

# Stardust to Storytellers: A Prehistory Workbook

## Instructor Guide & How-To

### Welcome to Stardust to Storytellers!

This workbook takes your learner on a journey through the history of the universe and life on Earth from the Big Bang all the way to the dawn of recorded history. Each lesson includes a reading passage alongside a variety of activities designed to build comprehension, writing skills, scientific thinking, and creative engagement.

This guide will walk you through the structure of the workbook, explain each type of activity, and help you customize the experience for your learner's needs, pace, and learning style.

### How This Workbook Is Organized

Each lesson follows the same consistent structure:

- **Reading** — The core content passage for the lesson.
- **Timeline** — A drawing activity connected to the lesson's place in deep time.
- **Notebooking** — A visual or diagramming activity to process and record what was learned.
- **Vocabulary & Writing** — Structured writing exercises that build grammar and composition skills alongside science vocabulary.
- **Flip Book (select lessons only)** — A hands-on cut-and-assemble activity for sequencing key processes.

Some lessons have additional notebooking pages, extra writing pages, or a "Timeline Alternative" (a visual drawing activity in place of the main timeline format). These are clearly labeled.

### You Do NOT Need to Do Everything

This workbook is designed to be flexible, not prescriptive. Every learner is different, and you know yours best.

Here is some guidance on how to pick and choose:

- **Reading:** The Reading is the foundation.  
We recommend always starting here. It provides the content that the other activities are built around.
- **Timelines:** Timelines are great for visual learners and big-picture thinkers.  
If your learner finds drawing tedious, it is perfectly fine to skip or discuss the timeline prompt verbally instead. Some timelines are labeled "Alternative" these offer a drawing prompt even when there is no official timeline update.
- **Notebooking:** Notebooking pages vary widely.

Some involve labeling diagrams, some involve Venn diagrams, and some invite more creative responses. Some lessons have two notebooking pages. Feel free to choose whichever suits your learner, or spread them across multiple sessions.

- **Vocabulary & Writing:** The Vocabulary & Writing activities are the most structured. They are designed to be used as writing extensions, not just comprehension checks. See the full explanation below. If your learner is younger or not yet ready for structured writing instruction, you can use these oral practice or write the words your learner dictates to you instead.
- **Flip Books:** Flip Books are optional enrichment. They appear in a few lessons and work well as hands-on review or for learners who enjoy craft-style activities. Two versions are provided for each flip book: a blank version for learners to fill in themselves, and a pre-filled version as a reference or shortcut.
- **Creature Trading Cards:** Creature Trading Cards (at the back) are fully optional. They can be completed for any creature from any lesson and work well as an ongoing collection project throughout the course.

## Understanding the Writing Activities

The Vocabulary & Writing pages are central to the workbook's language arts component. A lot of the activities are inspired by the book, "The Writing Revolution". Each lesson includes one or more of the following writing exercise types. Here is what they are and how to use them.

### Because / But / So

This exercise presents one sentence and asks your learner to complete it three times: once with "because," once with "but," and once with "so." Each connector requires a different kind of thinking:

- Because requires an explanation of cause or reason.
- But requires a contrast, exception, or complication.
- So requires a result or consequence.

The goal is not just grammatical accuracy, but also flexible thinking. Your learner will need to revisit what they read and consider the topic from multiple angles. There is no single correct answer, only answers that are logical and supported by what they know.

Tip: If your learner is stuck, try asking: "Why did that happen?" (because), "What is the surprising or opposite thing about it?" (but), or "What happened as a result?" (so).

### Subordinating Conjunctions

These exercises ask learners to complete sentences that begin or include a conjunction such as although, because, since, when, before, after, or if. This teaches learners to build complex sentences with dependent clauses which is a key skill for mature writing.

Each sentence is partially given (either the main clause or the dependent clause) and the learner supplies the missing half. Answers must make the sentence logically and factually true based on what they read.

Tip: Encourage your learner to look back at the reading if they are unsure. The goal is accuracy and logic, not speed.

## Appositives

An appositive is a phrase placed next to a noun that describes or renames it. These exercises present a sentence with a blank in the middle, and the learner fills in a descriptive phrase from the reading.

For example: "Cyanobacteria, \_\_\_\_\_, would eventually change the entire atmosphere of Earth."

A correct answer might be: "the bacteria that invented photosynthesis."

This teaches learners to embed additional information into sentences smoothly, one of the hallmarks of sophisticated writing. Point out that the blank is surrounded by commas — this is a visual cue that the phrase inside is an appositive.

## Sentence Expansion

These activities give learners a very short, bare-bones sentence and ask them to rewrite it with added detail, using the reading as their source. A question in parentheses prompts what kind of detail to add.

For example: "Fish developed jaws. (When did this happen, why did it matter, and what could jawed fish do that earlier fish could not?)"

The goal is to move from simple, sparse sentences to rich, informative ones. This is excellent practice for non-fiction writing and report-style communication. A strong expanded sentence might be two to four sentences long.

## Vocabulary Fill-in-the-Blank and Matching

These appear in many lessons and are straightforward comprehension-plus-vocabulary activities. A word bank is always provided for fill-in-the-blank exercises. These can be completed independently, used for review, or discussed aloud for younger learners.

## Think and Write

This is the most open-ended writing activity in the workbook. It asks learners to synthesize what they have read into a short paragraph or multi-sentence response. Some prompts ask for explanation; others ask for analysis or a supported opinion.

Think and Write prompts can be completed in writing or orally for younger or reluctant writers. They are also excellent discussion starters for families who enjoy talking through ideas together.

A strong response will reference specific evidence from the reading, not just general knowledge. Encourage your learner to quote or paraphrase the text in their answers.

## Pacing Suggestions

This workbook is not designed to be completed in a single session per lesson. A typical approach might be:

- Day 1: Read the passage aloud or independently; discuss key ideas.

- Day 2: Complete the Timeline and Notebooking page(s).
- Day 3: Work through the Vocabulary & Writing activities.
- Any day: Creature Trading Card (if using) for that lesson's featured organism.

Some lessons have more activities than others. Adjust as needed. It is better to go slowly and discuss deeply than to rush through every page.

## A Note on Drawing Activities

Several activities in this workbook (Timelines, some Notebooking pages, and the Creature Trading Card) ask learners to draw. These are not art assessments. The drawing is a tool for memory, engagement, and visual thinking.

Encourage your learner to try, but do not stress about the quality. Stick figures, labeled diagrams, and rough sketches all count. The act of deciding what to draw and where to put things is the learning. You can also offer to draw together, or describe the scene verbally if drawing creates frustration.

## Final Note

This workbook covers some of the most awe-inspiring ideas in all of science: the age of the universe, the origin of life, the making of the human brain. We hope it sparks wonder, conversation, and a sense of connection to the deep past that made us possible.

Take your time. Follow your learner's curiosity. Skip what does not work and linger on what does.

# Lesson 1: The Big Bang

Have you ever wondered where *everything* came from? Not just the ground under your feet or the air you breathe, but every star, every ocean, every atom in your fingernail. The answer, as best as scientists can tell, is that it all started from a single unimaginably tiny point. About 13.8 billion years ago, space itself did not exist. Time did not exist. And then something happened.

Scientists call it the **Big Bang**. But do not picture a bomb going off in an empty room. There was no room yet. The Big Bang was not an explosion in space. It was the creation of space itself, beginning to stretch and grow. In less than a second, the **universe** went from being smaller than a grain of sand to incomprehensibly vast. And it has been growing ever since. Right now, as you read this sentence, the galaxies around us are drifting further apart, carried outward by that original surge, which scientists call **expansion**.

At first, everything was pure energy, far too hot for any matter to exist. But as space stretched and cooled, particles appeared, then joined together into simple atoms: mostly hydrogen and helium. From those humble ingredients, gravity would slowly draw stars into being, and from stars, everything else would eventually grow.

How do we know the Big Bang really happened? Two powerful clues. First, astronomers can see that galaxies are moving away from us in every direction, like dots on a balloon drifting apart as it inflates. Wind that movement back in time and you arrive at a single starting point. Second, wherever scientists point their instruments in space, they detect a faint warmth: the leftover glow from the very first moments of existence. This faint glow is called **cosmic background radiation**, and it is like a photograph of the universe just after its birth. It fills the entire sky, in every direction, an echo of the moment everything began.

Here is something worth sitting with: every atom in your body, the carbon in your cells, the oxygen in your lungs, the iron in your blood, was born in those first moments or forged inside stars that came later. You are not just living in the universe. You are part of it, made from the same ancient stuff. It is not poetry. It is science. And it is where our long story of life on Earth begins.

# The Big Bang

## 13.8 Billion Years Ago

Draw a single blazing point of light at the center of the page with waves of energy and light exploding outward in every direction. Remember: no stars yet, no planets, just pure heat and expanding space.

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# Lesson 1: The Big Bang

Draw and label a diagram showing the Big Bang moment (the singularity) and then the resulting expansion. Label how long ago each part was.

# Lesson 1: The Big Bang

## Vocabulary:

Fill in the Blank

**Word Bank:** *Big Bang universe expansion cosmic background radiation singularity*

1. Everything that exists — all stars, planets, and living things — is part of the

\_\_\_\_\_.

2. Scientists call the moment when space, time, and energy first began the

\_\_\_\_\_.

3. The tiny, impossibly hot and dense point where it all began is called a

\_\_\_\_\_.

4. The ongoing stretching of space that carries galaxies further apart is called

\_\_\_\_\_.

5. The faint heat energy left over from the very first moment of time is called

\_\_\_\_\_.

## Because / But / So

Complete each sentence using the connector word shown.

The universe began as a single tiny point **because**

\_\_\_\_\_.

The universe began as a single tiny point, **but**

\_\_\_\_\_.

The universe began as a single tiny point, **so**

\_\_\_\_\_.

# Lesson 2: Star Formation

After the Big Bang, for millions of years, the universe was dark. No stars, no light, no warmth. Just vast, drifting clouds of hydrogen and helium gas in the cold and the black. Nothing seemed to be happening. But **gravity** was quietly getting to work, and everything was about to change.

Gravity is a pull that exists between anything that has mass, and everything in the universe has mass. Slowly, inevitably, gravity pulled the gas clouds together. As they collapsed inward, the pressure and temperature at the center climbed higher and higher. When the temperature reached millions of degrees, something extraordinary happened: atoms began smashing together so hard they fused. This is called **nuclear fusion**, and it releases enormous energy. A star switched on. Somewhere in the darkness, the first light appeared.

