WEEK 1 SYSTEMS

What Is a System?

A pen is a handful of parts. Together they do two jobs that no single part can.

SITS BESIDE
The body as a system of subsystems (MS-LS1-3)

NOTICE FIRST · 2 MINUTES
Click a pen in and out ten times. What has to happen inside it, each time?

TRY IT · YOU WILL NEED

- a click pen that can be taken apart
- a sheet of paper

Safely: Point the spring away from faces as you take the pen apart.

WORDS TO KEEP

system	A group of parts that work together, so the whole can do something no single part can.
subsystem	A system that is one part of a bigger system.

Take it apart

Unscrew a click pen and lay its parts in a row. Put it back together, leaving out one part at a time, and test it.

A pen is a **system**: parts that work together to do something none of them can do alone. Some parts do one job, some share a job, and some are not needed for either.

Your body is a system too, made of smaller systems, or **subsystems**: one moves blood, one moves air in and out, one breaks down food, one carries signals. This year takes systems apart, from a cell to the weather, and asks what each part does.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

One part missing

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class rebuilt a pen four times, each time without one part, and tested both of its jobs.

Part left out	Does it still write?	Does it still click?
ink tube	no	yes
spring	yes	no
clip	yes	yes
click button	yes	no

Which part can be left out without stopping either job? _____

Which TWO parts does the clicking need? _____

Which part does the writing need? _____

▶ ADD TO YOUR SYSTEM FILE

Start your System File. On the first page, draw the pen's parts in a row and label the job each one does.

💬 TALK ABOUT IT

Name a system at school, and two of its parts.

What happens to a bicycle if one part breaks? Does it matter which part?



STUCK? TRY THIS

Read each column on its own. A job needs a part if the job stops when that part is left out.

★ CHALLENGE ZONE

Choose another everyday object with moving parts. List its parts and the job each one does. Which part could it lose and still work?

WEEK 2 SYSTEMS

Made of Cells

Every living thing is made of cells: one, or trillions.

SITS BESIDE
Living things are made of cells (MS-LS1-1)

NOTICE FIRST · 2 MINUTES
Look closely at the skin of an onion. Is it smooth, or made of something smaller?

TRY IT · YOU WILL NEED

- an onion
- a hand lens, or a microscope and slide if your school has them
- a dropper of water

Safely: An adult cuts the onion.

WORDS TO KEEP

cell The smallest unit of a living thing. Every living thing is made of one cell or of many.

The unit of life

Peel the thin, clear skin from the inside of an onion layer. Lay it flat in a drop of water and look as closely as you can.

With a microscope you see it is built of tiny boxes, like bricks in a wall. Each one is a **cell**. A hand lens may only show faint lines, which is why scientists needed microscopes to find cells at all.

Every living thing is made of cells. Some, like bacteria and yeast, are a single cell. A person is made of trillions. And every cell comes from another cell.

DRAW IT

Draw what you saw, as closely as you can. Label anything that looks like a wall between cells.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Six samples under a microscope

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class looked at six samples under a microscope and recorded whether they saw cells.

Sample	Cells seen?
onion skin	yes
cork	yes
a drop of pond water	yes
sand	no
table salt	no
a thin slice of leaf	yes

How many samples showed cells? _____

Which samples showed no cells? _____

Cork is the bark of a tree and is not alive. Why did it still show cells?

_____

TALK ABOUT IT

Why do you think nobody knew about cells until microscopes were invented?

Name something living that is too small to see without a microscope.



STUCK? TRY THIS

Count the yes rows. For the cork, ask where it came from.

★ CHALLENGE ZONE

A drop of pond water showed cells, but the water is not alive. What do you think the cells belonged to?

WEEK 3 SYSTEMS

Inside a Cell

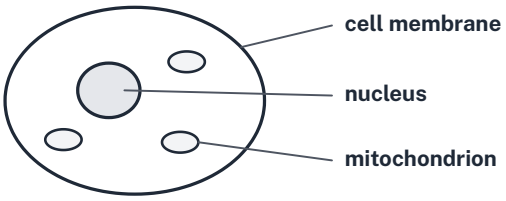
A cell is a system too, with parts that each do a job.

SITS BESIDE
The parts of a cell and their jobs (MS-LS1-2)

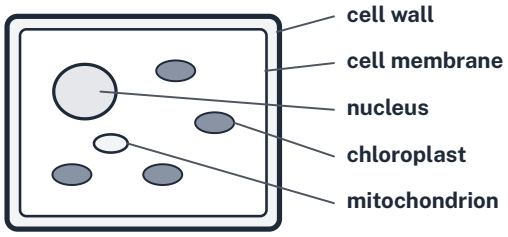
NOTICE FIRST · 2 MINUTES
Think of a factory or a busy kitchen. What jobs have to happen inside it for it to work?

WORDS TO KEEP

nucleus	The part of a cell that holds its instructions and controls what the cell does.
chloroplast	The part of a plant cell that captures the energy of light to make food.



animal cell



plant cell

A cell has parts

Every cell is wrapped in a **cell membrane**, which controls what goes in and out.

Inside, the **nucleus** holds the cell's instructions. **Mitochondria** release the energy stored in food so the cell can use it. Plant and animal cells both have these.

Plant cells also have a stiff **cell wall** outside the membrane, which is why plants can stand up without bones, and **chloroplasts**, which capture the energy of light to make food.

DRAW IT
Draw a plant cell and an animal cell from memory, and label every part you can.

Plant cells and animal cells

Use the card and the two drawings on page 1 to fill in the table.

Part	Its job	In animal cells?	In plant cells?
cell membrane	controls what goes in and out		
nucleus	holds the instructions and controls the cell		
mitochondria	release energy from food		
cell wall	a stiff outer layer that supports the cell		
chloroplasts	capture light energy to make food		

Which TWO parts are only in plant cells? _____

How many of the parts do both kinds of cell have? _____

Which part makes food from light? _____

TALK ABOUT IT

Why do you think a plant cell needs a stiff wall and an animal cell does not?

Where in your body do you think cells need the most energy?



STUCK? TRY THIS

Go part by part through the card. If it says plant and animal cells both have a part, mark both. If it says plant cells ALSO have a part, only plant cells do.

★ CHALLENGE ZONE

Build a model of a plant cell from things in the classroom. Which object stands for which part, and why?

WEEK 4 SYSTEMS

Cells, Tissues, Organs

Cells make tissues, tissues make organs, and organs make the systems of your body.

SITS BESIDE
The body as a system of subsystems (MS-LS1-3)

NOTICE FIRST · 2 MINUTES
Put your hand on your chest and feel your heart. How many parts do you think it is made of?

WORDS TO KEEP

tissue	A group of similar cells working together, like muscle.
organ	A body part made of several tissues that does one main job, like the heart.



Levels of a body

A body is built in levels, each made of the one before.

Similar cells working together make a **tissue**, like muscle. Several tissues make an **organ**, like the heart, which has muscle tissue, nerve tissue and more. Organs that work together make an organ system.

The heart, the blood and the blood vessels together are the circulatory system. The lungs and airways are the respiratory system. Each is a subsystem of you.

NOTES AND DRAWINGS

Which level?

Write the level for each row: cell, tissue, organ or system.

	Part of the body	Level
a	a single muscle cell	
b	the heart	
c	heart muscle, made of many muscle cells	
d	the heart, the blood and the blood vessels together	
e	a nerve cell	
f	the stomach	

Which TWO levels have only one row each? _____

Put rows a, b, c and d in order from smallest to largest. _____

What is the name of the system in row d? _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Levels of Me: draw one cell, the tissue it is part of, the organ, and the system, each inside the next.

💬 TALK ABOUT IT

Name an organ besides the heart, and what it does.

Why might a problem in one organ affect the whole body?



STUCK? TRY THIS

A tissue is many similar cells. An organ is several tissues. A system is several organs or parts working together.

★ CHALLENGE ZONE

Pick one body system. Name two organs in it, and one tissue inside one of those organs.