Stars are the universe's great factories. Inside them, simple hydrogen is hammered by pressure and heat into heavier **elements**: carbon, oxygen, nitrogen, iron. This is not just interesting chemistry. Carbon is the backbone of every living molecule. Oxygen is what your cells burn. Iron carries oxygen through your blood. Everything the universe needed to eventually make life, stars spent billions of years building. The great clouds of gas and dust in space where new stars are born are called **nebulae**, and they are still forming stars today, all across the galaxy.

When a massive star finally runs out of fuel, it does not simply dim. It collapses and then explodes in a spectacular burst called a **supernova**. In that explosion, the heaviest elements are forged, and all the elements the star built over its lifetime are flung outward into space, scattered like seeds. Those atoms drift, drift, drift through the universe. They gather into new clouds. New stars ignite. Planets form. Life begins. The iron in your blood was made inside a star that exploded before our Sun existed. The calcium in your bones, the oxygen in your lungs, the carbon in every cell: all of it came from stars. You are made of stardust. That is not just a beautiful thought. It is one of the most wonderful facts in all of science.

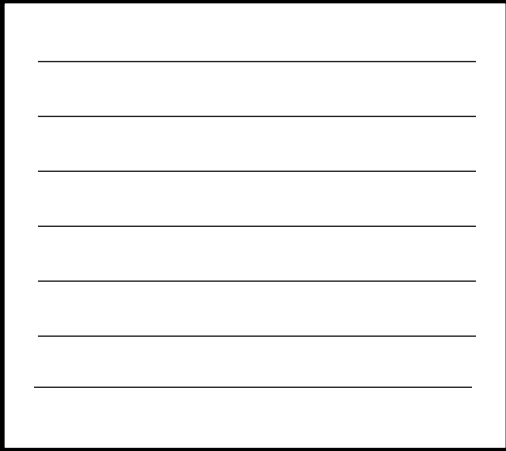
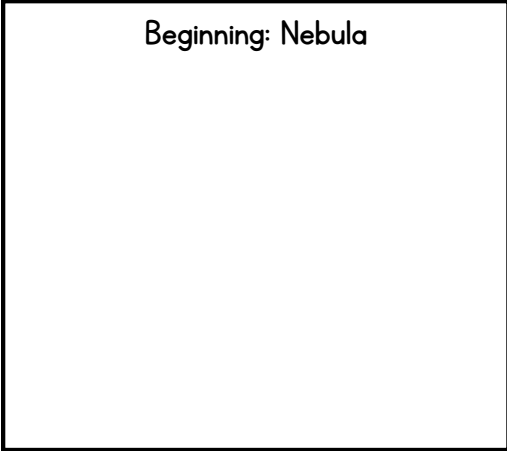
# Formation of Stars: 13.6 Billion Years Ago

Draw a giant nebula, a swirling cloud of hydrogen and helium gas, with a bright new star igniting at its center. You could include smaller stars beginning to glow in the darkness around it.

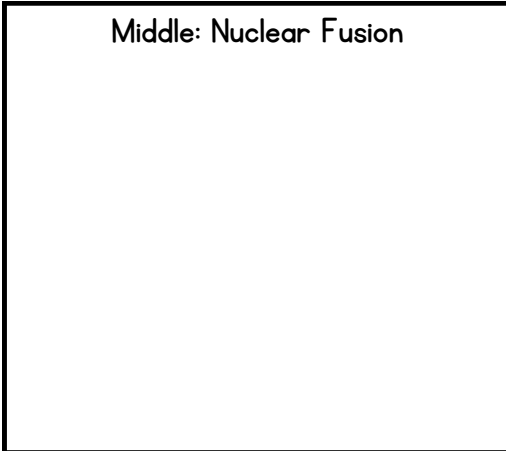
# Lesson 2: Star Formation

Create a timeline showing the "Life Cycle of a Star": beginning (cloud of gas), middle (fusion happening inside), and end (explosion or gentle fading). Write one sentence for each stage explaining what's happening inside the star.

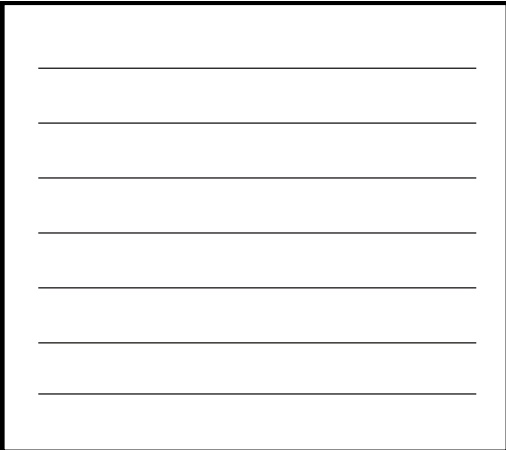
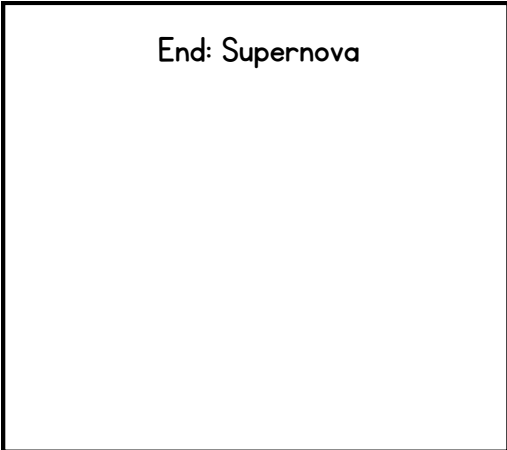
Beginning: Nebula



Middle: Nuclear Fusion



End: Supernova



# Lesson 2: Star Formation

## Because / But / So

Complete each sentence using the connector word shown.

Stars are important to life on Earth because

---

Stars are important to life on Earth, but

---

Stars are important to life on Earth, so

---

## Subordinating Conjunctions

Complete each sentence using the conjunction shown. Your answer must make the sentence true.

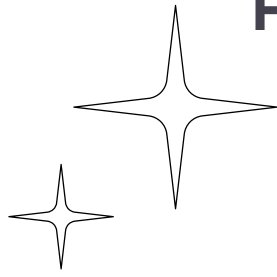
Stars explode in supernovas because \_\_\_\_\_.

After \_\_\_\_\_, it explodes in a supernova.

If \_\_\_\_\_, there would be no carbon, oxygen, or iron for life.

## Think and Write

There is a common phrase, 'We are all made of stardust.' Using what you read, explain exactly what this means and why it is true.



# FORMATION OF STARS

FLIP BOOK

GLUE OR STAPLE HERE

**1**

**First**

GLUE OR STAPLE HERE

**2**

**Next**

GLUE OR STAPLE HERE

**3**

**Then**

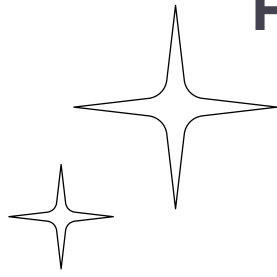
GLUE OR STAPLE HERE

**4**

**Last**

**1** Complete with the steps of formation of stars (draw/write).

**2** Cut the boxes and glue them in order.



# FORMATION OF STARS

FLIP BOOK

GLUE OR STAPLE HERE

Stars begin in giant clouds of gas and dust, called nebulas.

**1**

**First**

GLUE OR STAPLE HERE

Gravity pulls the gas together. The cloud grows denser and starts to glow. This is a protostar.

**2**

**Next**

GLUE OR STAPLE HERE

When the center gets hot enough, hydrogen atoms fuse into helium. A star is born! It shines for millions or billions of years.

**3**

**Then**

GLUE OR STAPLE HERE

Big stars end in a powerful explosion called a supernova. This blast spreads heavy elements into space. These become part of new stars, planets, and even living things.

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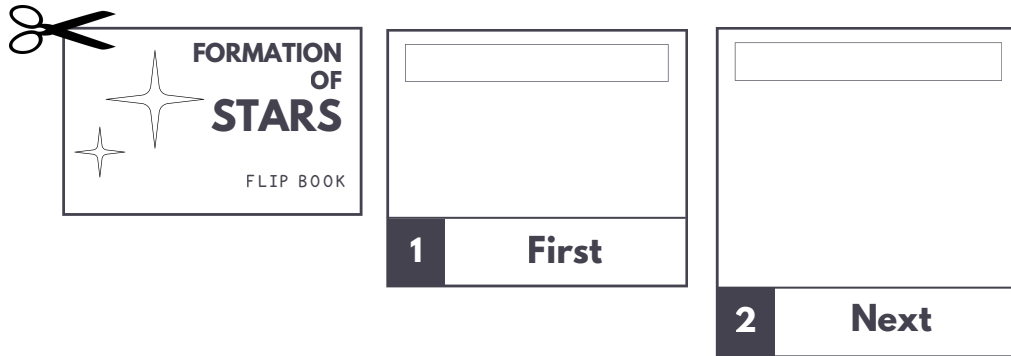
**2** Cut the boxes and glue them in order.

# FORMATION OF STARS

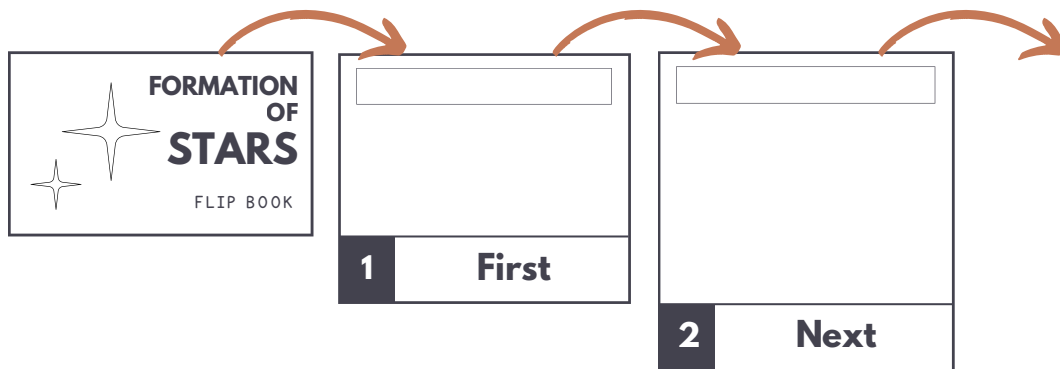
## FLIP BOOK

**1** Ask learners to complete the steps to Formation of Stars (write and/or draw)

**2** When they finish ask them to cut the 5 boxes (pages) of the Flip Book.



**3** Tell students to glue or staple the pages together, one onto the other, following the numbers.



**4** The Flip Book will look like this:



# Lesson 3: Our Solar System

Stars do not wander alone. They gather in vast communities called **galaxies**, enormous collections of stars, gas, and dust all held together by gravity. Some galaxies contain only a few million stars. Others hold hundreds of billions. Our own galaxy, the **Milky Way**, holds somewhere between 200 and 400 billion stars. On a clear dark night, you can see the pale glow of it stretching across the sky, millions of distant suns too far away to see individually, blurring into a ribbon of light.

Our Sun is just one of those stars. An ordinary yellow star near the edge of one of the Milky Way's spiral arms, nothing special in the cosmic scheme of things. And yet, about 4.6 billion years ago, a cloud of gas and dust near the edge of our galaxy began to collapse under gravity. Most of the material pulled toward the center and ignited into our Sun. The rest swirled outward and slowly clumped together into the planets. This is how our **solar system** was born, not built by a designer, but assembled, piece by piece, from the leftover debris of ancient stars.

Earth sits in a location called the **habitable zone**, sometimes called the Goldilocks Zone, the region around a star where it is neither too hot nor too cold for liquid water to exist on a planet's surface. Venus is inside the habitable zone and too hot. Mars is just outside and too cold. Earth is right in the middle. Our planet travels in a stable **orbit** around the Sun, pulled along by gravity year after year, century after century, maintaining just the right distance. This has been going on for 4.6 billion years, long enough for life to appear and flourish.

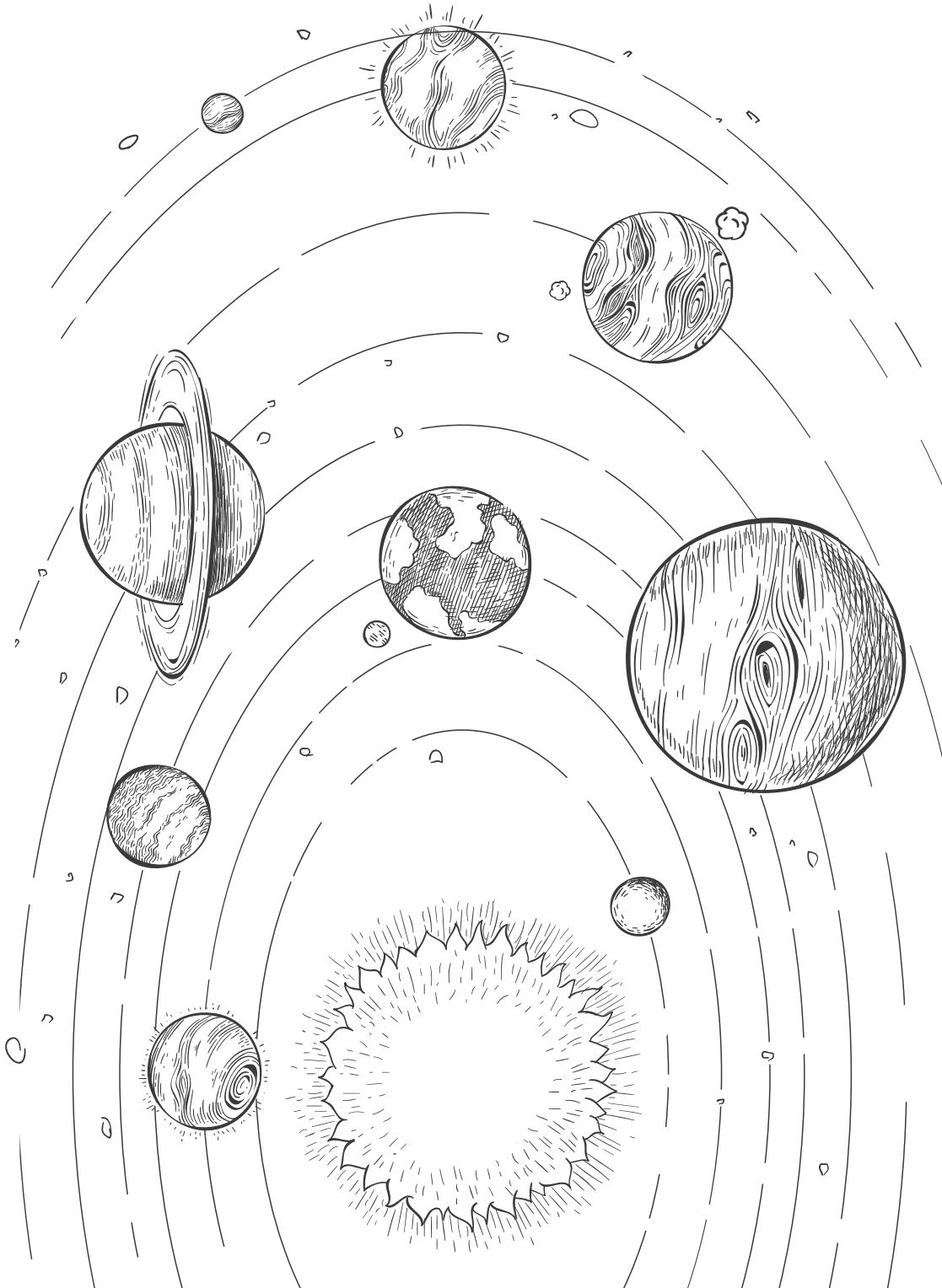
From the Big Bang came hydrogen. From hydrogen came stars. From dying stars came the elements. From the elements came our solar system. From our solar system came Earth, a small, rocky world in just the right place, circling an ordinary star, in one of hundreds of billions of galaxies. And somehow, here, on this small and fortunate world, the universe produced life. The story of life on Earth is just the newest chapter in the longest story ever told.

# Our Solar System Forms 4.6 Billion Years Ago

Draw a spiral galaxy from above with a small arrow pointing to a dot near one of the outer arms labeled "You Are Here," and beside it a tiny solar system with the Sun at the center and eight planets orbiting around it.

# Lesson 3: Our Solar System

Label each planet and write one word that describes something special about it (e.g., "hottest," "biggest," "has rings," "icy").



# Lesson 3: Our Solar System

## Vocabulary: Match the Term

Write the matching letter on the blank next to each term.

- |                   |   |
|-------------------|---|
| 1. galaxy         | A. The region around a star where temperatures allow liquid water on a planet's surface |
| 2. Milky Way      | B. The curved path one object travels around another due to gravity                     |
| 3. solar system   | C. The Sun and all the planets, moons, and other objects that orbit it                  |
| 4. habitable zone | D. A massive system of stars, gas, and dust held together by gravity                    |
| 5. orbit          | E. The name of our home galaxy, containing hundreds of billions of stars                |

## Because / But / So

Complete each sentence using the connector word shown.

Earth is located in the habitable zone **because**

---

Earth is located in the habitable zone, **but**

---

Earth is located in the habitable zone, **so**

---

**Appositives**

Fill in the blank with an appositive — a phrase that describes the noun. Use information from the reading.

The Milky Way, \_\_\_\_\_, contains between 200 and 400 billion stars.

Earth, \_\_\_\_\_, orbits the Sun at just the right distance for liquid water

Our Sun, \_\_\_\_\_, ignited from a collapsing cloud of gas and dust 4.6 billion years ago.