WEEK 5 SYSTEMS

Systems Working Together

Exercise, and your heartbeat and your breathing speed up at the same moment. Two systems are working as a team.

SITS BESIDE
The body as a system of subsystems (MS-LS1-3)

NOTICE FIRST · 2 MINUTES
Put your hand on your chest and breathe in deeply. What two things inside your chest can you feel working?

TRY IT · YOU WILL NEED

- a timer with seconds

Safely: Jog in place, or pump your arms fast while seated, only as hard as feels comfortable. Your pulse numbers are yours to keep. Anyone who prefers can count a partner's pulse instead, after asking first.

Count your pulse

Find your pulse on the inside of your wrist. Count the beats for 15 seconds and multiply by 4: that is your heartbeats each minute.

Now jog in place, or pump your arms fast while seated, for one minute and count again, and count your breaths too. Both go up.

Working muscles need more oxygen. The respiratory system takes it in at the lungs, and the circulatory system carries it in the blood to the muscles. Neither system can do it alone, so both speed up together.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Heart and lungs together

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class measured one student's heartbeats and breaths each minute during four activities.

Activity	Heartbeats each minute	Breaths each minute
sitting still	72	14
walking	95	20
jogging in place	130	30
after 2 minutes of rest	90	18

How many more heartbeats a minute while jogging than while sitting still? _____

How many more breaths a minute? _____

Why do the heart and the lungs speed up together?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Two Systems, One Job: draw the lungs, the heart and a muscle, with arrows showing where oxygen goes.

💬 TALK ABOUT IT

What other body system do you think speeds up when you exercise?

Why do you think your breathing slows down again after you rest?



STUCK? TRY THIS

Subtract the sitting-still row from the jogging row, one column at a time.

★ CHALLENGE ZONE

The heartbeats after 2 minutes of rest are still higher than sitting still. What do you think the body is still doing?

WEEK 6 SYSTEMS

Signal to the Brain

You see a ruler fall, and your hand closes. A signal made that whole trip in a fifth of a second.

SITS BESIDE
Senses send signals to the brain (MS-LS1-8)

NOTICE FIRST · 2 MINUTES
Someone tosses you a ball. List everything that happens inside you before your hands move.

TRY IT · YOU WILL NEED

- a 30 cm ruler
- a partner

WORDS TO KEEP

receptor	A cell that senses something, like light, touch or sound, and starts a signal.
nerve	A bundle of long fibers from nerve cells, carrying signals between the body and the brain.



Catch it

Your partner holds the top of a ruler so it hangs straight down, with the 0 mark level with your open thumb and finger, and drops it without warning. Catch it, and read the centimeters at the top of your thumb.

Light from the falling ruler reaches **receptors** in your eyes. A signal travels along **nerves** to your brain, the brain decides, and a signal travels back to the muscles in your hand. The shorter the distance the ruler fell, the faster that trip.

Agree on it with your partner first. Then close your eyes, and they tap your shoulder at the moment of the drop. This time the signal starts at receptors in your skin.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Sight or touch?

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class measured one student's five catches with each signal. The second table turns centimeters into seconds.

Try	1	2	3	4	5
Sight (cm)	20	18	17	15	15
Touch (cm)	14	13	13	12	13

Ruler fell	10 cm	12 cm	15 cm	17 cm	20 cm
Seconds	0.14	0.16	0.17	0.19	0.20

Which signal gave a quicker catch on every try? _____

What was the average of the five sight catches? _____

About how many seconds is that? _____

TALK ABOUT IT

Why do you think drivers are told to leave space behind the car ahead?

Name a sport where a quick reaction matters most.



STUCK? TRY THIS

Add the five sight numbers and divide by 5. Then find that distance in the second table.

★ CHALLENGE ZONE

Did the catches get quicker with practice? Use the numbers to say whether the brain learned, or whether it is too soon to tell.

WEEK 7 WATER

Water Through Everything

The water in a puddle today may be in a cloud tomorrow, and in a river next week.

SITS BESIDE
Water cycles, driven by sunlight and gravity (MS-ESS2-4)

NOTICE FIRST · 2 MINUTES
Leave a glass of ice water on a table. Where do the drops on the outside come from?

TRY IT · YOU WILL NEED

- three pans of the same size
- a measuring cup
- water
- plastic wrap
- a sunny spot and a shady spot

Safely: Never look straight at the sun.

WORDS TO KEEP

condense To change from a gas into a liquid, the way water vapor cools into drops.



Where the water goes

Earth's water moves in a cycle. Sunlight warms water in oceans, lakes and soil, and it evaporates into the air as water vapor.

High up, the air is cooler, and the vapor **condenses** into tiny drops: a cloud. The drops join, grow heavy, and fall as rain or snow. On the ground the water flows downhill in rivers, or soaks into the soil, and the cycle goes on.

Test the first step. Put the same amount of water in three pans: one in the sun, one in the shade, and one in the sun covered with plastic wrap. After three days, measure how much water is gone from each.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Three pans, three days

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class put 500 mL of water in each of three pans and measured how much was gone after three days.

Pan	Water gone after 3 days
in the sun	60 mL
in the shade	25 mL
in the sun, covered with plastic wrap	0 mL

Which pan lost the most water? _____

How many more milliliters did the sunny pan lose than the shady one? _____

The covered pan sat in the sun and lost none. What happened to its water?

_____

TALK ABOUT IT

Why do you think puddles dry faster on sunny days?

Where have you seen water condense?



STUCK? TRY THIS

Compare the first two rows for the sun. Compare the first and third rows for the cover.

★ CHALLENGE ZONE

Draw the covered pan and show the path one drop of water took during the three days.

WEEK 8 WATER

Sunlight and Gravity

Two things run the water cycle: sunlight lifts the water, and gravity brings it back down.

SITS BESIDE
Water cycles, driven by sunlight and gravity (MS-ESS2-4)

NOTICE FIRST · 2 MINUTES
After a big rain, where does all that water go? Follow it from the roof to the street.

TRY IT · YOU WILL NEED

- a zipper bag
- a little water
- tape
- a sunny window

Safely: Never look straight at the sun.

Up and down

Put a little water in a zipper bag, seal it, and tape it to a sunny window. Watch it for a few days.

Sunlight warms the water and it evaporates. The vapor condenses on the cooler plastic, the drops grow, and they slide back down. The energy to lift the water came from the sun. The pull that brings it down is gravity.

The same two run the whole planet's water cycle. Gravity pulls rain from clouds, pulls rivers downhill to the sea, and pulls rainwater down through the soil.

DRAW IT
Draw your bag each day. Mark where the drops form and where they run.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

A river after a storm

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A town measured the water flowing past a bridge each day, starting the day before a big storm.

Day	Water flowing past (cubic meters each second)
0	40
1	160
2	110
3	75
4	55
5	45

On which day was the flow highest? _____

How much higher was it on day 1 than on day 0? _____

What pulls the rainwater down the hills and into the river? _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called The Water System: draw the water cycle, and mark each step that sunlight drives and each step that gravity drives.

💬 TALK ABOUT IT

Why do you think rivers stay high for days after the rain stops?

Where does the rain that falls on your school go?



STUCK? TRY THIS

Day 0 is the day before the storm. Find the biggest number in the table.

★ CHALLENGE ZONE

The flow takes days to return to 40. Where do you think the extra water was while it was still on its way to the river?

WEEK 9 REVIEW

Systems Inside Systems

Eight weeks in one idea: every system is made of smaller systems, all the way down.

SITS BESIDE
The body as a system of subsystems (MS-LS1-3)

NOTICE FIRST · 2 MINUTES
Think of a box inside a box inside a box. What is the biggest box you are part of?

Part 1 on one card

A **system** is parts that work together, and each part may be a **subsystem** of its own.

Every living thing is made of **cells**. A cell has parts: a membrane, a **nucleus**, mitochondria, and in plants a wall and **chloroplasts**. Cells make **tissues**, tissues make **organs**, and organs make systems.

Systems work together: the heart and lungs share one job, and **nerves** carry signals from **receptors** to the brain.