# WHERE AM I IN THE UNIVERSE

GLUE OR STAPLE HERE

**1**

**Me!**

GLUE OR STAPLE HERE

**2**

**Earth**

**1** Complete where you are in the universe (draw/write).

**2** Cut the boxes and glue them in order.

GLUE OR STAPLE HERE

**3**

**Solar System**

GLUE OR STAPLE HERE

**4**

**Milky Way**

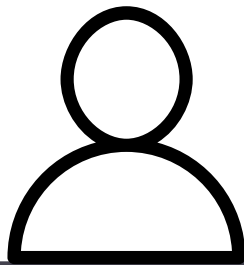
GLUE OR STAPLE HERE

**5**

**Universe**

# WHERE AM I IN THE UNIVERSE

GLUE OR STAPLE HERE



**1**

**Me!**

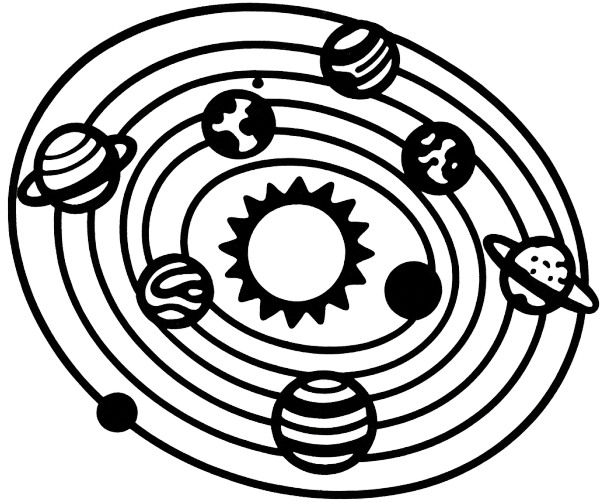
GLUE OR STAPLE HERE



**2**

**Earth**

GLUE OR STAPLE HERE



**3**

**Solar System**

GLUE OR STAPLE HERE



**4**

**Milky Way**

**1** Complete where you are in the universe (draw/write).

**2** Cut the boxes and glue them in order.

GLUE OR STAPLE HERE

**5**

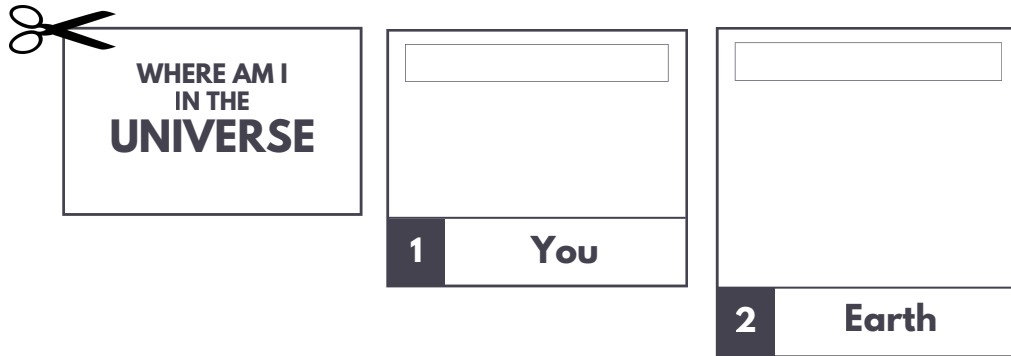
**Universe**

# WHERE AM I IN THE UNIVERSE?

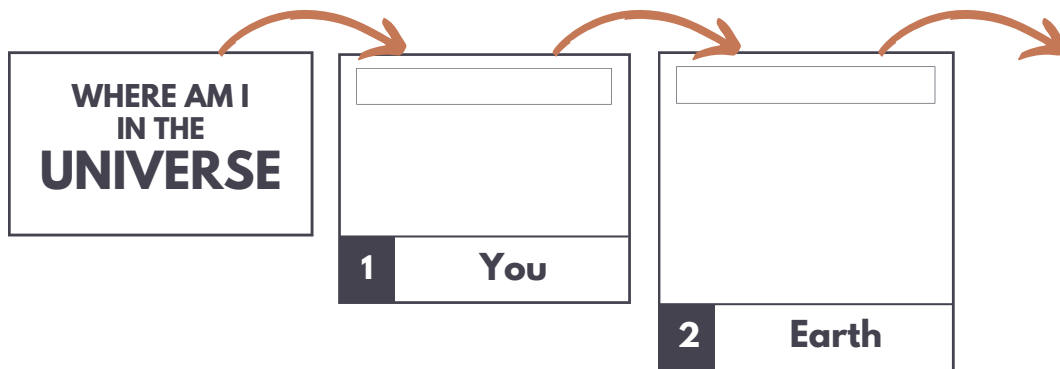
## FLIP BOOK

**1** Ask learners to complete the steps to Formation of Coal (write and/or draw)

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**3** Tell students to glue or staple the pages together, one onto the other, following the numbers.



**4** The Flip Book will look like this:

WHERE AM I IN THE UNIVERSE	
1	You
2	Earth
3	Solar System
4	Milky Way
5	Universe

# Lesson 4: Gravity

Right now, even as you sit perfectly still, a force is acting on every cell of your body. It is pressing you gently into your seat. It is holding the sky in place above you. It is pulling rain down from clouds and rivers down to the sea. It is keeping the Moon swinging around Earth and Earth sweeping around the Sun. This force is **gravity**, and it may be the single most important force in the history of the universe.

Gravity is a pull that exists between everything that has **mass**, and everything in the universe has mass. The greater the mass of an object, the stronger its gravitational pull. The Sun is so massive that its gravity reaches all the way to the outer edges of the solar system, holding every planet in its **orbit**. Earth is massive enough to hold its oceans, its atmosphere, and all of us firmly on its surface. Even you pull on everything around you, though your pull is so small compared to Earth's that you never notice it.

Isaac Newton was among the first to understand gravity mathematically. The famous story says an apple fell from a tree near him and he began to wonder: why does everything fall *down*? Why not up or sideways? His answer, that every object in the universe attracts every other object, transformed science. Later, Albert Einstein revealed something even stranger: gravity is not really a force at all. It is a curve in the fabric of space itself, the way a heavy ball makes a dent in a stretched rubber sheet, and everything nearby rolls toward it.

For life on Earth, gravity is not just essential. It is also irreplaceable. It pulled the planet together from dust and rock billions of years ago. It keeps the atmosphere wrapped around us so we have air to breathe and water in the oceans rather than floating away into space. **Weight** is the force you feel when you stand on a scale: it is gravity pulling on your mass. Every raindrop that reaches a root, every river that reaches the sea, every seed that falls into soil, all of it happens because of gravity. Without gravity, there is no Earth. Without Earth, there is no life.

# Gravity: The Universal Pull

Draw the Sun at the center with Earth orbiting around it, and the Moon orbiting around Earth. Include curved arrows showing the invisible pull of gravity keeping each one in its path.



# Lesson 4: Gravity

## Because / But / So

Complete each sentence using the connector word shown.

Gravity holds Earth's atmosphere in place **because**

---

Gravity holds Earth's atmosphere in place, **but**

---

Gravity holds Earth's atmosphere in place, **so**

---

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

- **If** \_\_\_\_\_, there would be no Earth, no ocean, and no life.
- The Sun has far more mass than Earth **because** \_\_\_\_\_.
- **Although** \_\_\_\_\_, it is the most important force in the universe.

## Think and Write

Give two specific examples from the reading of how gravity makes life on Earth possible. Explain each one fully.

# Lesson 5: Earth's Formation

Four and a half billion years ago, there was no Earth to stand on. Where our planet now travels through space, there was only a swirling cloud of gas and dust left over from the birth of the Sun. But gravity does not rest. Slowly, pieces of that cloud began to collide and stick together. Each collision added more material and released more heat. Over millions of years, this gradual piling-up of rock and dust, called **accretion**, built our planet piece by piece, like the universe rolling a snowball through space.

The young Earth looked nothing like the world we know. With every collision came heat, and there were so many collisions that the entire planet became **molten**: liquid rock glowing orange and red, with no solid surface anywhere. But inside that chaos, something important was happening. As Earth stayed liquid, the heaviest materials, mainly iron and nickel, sank toward the center, forming the dense **core**. Lighter rocks floated upward to form the **mantle**. The lightest materials of all rose to the very surface and eventually hardened into the thin outer layer we call the **crust**. Scientists call this sorting process **differentiation**, and it is why Earth is layered inside like a peach, with its thin skin, thick flesh, and hard center.

Over hundreds of millions of years, Earth slowly cooled. The surface hardened into rock. Volcanoes poured gases from deep inside the planet into the sky, beginning to build an atmosphere. Slowly, a world was taking shape: a planet with solid ground, layered depths, and just enough warmth from the Sun to make something extraordinary possible one day.

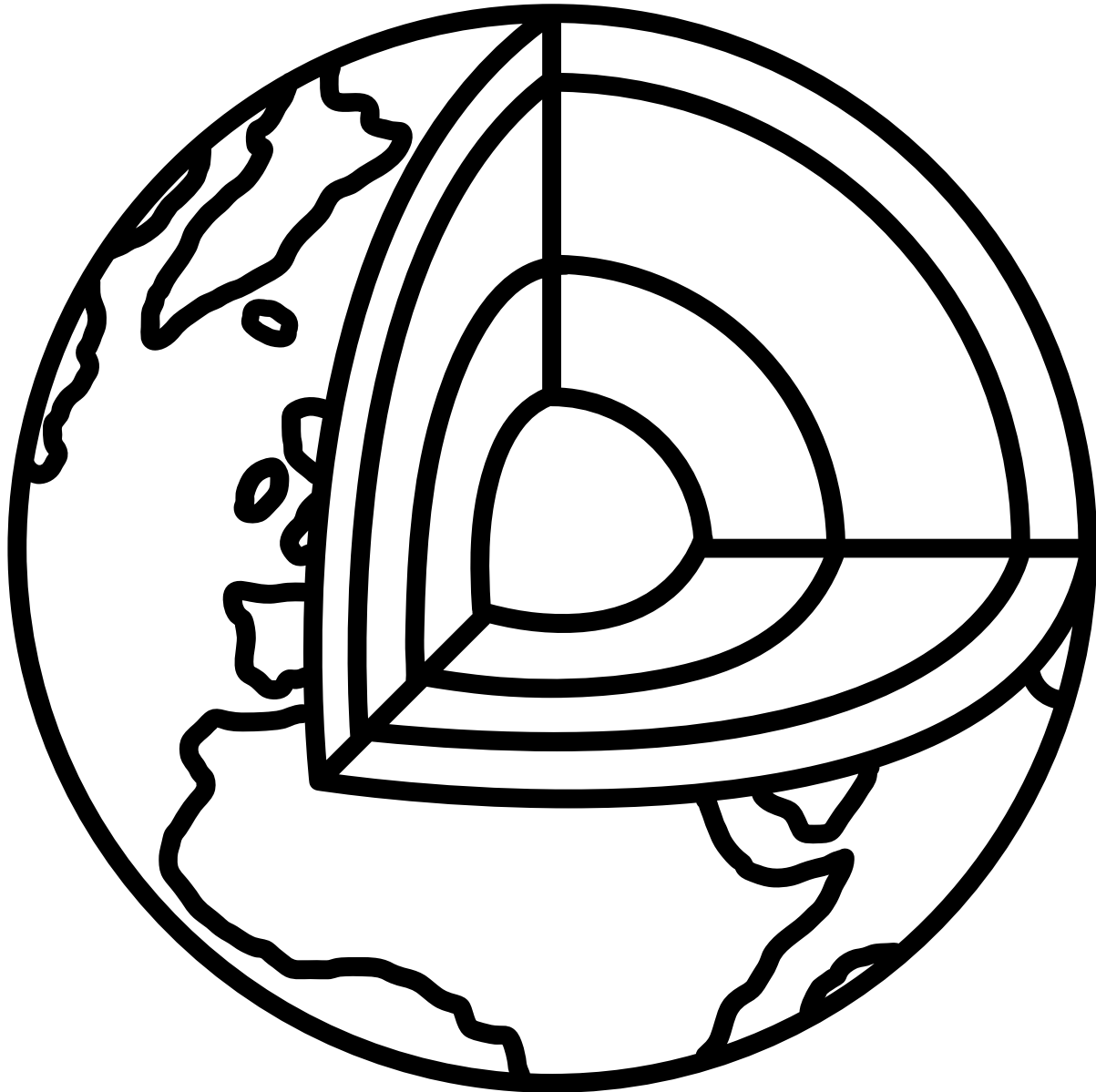
Earth was not handed to us finished and ready. It built itself from raw material left behind by our Sun's birth, assembled by gravity, shaped by heat, layered by time. Everything about our world today, its magnetic field, its volcanic mountains, its churning interior, its rocky crust, came from that long violent beginning. Out of fire and collision, the foundation of a living world was slowly, patiently laid.

# Formation of Earth: 4.5 Billion Years Ago

Draw a molten, glowing early Earth with no oceans, no continents, just a swirling ball of red and orange magma being pelted by asteroids from the surrounding cloud of space debris.

# Lesson 5: Earth's Formation

Label the diagram of Earth's layers (core, mantle, crust). Write the general thickness of each layer.



# Lesson 5: Earth's Formation

## Vocabulary: Fill in the Blank

**Word Bank:** *accretion molten core mantle crust differentiation*

1. The gradual buildup of a planet through collisions of rocks and dust is called

\_\_\_\_\_.

2. When rock melts into liquid form due to extreme heat, we say it is

\_\_\_\_\_.

3. The innermost, densest layer of Earth, made mostly of iron and nickel, is called the

\_\_\_\_\_.

4. The thick layer of rock between Earth's core and its outer layer is called the

\_\_\_\_\_.

5. The thin, cooled outermost layer of Earth where we live is called the

\_\_\_\_\_.

6. The process by which heavy materials sank to Earth's center and lighter ones rose to the top is called \_\_\_\_\_.

## Because / But / So

Complete each sentence using the connector word shown.

Early Earth was completely molten **because**

\_\_\_\_\_.

Early Earth was completely molten, **but**

\_\_\_\_\_.

Early Earth was completely molten, **so**

\_\_\_\_\_.

# Lesson 6: The Story of Rocks

Pick up a rock and look at it closely. Does it have layers? Is it speckled with crystals, or smooth and sandy? Does it contain the faint outline of a shell or a leaf? Each of those things is a clue about where that rock has been and what it has been through. Rocks are not just hard lumps on the ground. They are Earth's oldest record-keepers, and once you know how to read them, they open a window into billions of years of history.

There are three families of rock, and each has its own origin story. **Igneous rock** forms when molten rock cools and hardens, either deep underground or on the surface as lava flowing from a volcano. Granite beneath your feet and basalt on the ocean floor are both igneous. **Sedimentary rock** forms when particles of sand, mud, and the remains of living things pile up in layers over thousands or millions of years. As the layers grow heavier, they compress and cement into stone. The stripes in canyon walls are sedimentary layers, and they often preserve **fossils**, the shapes and traces of ancient creatures, locked inside. **Metamorphic rock** is any rock that has been changed by intense heat and pressure without melting, transformed into something new. Marble and slate are metamorphic.

These three types are not separate and fixed forever. They are connected in an endless **rock cycle**. Igneous rock weathers and breaks apart into sediment. That sediment compresses into sedimentary rock. Sedimentary rock, buried deep, becomes metamorphic. Metamorphic rock, heated still further, melts and cools as igneous rock again. The cycle has no beginning and no end, driven by **erosion** on the surface and heat from within the Earth, reshaping our planet in ways that are slow but absolutely certain.

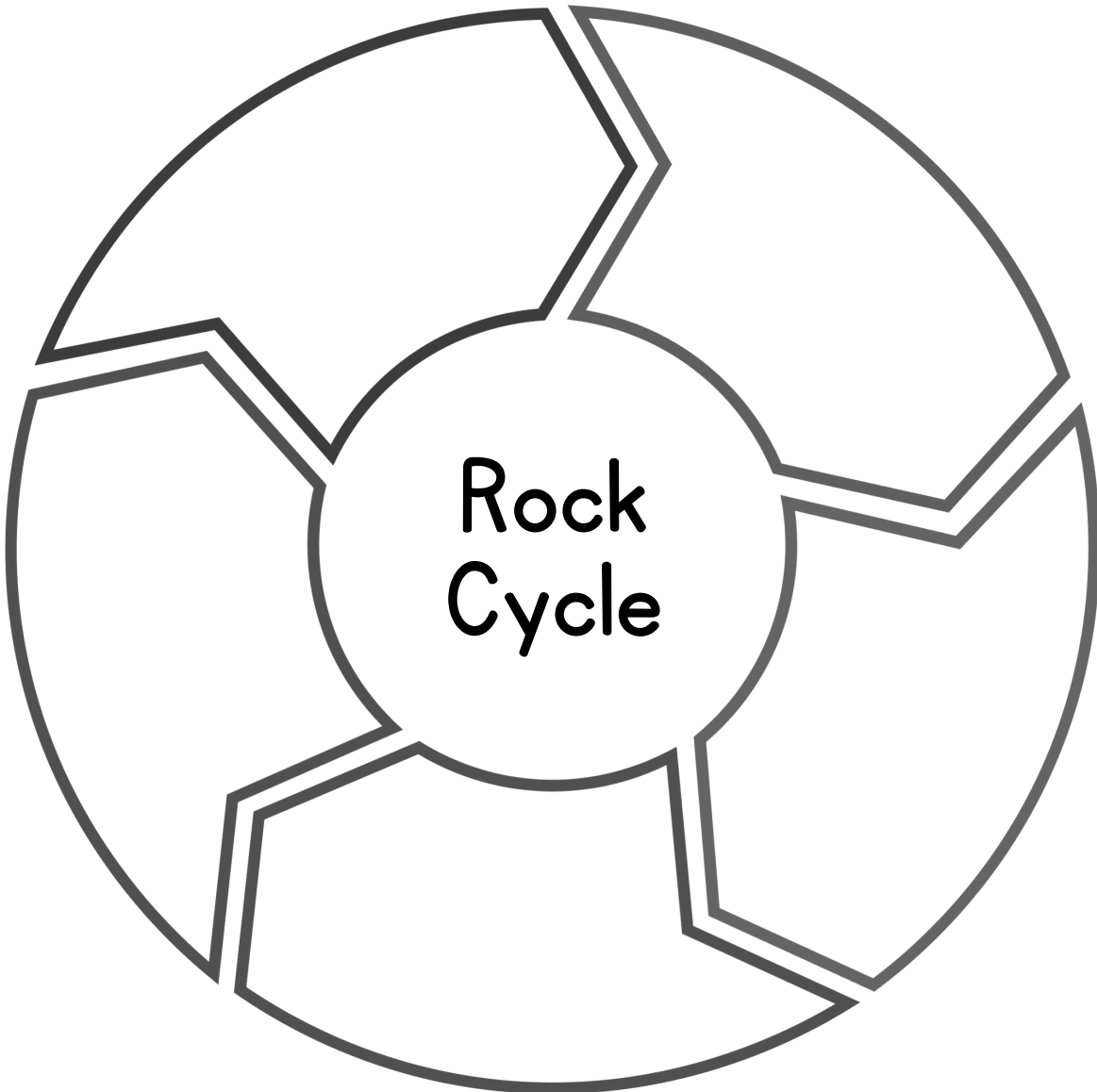
For the story of life on Earth, sedimentary rock is the most precious of all. Its layers are like pages in a history book. The deeper the layer, the older it is. The fossils locked inside those layers tell us which creatures lived in which era, how they changed over time, and which ones disappeared. Without rocks, we could not read the story of life. Rocks remember what nothing else could.

# The Story of Rocks

Draw the three types of rocks. Consider doing an igneous rock cooling from lava, sedimentary layers stacking up at a riverbed, and a metamorphic rock being squeezed deep underground.

# Lesson 6: The Story of Rocks

Label the diagram to show a sample rock cycle. Include the three main types of rocks (Igneous, Sedimentary, and Metamorphic) and how they interact. Identify the process required for the change (e.g., "Heat and Pressure," "Melting," or "Weathering and Erosion").



# Lesson 7: Pangea & Plates

The ground beneath your feet feels permanent. Solid. Immovable. But it is not. Earth's outer layer, its crust and the solid rock just below, is broken into about a dozen great puzzle pieces called **tectonic plates**. They float on the hot, slowly flowing rock of the mantle beneath, and they are always moving. Not fast enough to feel, just a few centimeters per year, the speed of a growing fingernail, but moving nonetheless, and they have been moving for billions of years.

The results are written all over the world's map. About 300 million years ago, all of Earth's landmasses were joined in one enormous continent called **Pangea**. Animals could walk from what is now South America to what is now Antarctica. Plants spread freely across the whole connected land. Then the plates began to pull apart. Pangea cracked and drifted into the shapes we recognize today. South America and Africa still look like matching puzzle pieces because they were, in fact, once joined. The same fossils are found on both shorelines, thousands of kilometers apart.

Wherever tectonic plates meet, the Earth's surface is transformed. When plates collide, crust crumples upward into mountain ranges. The Himalayas are still being pushed higher every year by the collision of India and Asia. When plates pull apart, **magma** wells up from below, creating new ocean floor. When plates grind sideways past each other, the stress builds until the ground shakes in an **earthquake**. A **fault** is a crack in the crust where this movement occurs. And where magma forces its way to the surface, a **volcano** erupts, one of the most dramatic reminders that our planet is alive inside.

Every era of life on Earth has been shaped by the plates beneath it. When continents are joined, species can mingle. When they separate, they evolve in different directions, producing the remarkable variety of life we see across different parts of the world. Mountains change rainfall and climate. Volcanic eruptions change the atmosphere. The living world has always danced to the rhythm of the moving ground beneath it, and the dance is still going on.

# Pangea Forms: 335 Million Years Ago

Draw all of Earth's continents pushed together into one giant supercontinent with the ocean surrounding it.

# Lesson 7: Pangea & Plates

Show what happens in each of the plate boundaries.

Convergent Boundary

Divergent Boundary

Transform Boundary

# Lesson 7: Pangea & Plates

## Vocabulary: Fill in the Blank

**Word Bank:** *tectonic plates Pangea earthquake magma fault volcano*

1. The large, slow-moving pieces of Earth's crust are called \_\_\_\_\_.
2. The supercontinent where all of Earth's land was joined about 300 million years ago is called \_\_\_\_\_.
3. A crack in Earth's crust where rocks on either side can shift is called a \_\_\_\_\_.
4. Molten rock beneath Earth's surface is called \_\_\_\_\_.
5. A sudden shaking of the ground caused by plates slipping is called an \_\_\_\_\_.
6. An opening in Earth's crust where magma, ash, and gases erupt is called a \_\_\_\_\_.

## Because / But / So

Complete each sentence using the connector word shown.

The continents were once joined together as one supercontinent **because**

\_\_\_\_\_

The continents were once joined together as one supercontinent, **but**

\_\_\_\_\_

The continents were once joined together as one supercontinent, **so**

\_\_\_\_\_

## Lesson 8: Liquid Water & An Atmosphere

The water you drank this morning has been around for a very long time. The same water cycles endlessly around our planet, rising from the surface as invisible vapor, cooling into clouds, falling as rain or snow, flowing back to the sea. Scientists call this the **water cycle**, and it has been running for billions of years, moving the same water around and around our world. The drop on your tongue might once have watered a Jurassic fern, or been breathed out by a mammoth, or frozen in a glacier on a continent that no longer exists.

Early Earth had no liquid water at all. As the young planet cooled, volcanoes poured gases into the sky, including water vapor, nitrogen, and carbon dioxide, beginning to build an **atmosphere**. When Earth cooled enough, that vapor condensed and fell as rain. It rained for millions of years without stopping, until the first great **ocean** covered the planet. Some of Earth's water also arrived from space, carried inside icy comets and asteroids that pelted the early Earth. The ocean we swim in today is the ancient product of volcanoes, rain, and cosmic visitors.