Water moves in a cycle, lifted by sunlight and pulled down by gravity.

NOTES AND DRAWINGS

Largest to smallest

Number these from 1, the largest, to 5, the smallest.

	System or part	Order
a	your heart	
b	a muscle cell in your heart	
c	you	
d	heart muscle tissue	
e	your circulatory system	

Which row is the largest? _____

Which row is the smallest? _____

Name one thing that flows between your circulatory system and your respiratory system. _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Inside Inside Inside: draw any five levels of one system, each one inside the next.

💬 TALK ABOUT IT

Explain to someone at home how a cell, an organ and a system are related.

What is a system that you are one part of?



STUCK? TRY THIS

Each row is inside the row above it in your answer. Start with the whole person.

★ CHALLENGE ZONE

Make the same kind of list for the water cycle: from the whole cycle down to a single drop.

WEEK 10 HEAT

Heat Moves

Put something warm next to something cool, and energy flows from one to the other until they match.

SITS BESIDE
Mass, material and temperature change (MS-PS3-4)

NOTICE FIRST · 2 MINUTES
Wrap your hands around a cold can. What happens to your hands, and to the can?

TRY IT · YOU WILL NEED

- a small cup of warm tap water
- a bowl of cold water
- two thermometers
- a timer

Safely: Use warm tap water only, never hot.

WORDS TO KEEP

heat	Energy that flows from a warmer object to a cooler one.
temperature	How hot or cold something is: a measure of how fast its particles are moving.



Warm to cool, never the other way

Stand a small cup of warm water in a bowl of cold water. Put a thermometer in each and read both every two minutes.

The warm water cools and the cold water warms, until they reach the same **temperature**. Energy flowed from the warmer water to the cooler water. Energy flowing that way is **heat**.

Temperature measures how fast the particles are moving. In the warm water they move faster, and as they bump into slower particles they pass energy on.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

A warm cup in a cold bath

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class stood a cup of warm water in a bigger bowl of cold water and read both temperatures every two minutes.

Minutes	0	2	4	6	8	10
Cup (°C)	44	34	30	28	26	26
Bath (°C)	20	23	24	25	26	26

At which minute were the two temperatures first the same? _____

How many degrees did the cup drop in the first 2 minutes? _____

Which way did the heat flow? _____

▶ ADD TO YOUR SYSTEM FILE

Start a section of your System File called Heat: draw the cup in the bath with arrows showing which way the energy flowed.

💬 TALK ABOUT IT

Why does a metal spoon in hot soup get warm all the way up the handle?

When you hold an ice cube, does cold flow into your hand, or does heat flow out?



STUCK? TRY THIS

Look for the first column where the two numbers match.

★ CHALLENGE ZONE

The cup dropped 18 degrees and the bath rose only 6. The bath held about three times as much water. Explain why that makes sense.

WEEK 11 HEAT

Same Heat, Different Change

Give two things the same energy, and one may warm far more than the other.

SITS BESIDE
Mass, material and temperature change (MS-PS3-4)

NOTICE FIRST · 2 MINUTES
At the beach on a sunny day, which is hotter on your feet: the dry sand or the water?

TRY IT · YOU WILL NEED

- two cups the same size
- water
- dry sand
- a kitchen scale
- a thermometer
- a sunny spot

Safely: Never look straight at the sun.

Mass and material

Put 100 g of water in one cup and 100 g of dry sand in another. Set both in the same sun for 30 minutes and measure how much each warmed.

They got the same sunlight, but the sand warmed much more. Different materials need different amounts of energy to warm by one degree, and water needs a lot.

Mass matters too. Twice as much water, given the same energy, warms about half as much, because the energy is spread over twice as many particles.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Thirty minutes in the sun

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class set three cups in the same sunny spot for 30 minutes and measured how much each one warmed.

Cup	How much it warmed
100 g of water	4 °C
200 g of water	2 °C
100 g of sand	11 °C

Which cup warmed the most? _____

How many times more did 100 g of water warm than 200 g? _____

The sand and the water had the same mass and the same sun. Why did they warm differently?

_____

TALK ABOUT IT

Why do you think a swimming pool stays cool on the first hot day of summer?

Which would you rather hold on a cold morning: a warm stone or a warm water bottle? Why?



STUCK? TRY THIS

Compare the two water rows for mass. Compare the water and sand rows that have the same mass for material.

★ CHALLENGE ZONE

Sand cools quickly at night too. Predict which would be cooler by sunrise, the sand or the water, and explain.

WEEK 12 HEAT

Keep It Warm

You cannot stop heat from flowing. You can slow it down.

SITS BESIDE
Designing to slow the flow of heat (MS-PS3-3)

NOTICE FIRST · 2 MINUTES
Why do you think a winter coat is puffy?

TRY IT · YOU WILL NEED

- four cups of the same size
- warm tap water
- foil, a wool sock and bubble wrap
- a thermometer
- a timer

Safely: Use warm tap water only, never hot.

WORDS TO KEEP

insulator	A material that slows the flow of heat.
conductor	A material that lets heat flow through it easily, like most metals.

Slow the flow

Fill four cups with the same warm water. Leave one bare and wrap the others in foil, a sock and bubble wrap. Measure how far each one cools in 20 minutes.

A **conductor**, like most metals, lets heat through easily. An **insulator** slows it down. Many good insulators trap pockets of still air, because still air is a poor conductor.

That is a coat, a cooler and the walls of a house: none of them make heat, they slow it.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Four wraps, twenty minutes

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class started four cups at 40 °C and measured how many degrees each one dropped in 20 minutes. Only the wrap changed.

Wrap	Degrees it dropped
no wrap	12 °C
aluminum foil	10 °C
a wool sock	6 °C
bubble wrap	5 °C

Which wrap kept the water warmest? _____

How many fewer degrees did it drop than the cup with no wrap? _____

Which TWO wraps dropped within 1 degree of each other? _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Slowing Heat: draw your best-wrapped cup in cross section, and show where the heat leaves and what slows it.

💬 TALK ABOUT IT

Where in your school do you think heat escapes most?

Why do coolers keep cold drinks cold, if they are made to slow heat?



STUCK? TRY THIS

Warmest means it dropped the fewest degrees.

★ CHALLENGE ZONE

Foil helped a little. Explain why a metal wrap might still slow heat a bit, even though metal is a conductor.

WEEK 13 HEAT

Test the Insulator

If one layer helps, do two help twice as much? Test it, one change at a time.

SITS BESIDE
Designing to slow the flow of heat (MS-PS3-3)

NOTICE FIRST · 2 MINUTES
On a cold day, does a second sweater help as much as the first one did?

TRY IT · YOU WILL NEED

- five cups
- warm tap water
- paper towels
- rubber bands
- a thermometer
- a timer

Safely: Use warm tap water only, never hot.

More is not always more

Wrap cups of warm water in 0, 1, 2, 3 and 4 layers of paper towel, held with rubber bands. Change nothing else.

Each layer slows the heat a little more, but each extra layer helps less than the one before. Engineers look for the point where one more layer is not worth its cost, size or weight.

That is why a design is tested, not guessed: the numbers show where to stop.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Layers of paper towel

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class started five cups at 40 °C and measured how many degrees each dropped in 20 minutes.

Layers	Degrees it dropped
0	12 °C
1	7 °C
2	5 °C
3	4 °C
4	3.5 °C

How many fewer degrees did the cup drop with 1 layer than with none? _____

Between which two numbers of layers did adding one more help least?

_____

Would a fifth layer be worth adding? Use the pattern.

_____

TALK ABOUT IT

Name something that is designed to keep heat in, and something designed to keep it out.

Why might an engineer stop at three layers instead of four?



STUCK? TRY THIS

Subtract each row from the one before. The smallest difference is where one more layer helped least.

★ CHALLENGE ZONE

Design version 2 of the best wrap from last week. Change one thing, and say how you will know whether it helped.

WEEK 14 HEAT

Motion and Energy

Shake a jar of sand long enough and the sand gets warmer. The motion became heat.

SITS BESIDE
Motion energy turning into heat (MS-PS3-5)

NOTICE FIRST · 2 MINUTES
Rub your hands together fast for ten seconds. Where did the warmth come from?

TRY IT · YOU WILL NEED

- a plastic jar with a tight lid
- dry sand
- a thermometer

WORDS TO KEEP

kinetic energy The energy of motion. The faster something moves, the more it has.



Where the motion goes

Fill a jar halfway with dry sand, measure its temperature, close the lid and shake it hard 200 times. Measure again.

Your arm gave the sand **kinetic energy**, the energy of motion. Each time the sand stopped, grains rubbed and bumped, and that energy went into the tiny particles of the sand, making them move faster. Faster particles are a higher temperature.

Whenever something speeds up or slows down, energy moves somewhere. Brakes get hot. So do your hands.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Shaking a jar of sand

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class shook one jar of sand and measured how much warmer it got.

Shakes	How much warmer
0	0.0 °C
200	0.5 °C
400	1.0 °C
600	1.5 °C
800	2.0 °C

How much warmer was the sand after 800 shakes? _____

How much warmer did every 200 shakes make it? _____

Where did the energy of your shaking go?

_____

TALK ABOUT IT

Why do you think a bicycle's brakes can feel warm after a long hill?

What happens to the energy of a ball that rolls to a stop?



STUCK? TRY THIS

Read the last row for the first question. Then compare any row with the next.

★ CHALLENGE ZONE

Predict how much warmer the sand would be after 1,200 shakes. What might make the real result a little lower?

WEEK 15 WEATHER

Uneven Heating

The sun heats land and sea by different amounts, and the air starts to move.

SITS BESIDE
Uneven heating drives air and ocean (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
On a hot afternoon near the coast, which way does the breeze blow: from the land or from the sea?

WORDS TO KEEP

convection	Heat carried by a moving liquid or gas: warm air rises, and cooler air moves in to take its place.

A breeze from the sea

On a sunny day the land warms faster than the sea, just as the sand warmed faster than the water in week 11.

Air over the warm land warms, spreads out and rises. Cooler air from over the sea moves in to take its place: a sea breeze. Heat carried by moving air or water like this is **convection**.

At night the land cools faster than the sea, and the breeze can turn around. The same uneven heating, on the scale of the whole Earth, drives the great winds and ocean currents.

NOTES AND DRAWINGS

Land and sea, one summer day

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A weather station near a beach measured the air over the land and over the sea through one day.

Time	Over the land	Over the sea
6 a.m.	14 °C	16 °C
9 a.m.	18 °C	16 °C
noon	25 °C	17 °C
3 p.m.	27 °C	17 °C
6 p.m.	21 °C	17 °C
9 p.m.	16 °C	17 °C

At what time was the land warmest? _____

How many degrees did the land warm from 6 a.m. to 3 p.m.? _____

At which TWO times was the land cooler than the sea? _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called A Sea Breeze: draw the land, the sea and the air moving between them on a sunny afternoon, with arrows.

💬 TALK ABOUT IT

Why do you think beaches are often breezy on hot afternoons?

Have you ever felt a cool breeze near water on a hot day? Which way was it blowing?



STUCK? TRY THIS

For the last question, compare the two temperature columns row by row.

★ CHALLENGE ZONE

At 3 p.m., which way would the breeze blow, from the sea or from the land? At 6 a.m.? Explain both with the table.

WEEK 16 WEATHER

Air Masses Meet

When a cold air mass pushes into a warm one, the weather can change within an hour.

SITS BESIDE
Air masses and changing weather (MS-ESS2-5)

NOTICE FIRST · 2 MINUTES
Have you ever felt the weather change suddenly, warm one hour and cold and windy the next?

WORDS TO KEEP

air mass	A huge body of air with about the same temperature and moisture all through it.
front	The boundary where two air masses meet. The weather often changes when a front passes.

Where air masses meet

An **air mass** is a huge body of air that has taken on the temperature and moisture of the place it formed: cold and dry over land in the far north, warm and wet over a tropical ocean.

Where two air masses meet is a **front**. When a cold front passes, the heavier cold air pushes under the warm air and lifts it. The lifted air cools, its water vapor condenses, and clouds and rain often form.

After the front, the temperature drops, the wind changes direction, and the air pressure, which fell as the front came near, starts to rise.

NOTES AND DRAWINGS

A front passes a weather station

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A weather station recorded these readings through one day. Air pressure is in hectopascals (hPa).

Time	Temperature	Wind from	Air pressure
6 a.m.	18 °C	south	1,012 hPa
9 a.m.	20 °C	south	1,009 hPa
noon	21 °C	southwest	1,006 hPa
3 p.m.	13 °C	northwest	1,010 hPa
6 p.m.	11 °C	northwest	1,014 hPa

Between which two readings did the temperature drop the most?

_____

When was the air pressure lowest? _____

When do you think the cold front passed? Give two clues from the table.

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called A Front: draw a cold air mass pushing under a warm one, with the clouds that form where they meet.

💬 TALK ABOUT IT

Why do you think weather forecasters watch the air pressure?

What kind of weather would you expect the day after a cold front passes?



STUCK? TRY THIS

Subtract each temperature from the one before. Then look at what else changed at the same time.

★ CHALLENGE ZONE

Sketch a graph of the temperature through the day. Mark where the front passed and label the clues.

WEEK 17 WEATHER

Reading a Forecast

A 70 percent chance of rain is not a promise. It says how often it rains on days like this one.

SITS BESIDE
Air masses and changing weather (MS-ESS2-5)

NOTICE FIRST · 2 MINUTES
If the forecast says a 50 percent chance of rain, do you take an umbrella? Why?

What a chance means

Forecasters use measurements of air pressure, temperature, wind and moisture, and computer models of how air masses move.

A forecast of a 70 percent chance of rain means that on days with conditions like these, it rains on about 7 out of 10. On the other 3, it stays dry, and the forecast was not wrong.

So the way to check a forecaster is over many days: of all the days they said 70 percent, did it rain on about 70 percent of them?

NOTES AND DRAWINGS

Ten days of forecasts

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class wrote down each morning's chance of rain and whether it rained that day.

Day	1	2	3	4	5	6	7	8	9	10
Chance (%)	10	20	80	90	70	30	80	10	60	90
Rained?	no	no	yes	yes	no	no	yes	no	yes	yes

On how many days was the chance 70 percent or more? _____

On how many of those days did it rain? _____

Day 5 said 70 percent and it stayed dry. Was the forecast wrong?

_____

TALK ABOUT IT

Why do you think forecasts for next week are less certain than for tomorrow?

When would a 30 percent chance of rain still matter to someone?



STUCK? TRY THIS

Circle every day with 70, 80 or 90. Then count the yes answers among only those days.

★ CHALLENGE ZONE

On the days with 30 percent or less, how often did it rain? Does that fit the forecasts? Explain.

WEEK 18 REVIEW

Why Weather Happens

Eight weeks in one idea: uneven heating moves air and water, and that is the weather.

SITS BESIDE
Uneven heating drives air and ocean (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
Look outside. Name one thing the weather is doing right now, and one thing that might be causing it.



Part 2 on one card

Heat flows from warmer to cooler. **Temperature** measures how fast particles move.

The same energy changes different materials, and different masses, by different amounts. **Insulators** slow heat; **conductors** let it through. **Kinetic energy** can become heat.

The sun heats the Earth unevenly, so air moves by **convection**. **Air masses** meet at **fronts**, and the weather changes. A forecast is a probability, checked over many days.

NOTES AND DRAWINGS

A sea breeze, step by step

Number these steps from 1 to 4 in the order they happen.

	Step	Order
a	air over the warm land rises	
b	the sun heats the land faster than the sea	
c	cooler air from over the sea moves in to take its place	
d	you feel a cool breeze from the ocean	

Which step comes first? _____

Which step comes last? _____

Which week 11 result explains step b?

_____

TALK ABOUT IT

Explain to someone at home why the weather changes, using the word heat.

What would weather be like on an Earth that the sun heated perfectly evenly?