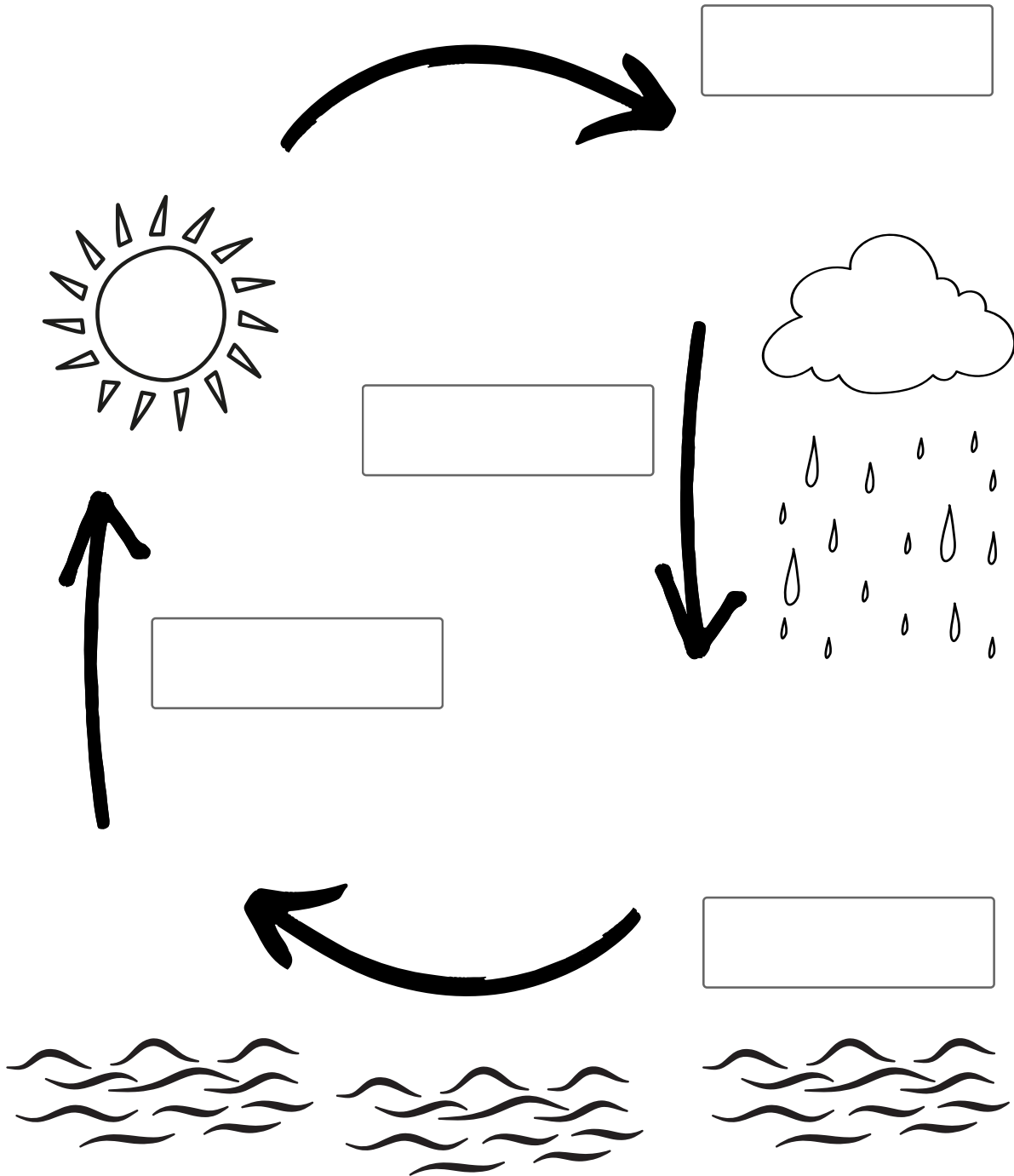
The atmosphere does more than just hold rain. It wraps the planet like a blanket, trapping some of the Sun's heat through what is called the **greenhouse effect**. Without this natural warming, Earth's surface would average far below freezing, a world of permanent ice with no liquid water and no life. The early atmosphere had no oxygen, but it was warm enough to keep water liquid, and that made all the difference. **Evaporation** lifts water from the surface into the air. **Condensation** turns it back into liquid droplets that form clouds. Then **precipitation**, including rain, snow, and sleet, returns it to Earth. This cycle is what delivers fresh water to forests and meadows and mountain streams far from any ocean. Water and air working together created the conditions for life. In a very real sense, the water cycle is not just a feature of Earth. It is what makes Earth alive.

# Earth's First Oceans Form: 4.4 Billion Years Ago

Draw volcanoes releasing steam into a dark sky, with rain falling and collecting into the first oceans below.

# Lesson 8: Liquid Water & An Atmosphere

Label the diagram of the water cycle with the words evaporation, condensation, precipitation, and collection.



# Lesson 8: Liquid Water & An Atmosphere

## Vocabulary: Match the Term

Write the matching letter on the blank next to each term.

- |                      |  |
|----------------------|--|
| 1. water cycle       | A. Water that falls from the atmosphere as rain, snow, or sleet                                      |
| 2. evaporation       | B. The warming of Earth's surface when gases trap the Sun's heat in the atmosphere                   |
| 3. condensation      | C. The process by which water vapor cools and becomes liquid, forming clouds                         |
| 4. precipitation     | D. The continuous movement of water through evaporation, condensation, precipitation, and collection |
| 5. greenhouse effect | E. The process by which liquid water is heated and becomes water vapor                               |

## Sentence Expansion

Each sentence below is missing important details. Rewrite it on the lines, adding information that answers the question in parentheses.

Water evaporates. (*Where does it evaporate from, and what happens to it next?*)

Early Earth had no liquid water. (*Why not, and how did the oceans eventually form?*)

# Lesson 9: The Definition of Life

What makes something alive? It sounds obvious: a dog is alive and a rock is not. But the closer you look, the trickier the question becomes. Is a virus alive? It can reproduce, but only by hijacking another cell. Is a crystal alive? It grows. Is a fire alive? It consumes fuel, grows, and responds to the wind. Drawing a careful line between living and non-living turns out to require real thought, and scientists have spent a great deal of effort getting this right.

The answer they have agreed on is a set of shared characteristics. Every living thing is made of one or more **cells**, tiny enclosed packages of chemistry, each one sealed from the outside world by a membrane. Every living thing has **metabolism**: all the chemical processes that turn food into energy and keep the organism running. Every living thing grows and develops. Every living thing responds to its environment. Every living thing **reproduces**, passing its traits forward. And all of this is directed by instructions encoded in a molecule called **DNA**, which every living cell contains.

DNA is one of the most important molecules ever discovered. It is found inside the cells of every living thing on Earth, from the smallest bacterium to the largest blue whale, and it carries the recipe for building and running the organism. Remarkably, all life uses the same DNA code. The same four chemical letters spell out the instructions for a bacterium, a mushroom, a fish, and a human. This shared code is one of the most powerful pieces of evidence that all life on Earth descended from the same ancient ancestor.

All life is one family. No matter how different a whale looks from a dandelion, no matter how alien a deep-sea bacterium seems from a butterfly, they share the same fundamental chemistry, the same molecule carrying their instructions, the same cellular architecture. Life is not a collection of separate inventions. It is one long, branching, interconnected story, and we are part of it.

# Lesson 9: The Definition of Life

Create a mnemonic device to remember the seven characteristics of life

**Cellular**

Structure and Composition

**C**

---

**Growth**

and Development

**G**

---

**Reproduce**

Offspring

**R**

---

**Hereditary**

Of Traits

**H**

---

**Respond**

to the Environment

**R**

---

**Homeostasis**

Stable inner connection

**H**

---

**Metabolism**

Energy from Chemical Reactions

**M**

---

---

My Mnemonic Phrase

# Lesson 9: The Definition of Life

## Because / But / So

Complete each sentence using the connector word shown.

All living things share the same molecule, DNA **because**

---

All living things share the same molecule, DNA, **but**

---

All living things share the same molecule, DNA, **so**

---

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

**Although** \_\_\_\_\_, it is not a living thing.

**If** \_\_\_\_\_, it does not meet the definition of life.

## Think and Write

1. Name at least four characteristics that all living things share. Then explain one of them in your own words with an example.

# Lesson 10: The First Life

Close your eyes and imagine Earth about 3.5 billion years ago. The sky is a thick haze of volcanic gases. The oceans are warm and full of dissolved minerals. There are no plants, no animals, no forests, no sound except the slap of waves against bare volcanic rock. And yet, in the water, deep near hydrothermal vents and in shallow sunlit pools along the rocky shores, something extraordinary is already happening. The first living things are quietly getting on with life.

These first organisms were incredibly simple. Each one was a single cell, a tiny bag of chemistry with no complex parts inside. Scientists call them **prokaryotes**, meaning cells without a nucleus, and there are two main groups. **Bacteria** are still everywhere today: in the soil beneath every garden, in your gut right now, on your skin, in the deepest ocean trenches. **Archaea** are perhaps even more remarkable. They thrive in conditions that would destroy almost anything else, including boiling hot springs, the Dead Sea, and scalding vents on the ocean floor. Both are invisible to the naked eye. Both are **microbes**, living things too small to see. And both were here first, for billions of years before anything else.

We know these ancient microbes really existed because they left physical evidence behind. In Western Australia, scientists have found **stromatolites**, layered dome-shaped mounds built up by ancient bacterial communities, one thin film of microbes at a time, over thousands of years. The oldest stromatolite **fossils** are more than 3.5 billion years old, making them among the oldest signs of life ever discovered on Earth. What makes this truly astonishing is that living stromatolites can still be found today in a few salty, shallow bays in Australia, growing at the same patient pace as their ancient ancestors, looking almost exactly the same as they did when the first fish were still hundreds of millions of years away.