STUCK? TRY THIS

Start with the sun. Nothing moves until something is warmer than something else.

★ CHALLENGE ZONE

Write the same kind of chain, in four steps, for a cold front bringing rain.

WEEK 19 CLIMATE

Weather Is Not Climate

One hot day is weather. Thirty years of summers is climate.

SITS BESIDE
Regional climates: the usual weather of a place (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
Is your town's weather today what you would call usual for this time of year? How do you know what usual is?

WORDS TO KEEP

weather	What the air is doing in one place at one time.
climate	The usual weather of a place over many years: its averages and its patterns.

Today, or the usual?

Weather is what the air is doing in one place right now: hot, rainy, windy. It can change in an hour.

Climate is the usual weather of a place over many years: its average temperatures, how much rain falls in each season, and how often there are storms.

To know the climate you need many years of measurements and an average. A single record-breaking day tells you about the weather. Only a long run of years can tell you whether the climate is changing.

NOTES AND DRAWINGS

Ten Julys in one town

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The average high temperature for July, in one town, for ten years.

Year	July average high	Year	July average high
2015	31 °C	2020	33 °C
2016	30 °C	2021	31 °C
2017	32 °C	2022	32 °C
2018	31 °C	2023	30 °C
2019	30 °C	2024	31 °C

What is the average of the ten Julys? _____

Which year's July was the warmest? _____

One day last July reached 39 °C. Is that weather or climate? _____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Weather or Climate: write three sentences about weather and three about climate, and say what makes each one which.

💬 TALK ABOUT IT

Ask your teacher, or someone who has lived in your town a long time, whether its summers have changed. How could you check?

Why might a farmer care more about climate than about tomorrow's weather?



STUCK? TRY THIS

Add the ten temperatures and divide by 10.

★ CHALLENGE ZONE

How many of the ten Julys were warmer than the ten-year average? Is one warm July evidence that the climate is warming?

WEEK 20 CLIMATE

Why Coasts Are Mild

Two towns at the same distance from the equator can have very different summers.

SITS BESIDE
Uneven heating drives air and ocean (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
Think of a place near the ocean and a place far inland. Which do you think has hotter summers?

The ocean evens it out

Water warms and cools slowly, as you found in week 11. A huge ocean changes temperature very little from summer to winter.

Air that blows in from the ocean takes on its temperature. So a town on the coast gets mild summers and mild winters. A town far inland, away from that steady ocean air, gets hotter summers and colder winters.

The difference has nothing to do with distance from the sun. It is about what the air passed over before it arrived.

NOTES AND DRAWINGS

Seaside and Valley

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The average high temperature in two made-up towns at the same latitude. Seaside is on the coast; Valley is 150 km inland.

Month	January	April	July	October
Seaside	18 °C	19 °C	22 °C	21 °C
Valley	13 °C	22 °C	35 °C	26 °C

Which town's temperature changes more between January and July? _____

How many degrees hotter is Valley than Seaside in July? _____

Why does Seaside change so little?

_____

TALK ABOUT IT

Why do you think many people choose to live near the coast?

Would you rather live in Seaside or Valley? What would you miss about the other?



STUCK? TRY THIS

For the first question, subtract January from July for each town.

★ CHALLENGE ZONE

Draw a bar graph of both towns in July and January. What does the graph show more clearly than the table?

WEEK 21 CLIMATE

Rivers in the Ocean

Ocean currents are rivers of water thousands of kilometers long, carrying heat as they go.

SITS BESIDE
Uneven heating drives air and ocean (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
If you have been in the ocean in California in summer, was the water as warm as the air?

WORDS TO KEEP

current	A river of water moving through the ocean, carrying heat with it.

Heat on the move

Uneven heating moves the ocean as well as the air. Wind and the turning of the Earth push surface water into huge loops called **currents**.

Some currents carry warm water away from the equator, and some carry cold water toward it. Along California, the California Current carries cold water south, which is one reason the ocean at many California beaches stays chilly even in summer.

A current changes the climate of the land beside it: cool water means cool, often foggy, summers on the coast.

NOTES AND DRAWINGS

Four beaches along one coast

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

Summer water temperatures at four beaches along one coast, where a cold current flows from north to south.

Beach	Position	Water temperature
A	farthest north	11 °C
B		13 °C
C		15 °C
D	farthest south	17 °C

Which beach has the coldest water? _____

How many degrees warmer is the water at D than at A? _____

Far out in the open ocean, as far south as D, the water is 21 °C. Why is the water at D colder?

_____

TALK ABOUT IT

Why do you think fog is common on the California coast in summer?

Where else might moving water carry heat, in a house or in your body?



STUCK? TRY THIS

The current starts in the cold north. Ask what happens to its water as it flows south.

★ CHALLENGE ZONE

The current warms as it flows south. Use the table to say about how many degrees it warms between each beach and the next.

WEEK 22 CLIMATE

The Dry Side of a Mountain

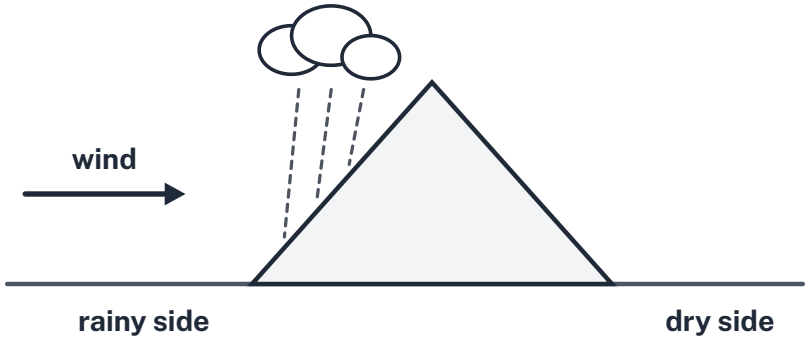
Wind carries ocean air into a mountain range. The air leaves its water mostly on one side.

SITS BESIDE
Mountains and landforms shape regional climates (MS-ESS2-6)

NOTICE FIRST · 2 MINUTES
Look at a map of California. What is on the east side of the Sierra Nevada?

WORDS TO KEEP

rain shadow	The dry land on the side of a mountain range away from the wind.



Up one side, down the other

Wet air from the ocean blows into a mountain range and is pushed up the slope.

As it rises it cools, its water vapor condenses into clouds, and rain or snow falls on the side facing the wind. By the time the air crosses the top, most of its water is gone.

Coming down the other side, the air warms and dries the land beneath it. That dry side is a **rain shadow**. East of the Sierra Nevada lie some of the driest places in North America.

NOTES AND DRAWINGS

Rain across a mountain range

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The rain and snow a year at five stations along a line from the coast, across a range, into the valley beyond.

Station	Where	Rain and snow each year
A	near the coast	50 cm
B	west slope	120 cm
C	mountain top	150 cm
D	east slope	30 cm
E	valley east of the mountains	15 cm

Which station gets the most rain and snow? _____

How many times as much does B get as D? _____

Why is the east side so dry?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called A Rain Shadow: draw a mountain range with the wind, the clouds, the rain, and the dry side, and explain each step.

💬 TALK ABOUT IT

Why do you think forests grow on one side of some mountains and desert on the other?

Where does the water for many California cities come from? Ask your teacher.



STUCK? TRY THIS

Divide B's number by D's number.

★ CHALLENGE ZONE

Sketch the five stations on the mountain drawing and label each with its rain. What pattern does the drawing show?

WEEK 23 LIFE

Grown in a Climate

Seeds from one packet, grown in different places, become very different plants.

SITS BESIDE
Environment and genes shape growth (MS-LS1-5)

NOTICE FIRST · 2 MINUTES
Look at two trees of the same kind, one in a sunny spot and one in shade. Are they the same size?

TRY IT · YOU WILL NEED

- dry beans from one packet
- four cups of soil
- water
- a ruler

Safely: Never eat dry beans: raw, they can make you sick. Wash your hands after handling soil.

WORDS TO KEEP

environment	Everything around a living thing: light, water, temperature, soil and other living things.
gene	An instruction passed from parent to offspring that helps shape a trait.

Genes and environment

A plant's **genes**, passed on from its parents, set what it can become. Its **environment** decides how much of that it does.

Seeds from one packet have very similar genes. Grow them with different temperatures, light or water, and they grow to different heights. The differences come from the environment.

Animals too: a fish in a crowded tank stays smaller than its brother in a pond. Growth is genes and environment together.

DRAW IT

Draw your four cups. Label where each one will grow and how you will water it.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Beans in four places

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class grew beans from one packet in four places and measured them after three weeks.

	Where it grew	Water	Height after 3 weeks
a	cool, 15 °C	watered	8 cm
b	warm, 25 °C	watered	20 cm
c	hot, 35 °C	watered	12 cm
d	warm, 25 °C	dry	6 cm

Of the watered plants, which temperature grew the tallest? _____

Which TWO rows are a fair test of water? _____

The seeds all came from one packet. What does that tell you about why the heights differ?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Genes and Place: draw two plants from the same packet grown in two places, and label what was the same and what differed.

💬 TALK ABOUT IT

Why do you think gardeners plant some crops in spring and others in fall?

Is a tall plant always a healthy one? What else could you measure?



STUCK? TRY THIS

A fair test of water keeps the temperature the same and changes only the water.

★ CHALLENGE ZONE

Plan a fair test of light on these beans. What will you change, and what three things will you keep the same?

WEEK 24 LIFE

Behavior and Offspring

Some animals lay thousands of eggs and leave. Others raise a few young with great care.

SITS BESIDE
Behaviors and structures for reproduction (MS-LS1-4)

NOTICE FIRST · 2 MINUTES
Think of a bird building a nest. What does that behavior do for the eggs it will lay?

WORDS TO KEEP

offspring	The young of a living thing.

Many, or few with care

Animals have behaviors that raise the chance their **offspring** survive.

Some lay huge numbers of eggs and leave them. Most are eaten, but a few survive just by luck of numbers. Others lay a few eggs and guard them, build nests, feed their young and teach them, so a large share survive.

Courtship displays, nests, songs and herds are all behaviors that help animals reproduce and help their young survive.

NOTES AND DRAWINGS

Three made-up animals

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The number of eggs each animal lays in a season, what care it gives, and how many young live to become adults.

Animal	Eggs	Care given	Young that become adults
Fish A	1,000	none	2
Fish B	50	guards the eggs	10
Bird C	4	both parents feed the chicks	2

Which animal has the most young become adults? _____

What fraction of Bird C's eggs become adults? _____

Fish A lays 1,000 eggs and only 2 survive. Why might laying so many still work?

_____

TALK ABOUT IT

Name an animal that cares for its young, and what it does.

Why do you think some animals live in groups while raising young?



STUCK? TRY THIS

For the fraction, write the young that become adults over the eggs.

★ CHALLENGE ZONE

Fish A gets 2 adults from 1,000 eggs and Fish B gets 10 from 50. Compare their survival as a fraction or a percent. Which strategy is working better here?

WEEK 25 LIFE

Flowers and Pollinators

A flower's color and smell are not decoration. They are an advertisement.

SITS BESIDE
Behaviors and structures for reproduction (MS-LS1-4)

NOTICE FIRST · 2 MINUTES
Watch a flowering plant for two minutes. What visits it, and where on the flower does it go?

TRY IT · YOU WILL NEED

- a timer
- a notebook

Safely: Watch bees from at least 2 meters away, and never swat at them. Anyone allergic to stings, or not sure, watches from indoors.

WORDS TO KEEP

pollinator An animal that carries pollen from flower to flower, like a bee, a bird or a bat.

Why flowers look and smell the way they do

A plant cannot walk to another plant. To make seeds, most flowering plants need pollen carried from one flower to another.

A **pollinator**, like a bee, visits for the sweet nectar and gets dusted with pollen, which it carries to the next flower. Bright colors, strong smells and the shape of a flower are structures that attract the right visitors.

Count the visits a plant gets in ten minutes, and you are measuring how well its flowers work.

DRAW IT

Draw one flower you watched and the visitor that came. Mark where the visitor touched the flower.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Bee visits in ten minutes

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A team of scientists set out paper flowers, all the same size and shape, in two colors. Some were scented with flower oil. No sugar water was used. They counted bee visits for ten minutes.

Flower	Bee visits
blue, sweet smell	14
blue, no smell	6
white, sweet smell	9
white, no smell	3

Which flower got the most visits? _____

How many more visits did the sweet-smelling blue flower get than the blue one with no smell? _____

Does smell matter for the white flowers too? Use the numbers. _____

TALK ABOUT IT

Why do you think some flowers that bloom at night are white and strongly scented?

Name a food that would not exist without pollinators.



STUCK? TRY THIS

Compare flowers that differ in only one way: same color, different smell.

★ CHALLENGE ZONE

Which matters more to these bees, color or smell? Use two comparisons from the table to decide.

WEEK 26 LIFE

One Parent or Two

Offspring from one parent are copies. Offspring from two parents are each a little different.

SITS BESIDE
One parent or two: inheritance and variation (MS-LS3-2)

NOTICE FIRST · 2 MINUTES
Look at puppies or kittens from one litter, or a picture of them. Are they exactly alike?

TRY IT · YOU WILL NEED

- a cutting from a houseplant such as a pothos
- a jar of water

Safely: Never chew any part of the plant. Wash your hands after.

WORDS TO KEEP

asexual reproduction Making offspring from one parent. The offspring have the same genes as that parent.

sexual reproduction Making offspring from two parents, each giving half the genes, so the offspring vary.

Copies and mixes

Put a cutting from a houseplant in water. In a few weeks it grows roots and becomes a new plant, with only one parent.

In **asexual reproduction** the offspring get all their genes from that one parent, so they are copies of it and of each other.

In **sexual reproduction** each parent gives half the genes, in a new mix every time. So offspring vary: some a different color, some a different leaf shape. That variation is why most brothers and sisters are not identical. Identical twins are the exception: they began as one fertilized egg.

DRAW IT

Draw your cutting each week. Mark when the first root appears.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Cuttings and seeds

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class grew 10 plants from cuttings of one red-flowered plant, and 10 from seeds made by two parent plants, all side by side in the same soil, light and water. Then they counted the flower colors.

Grown from	Red flowers	White flowers
cuttings of one plant	10	0
seeds from two parents	6	4

Which group showed variation? _____

How many of the plants grown from seeds had white flowers? _____

Why are the plants grown from cuttings all alike?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called One Parent or Two: draw a parent plant with its cuttings, and two parent plants with their seedlings, and show which group varies.

💬 TALK ABOUT IT

Why might a gardener grow a prize rosebush from cuttings instead of seeds?

Why might variation help a kind of living thing survive when its environment changes?



STUCK? TRY THIS

Variation means the offspring are not all the same. Look for the row with two kinds.

★ CHALLENGE ZONE

A disease attacks only red-flowered plants. Which group, the cuttings or the seedlings, would still have some plants alive afterward? Explain.

WEEK 27 REVIEW

A Place and What Lives There

Eight weeks in one idea: a place's climate shapes the living things in it.

SITS BESIDE
Environment and genes shape growth (MS-LS1-5)

NOTICE FIRST · 2 MINUTES
Think of a desert, a rainforest and a snowy mountain. Name one living thing that fits each.

Part 3 on one card

Weather is today. **Climate** is the usual over many years.

Coasts are mild because the ocean changes temperature slowly. Ocean **currents** carry heat. Mountains leave a **rain shadow**.

A living thing's **genes** and its **environment** shape how it grows. Behaviors and structures, from nests to flowers that attract a **pollinator**, help it make **offspring**. One parent makes copies; two parents make variation.

NOTES AND DRAWINGS

One kind of tree, two places

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The average height of one kind of tree, measured in a warm, wet valley and high on a cold, windy mountain.