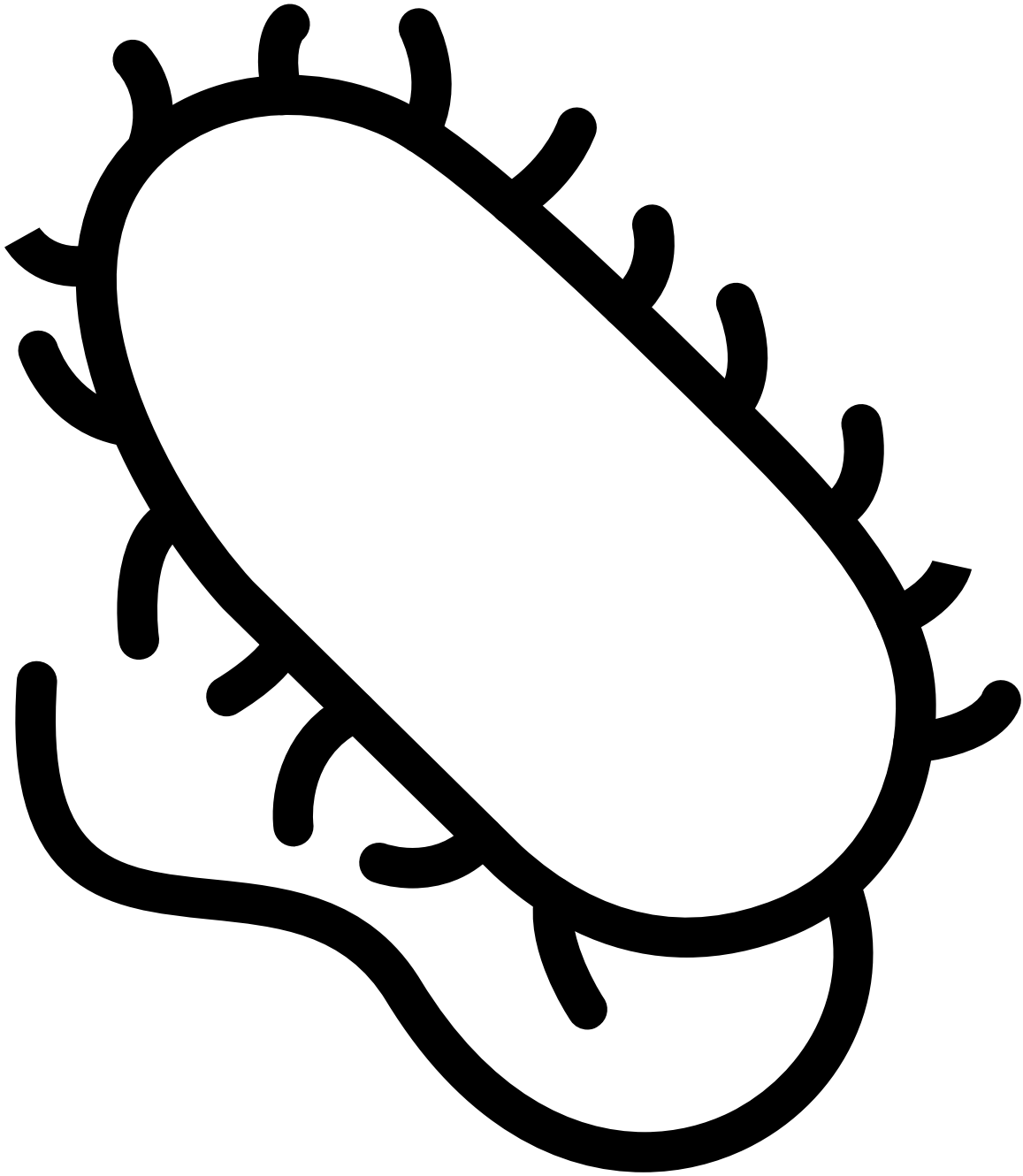
Here is something worth really thinking about: for more than two billion years, bacteria and archaea were the only life on Earth. If you squeezed all of life's history into a single calendar year, these microscopic pioneers would appear in mid-March, and complex animals would not show up until mid-November. Bacteria are not the humble beginning of life's story. They *are* the story, for most of it. And they did not just survive. They slowly, steadily changed the planet, reshaping the chemistry of the oceans and laying the foundations for everything that would one day follow.

# The First Life [Bacteria & Archaea]: 3.5 Billion Years Ago

Draw a shallow Precambrian ocean with tiny, bumpy stromatolite mounds rising from the seafloor – the oldest living structures on Earth.

# Lesson 10: The First Life

What would the inside of a bacteria look like? Draw and label the different parts.  
Use the words DNA, ribosome, cell wall, and plasma membrane.



# Lesson 10: The First Life

## Because / But / So

Complete each sentence using the connector word shown.

Bacteria have existed on Earth for 3.5 billion years **because**

\_\_\_\_\_

Bacteria have existed on Earth for 3.5 billion years, **but**

\_\_\_\_\_

Bacteria have existed on Earth for 3.5 billion years, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun. Use information from the reading.

Stromatolites, \_\_\_\_\_, are among the oldest evidence of life ever found on Earth.

Archaea, \_\_\_\_\_, often thrive in boiling hot springs and extremely salty lakes.

Cyanobacteria, \_\_\_\_\_, would eventually change the entire atmosphere of Earth.

## Think and Write

1. Even though bacteria are invisible and seem simple, they transformed the entire planet. How? Give specific examples from the reading.

# Lesson 11: Oxygen Changes Everything

Take a deep breath. Hold it a moment. That oxygen filling your lungs was not always there. For the first billion or more years of life on Earth, the atmosphere had almost no free oxygen at all. The ancient bacteria and archaea living in those early oceans had no need for it. Many would actually have been harmed by it. And then a particular group of bacteria discovered something that would transform the entire planet.

Cyanobacteria are a kind of bacteria that learned to use sunlight to make food, a process called **photosynthesis**. Using sunlight, water, and carbon dioxide, they produced food for themselves and released oxygen as a byproduct, the way a fire releases smoke. At first, that oxygen was absorbed by the iron dissolved in the oceans, forming rust. You can still see this evidence today in ancient banded iron rock formations: rusty red stripes laid down in ancient seafloors as oxygen began to accumulate. But eventually, the oceans became saturated, and oxygen began to spill into the atmosphere.

About 2.4 billion years ago came the **Great Oxidation Event**, one of the most dramatic turning points in Earth's history. For the **anaerobic** organisms that had evolved in an oxygen-free world, it was a catastrophe. Oxygen was toxic to them, and enormous numbers went extinct. But for other microbes, oxygen was an extraordinary gift. Organisms that could use oxygen for **aerobic** respiration could extract far more energy from their food than anything before them, energy enough to eventually support complex, large bodies. Oxygen transformed what life could be.

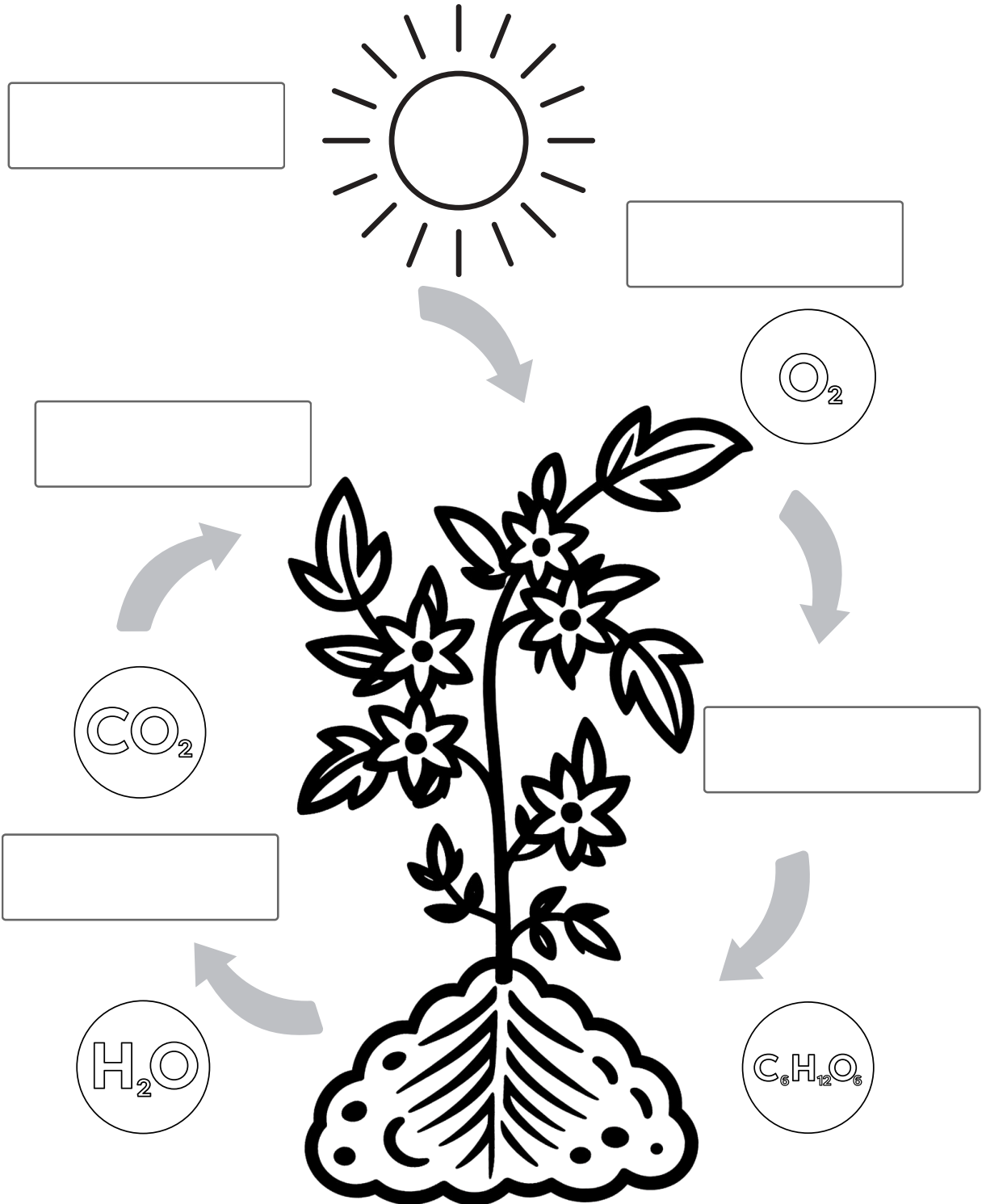
The oxygen also rose into the upper atmosphere, where it formed the **ozone layer**, a shield against the Sun's ultraviolet radiation. Before this layer existed, the land surface of Earth was bathed in harmful radiation that would damage the chemistry of life. The ozone layer changed that. Slowly, the land became available. The patient work of trillions of cyanobacteria, over billions of years, did not just change the air. It opened up an entirely new world.