Where	Average height
valley, warm and wet	2.0 m
mountain, cold and windy	0.5 m

How many times taller are the valley trees? _____

Seeds from the mountain trees, grown in the valley, reached 1.9 m. What does that tell you?

_____

Name one thing in the mountain environment that could keep a tree short.

_____

TALK ABOUT IT

Explain to someone at home why the same kind of tree can be tall in one place and short in another.

Which part of this year has changed how you see the place you live?



STUCK? TRY THIS

Divide the valley height by the mountain height.

★ CHALLENGE ZONE

Design an experiment to find out whether wind alone keeps the mountain trees short. What would you change, and what would you keep the same?

WEEK 28 WARMING

A Century of Temperatures

One warm year shows very little. A hundred years of averages can show a trend.

SITS BESIDE
Evidence for rising global temperatures (MS-ESS3-5)

NOTICE FIRST · 2 MINUTES
If you wanted to know whether your town is getting warmer, what would you need to measure, and for how long?

WORDS TO KEEP

average	The total divided by the number of values: one number that stands for a whole set.

Averages over a long time

Single days and single years jump up and down. To see a change in climate, scientists take an **average** over many years and compare the averages.

Scientists who measure temperatures all over the world, on land and at sea, find that Earth's average surface temperature has risen by a little more than 1 degree Celsius since the late 1800s.

One degree sounds small. Averaged over the whole planet, it is enough to melt ice, raise the sea and shift when plants flower, which is what the next weeks look at.

NOTES AND DRAWINGS

One made-up town, a century of averages

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The average yearly temperature of one town, worked out for six decades.

Decade	Average temperature
1910s	14.2 °C
1930s	14.3 °C
1950s	14.3 °C
1970s	14.6 °C
1990s	14.9 °C
2010s	15.3 °C

How much warmer were the 2010s than the 1910s? _____

Between which two decades in the table did it warm the most? _____

Why use the average of a whole decade instead of one hot year?

_____

▶ ADD TO YOUR SYSTEM FILE

Start the last section of your System File, called Warming: copy the table as a line graph, and write one sentence about what it shows.

💬 TALK ABOUT IT

Ask your teacher or someone older whether winters were different when they were your age. Is a memory the same as a measurement?

Why do you think scientists measure temperatures in so many places?



STUCK? TRY THIS

Subtract each decade from the next one in the table. Look for the biggest jump.

★ CHALLENGE ZONE

Two decades in the table had the same average. Does that mean the town stopped warming then? Explain using the whole table.

WEEK 29 WARMING

Good Questions About the Rise

Science answers questions about what is happening. Some questions also need people to decide what they value.

SITS BESIDE
Evidence for rising global temperatures (MS-ESS3-5)

NOTICE FIRST · 2 MINUTES
Think of a question about the weather or the climate that you would like answered. Could a measurement answer it?

WORDS TO KEEP

evidence	Observations and measurements that support an idea or argue against it.

What measurements can answer

Burning coal, oil and gas gives off carbon dioxide. Carbon dioxide in the air traps heat near Earth's surface, and scientists have measured the amount in the air rising for decades.

Questions such as "how much?" or "how fast?" or "does this cause that?" can be answered with **evidence**: careful measurements, repeated and checked.

Questions like "is it good?" or "what should we do?" need evidence too, but they also depend on what people value. Science informs those choices. It does not make them alone.

NOTES AND DRAWINGS

Six questions

For each question, write yes if measurements alone could answer it, or no if people would also have to decide what they value.

	Question	Measurements alone?
a	How much has the average temperature of our town changed since 1950?	
b	Is a warmer world good or bad?	
c	Does a car give off more carbon dioxide driving fast or driving slowly?	
d	Which month had the most rain last year?	
e	Should our town close its downtown streets to cars?	
f	Do trees planted in a parking lot lower its temperature?	

How many questions could measurements alone answer? _____

Which TWO need people to decide what they value? _____

Rewrite question e as a question measurements could answer.

_____

TALK ABOUT IT

Why do you think people can agree on the measurements and still disagree about what to do?

What is one question about your school that measurements could answer?



STUCK? TRY THIS

Ask: could two careful people with the same instruments disagree about the answer?

★ CHALLENGE ZONE

Write a question that measurements could answer about the carbon dioxide your buses or cars that come to your school give off. Say what you would measure.

WEEK 30 WARMING

What Changes for Living Things

A warmer spring can arrive before the animals that depend on it are ready.

SITS BESIDE
Temperature shapes when plants grow and flower (MS-LS1-5)

NOTICE FIRST · 2 MINUTES
Which plants near your school flower first in spring? Do you know when?

Timing matters

Many plants flower when the spring gets warm enough. In a warmer climate, that day comes earlier.

Some animals time their lives by something else, like the length of the day. If flowers open early and their pollinators come out at the usual time, the flowers may miss their pollinators and the pollinators may miss their food.

A change in one part of a system reaches the others. That is what systems have meant all year.

NOTES AND DRAWINGS

When the cherry trees flowered

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

The average day of the year a made-up town's cherry trees first flowered, by decade. Day 100 is about April 10.

Decade	First flowers (day of the year)
1950s	100
1970s	97
1990s	92
2010s	88

How many days earlier did the trees flower in the 2010s than in the 1950s? _____

Did they flower earlier in every decade in the table? _____

Why might earlier flowers be a problem for the bees that visit them?

_____

💬 **TALK ABOUT IT**

Why do you think some birds now arrive at their summer homes earlier than they used to?

Name something people do that depends on the timing of a season.



STUCK? TRY THIS

Subtract the 2010s day from the 1950s day.

★ **CHALLENGE ZONE**

Look back at week 25. Which idea from that week helps explain why a bee arriving late would matter to the tree?

WEEK 31 WARMING

Measure a Human Impact

Before anyone can fix a problem, someone has to measure it.

SITS BESIDE
Monitoring and reducing human impact (MS-ESS3-3)

NOTICE FIRST · 2 MINUTES
Think of the storm drains you have seen at school. What collects on top of them?

TRY IT · YOU WILL NEED

- gloves
- a bag
- a clipboard

Safely: Wear gloves. Never pick up glass, needles or anything sharp: tell an adult. Never lift a grate or reach into a drain, and stay out of parking lots and traffic. Wash your hands after.

WORDS TO KEEP

impact An effect, often a lasting one: what a change does to a place or to the living things there.

Where the drain goes

In most California towns, storm drains carry rainwater straight to creeks and the ocean, without cleaning it first.

So litter that reaches a drain can end up in a creek. That is a human **impact**: an effect people have on a place and on the living things there.

The first step to reducing an impact is to measure it, in a way that can be repeated. Count what collects at each drain, in the same way, on the same day each week.

DRAW IT

Draw a map of the drains near your classroom. Write the litter you find at each.

MY INVESTIGATION

I predict: _____

What happened: _____

What I think caused it: _____

Litter at four drains

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class counted the pieces of litter collected at four storm drains around a school in one week.

Drain	Pieces of litter
by the front gate	9
by the field	4
by the cafeteria	15
by the playground	7

Which drain collected the most litter? _____

How many pieces were collected in all? _____

Which drain would you work on first, and why?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Our Drains: map the school's storm drains and write this week's litter count beside each one.

💬 TALK ABOUT IT

Where do you think the litter at the cafeteria drain comes from?

What is one human impact on a place you know, and how could you measure it?



STUCK? TRY THIS

Add all four counts for the second question.

★ CHALLENGE ZONE

Litter counts can change with the weather and the day. Plan how you would make next week's count fair to compare with this week's.

WEEK 32 WARMING

Design a Monitor

A monitor is a measurement repeated on purpose, so a change cannot sneak past.

SITS BESIDE
Monitoring and reducing human impact (MS-ESS3-3)

NOTICE FIRST · 2 MINUTES
If you checked a plant only once a month, what might you miss?

How often to measure

To monitor something is to measure it again and again, the same way, so you can see it change.

Measure too rarely and a short event slips through. Measure too often and the work never ends, and people stop doing it. Designing a monitor means choosing what to measure, how, where and how often.

Good monitors also record what else happened: the weather, a school event, a change in the trash cans. That is what lets you explain an odd result later.

NOTES AND DRAWINGS

Four weeks at the cafeteria drain

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class counted the litter at the cafeteria drain every week for a month. Week 2 was the week of the school fair.

Week	Pieces of litter
1	15
2	40
3	12
4	14

How many pieces were collected in the whole month? _____

Which week was unusual? _____

A plan to count only once a month would have missed something. What, and why does it matter?

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Our Monitor: write your monitoring plan, and the results of the first two times you carry it out.

💬 TALK ABOUT IT

Name something at school that is measured regularly. Why that often?

What would you add to a litter count to help explain a strange week?



STUCK? TRY THIS

Add the four weeks. Then look for the week that does not fit the others.

★ CHALLENGE ZONE

Write a one-paragraph monitoring plan for the cafeteria drain: what, how, where, how often, and what else you will record each time.

WEEK 33 DESIGN

Criteria and Constraints

A design problem stated precisely is half solved.

SITS BESIDE
Defining a design problem precisely (MS-ETS1-1)

NOTICE FIRST · 2 MINUTES
If someone asked you to build a better drain cover, what would you need to know before you started?

WORDS TO KEEP

criteria	What a design must do to count as a success.
constraint	A limit on a design, like its cost, its size or the materials allowed.

Say exactly what success means

The problem: stop most of the litter at the cafeteria drain from reaching the creek.

“Stop most of the litter” is not precise enough to test. The **criteria** say exactly what success is, with numbers where possible. The **constraints** are the limits: cost, size, materials, the time to build it, and rules.

A precise problem also names what must NOT happen. A screen that catches every piece of litter and floods the walkway has failed.

NOTES AND DRAWINGS

Sort the requirements

Six requirements for a drain screen. Write criterion or constraint for each.

	Requirement	Criterion or constraint?
a	catches at least 8 of every 10 pieces of litter	
b	costs no more than $40	
c	lets rainwater through without flooding the walkway	
d	fits the drain, which is 50 cm wide	
e	is built only from materials the school already has	
f	keeps working through a whole rainy season	

How many are constraints? _____

A screen floods the walkway. Which requirement has it failed? _____

Write one more constraint the class might need.

_____

TALK ABOUT IT

Why do you think engineers write down the criteria before they build anything?

Name a constraint on a project you have done at school.



STUCK? TRY THIS

A criterion is something the design must DO. A constraint is a LIMIT on it.

★ CHALLENGE ZONE

Rewrite requirement f so it can be tested in one week instead of a whole season. What would you measure?

WEEK 34 DESIGN

Compare the Designs

The design with the best score is not the right choice if it breaks a rule.

SITS BESIDE
Evaluating designs against criteria (MS-ETS1-2)

NOTICE FIRST · 2 MINUTES
When you choose between two things, how do you decide which matters most?

A table for deciding

Engineers compare designs in a table: one row for each design, one column for each criterion, a score in every cell.

Add up the scores, but first check the constraints. A design that breaks a constraint is out, however well it scores: it costs too much, or does not fit, or cannot be built.

Then look past the total. A low score on one criterion can matter more than a high total, if that criterion is about safety or flooding.

NOTES AND DRAWINGS

Three drain screens

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class scored three designs from 1 to 5 on each criterion, and checked whether each stayed inside every constraint.

Design	Catches litter	Lets water through	Lasts	Inside every constraint?
A	4	5	3	yes
B	5	2	4	yes
C	5	5	5	no

Which design has the highest total score? _____

Which design should the class build? _____

B catches more litter than A. Why might it still be the worse choice?

_____

TALK ABOUT IT

Name a school project where you chose something that was not the “best” because of a limit like time or materials.

Who should decide which criterion matters most?



STUCK? TRY THIS

Cross out any design that is not inside every constraint before you compare totals.

★ CHALLENGE ZONE

Design C breaks a constraint. Suggest one change that might bring it inside the constraints, and say which score it might lower.

WEEK 35 DESIGN

Test and Improve

Build, test, change one thing, and test again, until the design meets every criterion.

SITS BESIDE
Testing and improving a design (MS-ETS1-4)

NOTICE FIRST · 2 MINUTES
Think of something you made more than once. What did you change the second time, and why?

TRY IT · YOU WILL NEED

- a plastic cup
- a pushpin
- a pencil for bigger holes
- a bowl to catch the water
- a measuring cup of water
- 10 scraps of paper
- a timer

Safely: An adult pushes the pin and the pencil through the cup.

One change, then test

Make a model drain screen: a cup with holes poked in the bottom. Drop in 10 scraps of paper and pour in a cup of water.

Count the scraps the screen catches, and time how long the water takes to drain. Then change ONE thing, such as the size of the holes or the tilt, and test again.

The criteria: catch at least 8 of the 10 scraps, and drain in 20 seconds or less. A change that fixes one criterion can break the other, which is exactly what testing is for.

DRAW IT
Draw your screen. Label the holes, the tilt and anything else you change.

MY INVESTIGATION

I predict:

What happened:

What I think caused it:

Four versions

PRACTICE DATA · MADE UP FOR THIS PAGE, NOT MEASURED

A class tested four versions of one screen, changing one thing each time.

Version	What changed	Scraps caught	Seconds to drain
1	first build: large holes, flat	7	10
2	made the holes small	9	40
3	tilted the screen	9	30
4	made the holes medium	9	18

Which version first met both criteria? _____

Which change made the draining too slow? _____

Is version 4 better than version 3? Use the numbers.

_____

▶ ADD TO YOUR SYSTEM FILE

Add a page called Version by Version: each version of your screen, the one thing you changed, and both results.

💬 TALK ABOUT IT

Why is it useful to change only one thing between tests?

When is a design good enough to stop improving?



STUCK? TRY THIS

Check each version against both criteria: 8 or more scraps, and 20 seconds or fewer.

★ CHALLENGE ZONE

Design version 5. Change one thing, predict both results, and say why.

WEEK 36 REVIEW

Inside the System

A whole year of taking systems apart: parts, what flows between them, and what happens when one changes.

SITS BESIDE
Monitoring and reducing human impact (MS-ESS3-3)

NOTICE FIRST · 2 MINUTES
Look back through your System File. Which system surprised you most?

The year on one card

Every **system** is parts that work together, and most parts are systems themselves: the body, the **cell**, the water cycle.

Things flow between the parts: oxygen and blood, **heat**, water, signals along **nerves**, energy from the sun.

Change one part and the others change too. That is why warming moves flowering dates, why a mountain dries a valley, and why a drain screen that floods a walkway has failed.

And every system can be measured, which is where every good decision about it starts.

NOTES AND DRAWINGS

Six systems

Write yes if the system is alive, or made of living things, and no if it is not.

	System	Living?
a	a click pen	
b	your body	
c	a plant cell	
d	the water cycle	
e	a town's storm drains	
f	a pond food web	

How many of the systems are living? _____

Pick one system that is not living and name something that flows through it.

_____

How could a change in a town's storm drains change a pond food web?

_____

TALK ABOUT IT

Explain to someone at home one system from this year, using its parts and what flows between them.

What is one system you would like to take apart next?



STUCK? TRY THIS

Ask whether the system is made of cells, or of things made of cells.

★ CHALLENGE ZONE

Choose any system you know well. Draw its parts, the arrows for what flows between them, and one change that would ripple through the whole.

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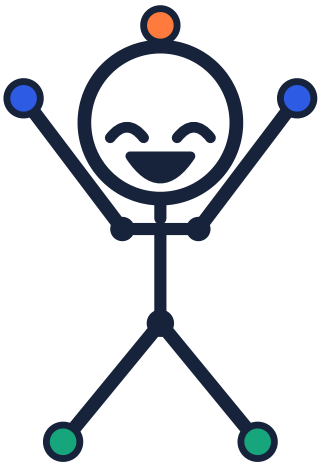
Grade 6 · Inside the System

Certificate of Completion

This is to certify that

_____

practiced taking systems apart for thirty-six weeks.



_____ _____

Teacher Date

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