# The Great Oxidation Event: 2.4 Billion Years Ago

Draw microscopic cyanobacteria releasing tiny oxygen bubbles into a Precambrian ocean, with the sky slowly turning from orange to blue.

# Lesson 11: Oxygen Changes Everything

Label this diagram of photosynthesis with the terms sunlight, oxygen, carbon dioxide, water, and sugar (glucose)



# Lesson 11: Oxygen Changes Everything

## Vocabulary: Fill in the Blank

**Word Bank:** *photosynthesis* *Great Oxidation Event* *aerobic* *anaerobic* *ozone layer* *cyanobacteria*

1. The process by which organisms use sunlight, water, and CO<sub>2</sub> to make food, releasing oxygen, is called

\_\_\_\_\_.

2. The bacteria that invented photosynthesis and transformed Earth's atmosphere are called

\_\_\_\_\_.

3. The period about 2.4 billion years ago when oxygen built up dramatically in Earth's atmosphere is called the

\_\_\_\_\_.

4. Organisms that require oxygen to survive are called \_\_\_\_\_.

5. Organisms or processes that do not need oxygen are called \_\_\_\_\_.

6. The layer in the upper atmosphere that protects life from harmful ultraviolet radiation is called the

\_\_\_\_\_.

## Because / But / So

Complete each sentence using the connector word shown.

The rise of oxygen was one of the most important events in the history of life **because**

\_\_\_\_\_

The rise of oxygen was one of the most important events in the history of life, **but**

\_\_\_\_\_

The rise of oxygen was one of the most important events in the history of life, **so**

\_\_\_\_\_

# Lesson 12: Eukaryotes

For two billion years, every living thing on Earth was a prokaryote, a simple cell with no complex internal structure. Then, about 1.7 billion years ago, a new kind of cell appeared. This cell had something that none of its ancestors had possessed: a **nucleus**, a compartment sealed off by its own membrane, where the cell's **DNA** was protected and organized. The nucleus acted as a command center, directing everything the cell did. Cells with a nucleus are called **eukaryotes**, and their appearance was one of the most important events in the entire history of life.

But the nucleus was not the only new feature. Eukaryotic cells also developed **organelles**, specialized structures inside the cell, each performing a particular job, like organs in a tiny body. The most important are the **mitochondria**, which act like power stations, converting food into energy the cell can use. The **cell membrane** controls what enters and leaves, protecting the organized interior. And plant cells developed chloroplasts, structures that capture sunlight for photosynthesis.

Here is one of the most astonishing discoveries in biology: mitochondria were once free-living bacteria. Billions of years ago, a larger cell engulfed a smaller one, and instead of digesting it, the two began working together in a partnership called **endosymbiosis**. The small cell provided energy; the large cell provided shelter. Over time, they became one. The evidence is extraordinary: mitochondria still carry their own separate DNA, a ghost of their ancient independence, distinct from the nucleus's DNA. The cells in your body today carry the descendants of a billion-year-old bacterial partnership.

Every plant, every animal, every fungus, and every human being is made of eukaryotic cells. This one invention, a cell with a nucleus and specialized internal parts, unlocked the door to all complexity that followed. Without eukaryotes, there could be no multicellular life, no plants, no animals, nothing with more than one cell working as a whole. Everything that makes the living world rich and beautiful traces back to this one ancient transformation.

# The First Complex Cells [Eukaryotes]: 2 Billion Years Ago

Draw a large cell with a visible nucleus in the center and small mitochondria inside.  
Note that one smaller cell is being absorbed by a larger one to show endosymbiosis.

# Lesson 12: Eukaryotes

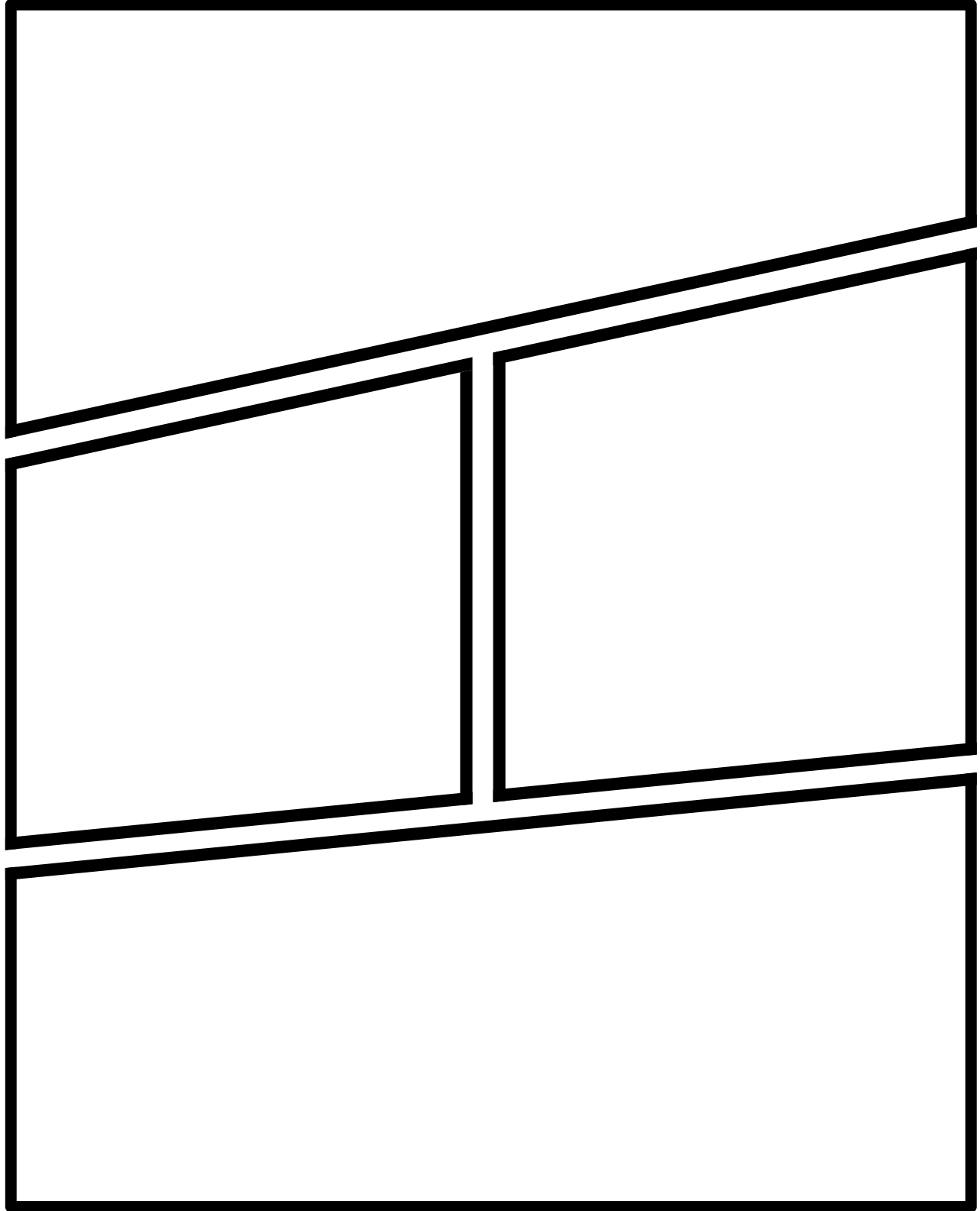
Label the different parts of an animal cell. Make sure to include the nucleus



Which organelles would a plant cell have that an animal cell does NOT have?

# Lesson 12: Eukaryotes

Create a comic strip detailing the endosymbiosis theory and how we might have ended up with mitochondria.



# Lesson 12: Eukaryotes

## Because / But / So

Complete each sentence using the connector word shown.

Mitochondria were once free-living bacteria **because**

---

Mitochondria were once free-living bacteria, **but**

---

Mitochondria were once free-living bacteria, **so**

---

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

**Although** \_\_\_\_\_, they still carry their own separate DNA.

**Since** \_\_\_\_\_, complex life has been possible on Earth.

# Lesson 13: Multicellular Life Begins

For billions of years, every living thing on Earth was a single cell doing everything alone, gathering food, reproducing, surviving. Then some cells began to do something new. They started sticking together. And when cells began to cooperate, the possibilities for life expanded in ways that no single cell could ever achieve on its own.

The key step was **cell specialization**. In a colony of identical cells, every cell does everything. But when some cells begin to specialize, with some gathering food, others holding the group together, and others sensing the environment, the whole group becomes far more capable than any individual cell. It can grow large. It can develop different parts for different tasks. These groups of specialized cells working together are called **tissues**, and organisms built from many cooperating cells with specialized tissues are called **multicellular** organisms. Every plant, every animal, every fungus alive today is multicellular, and that includes you.

The earliest multicellular life appeared about 600 to 800 million years ago, during a time called the **Ediacaran** Period. These first multicellular creatures were soft and strange, flat organisms drifting through warm, shallow seas. Some looked like quilted mats. Some like fronds. Some like discs. They left almost no hard parts to preserve as fossils, so we know them only from rare impressions pressed into ancient seafloor mud, found in places like the Ediacaran Hills of Australia. They are ghostly and mysterious, but they were real, and they were the first multicellular life Earth had ever seen.

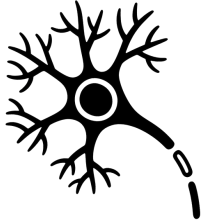
From those quiet, soft Ediacaran creatures, something extraordinary was building. The cooperation of cells was opening a door that could never be closed again. More complexity was coming, more diversity, more competition, more predators and prey, more bodies with more shapes than anything the world had ever seen. The age of animals was about to begin.

# Multicellular Life Begins [The Ediacaran Period]: 600 Million Years Ago

Draw soft, flat, frond-shaped Ediacaran creatures resting on the seafloor: no shells, no eyes, just strange quilted bodies drifting in the dark ocean.

# Lesson 13: Multicellular Life Begins

Red blood cells are designed to carry oxygen, while neurons are designed to carry messages. Compare and contrast their shape and function by filling in this Venn diagram.



Red Blood Cell



Neuron

# Lesson 13: Multicellular Life Begins

## Because / But / So

Complete each sentence using the connector word shown.

Cells began to work together in groups **because**

---

Cells began to work together in groups, **but**

---

Cells began to work together in groups, **so**

---

## Appositives

Fill in the blank with an appositive that describes the noun. Use information from the reading.

The Ediacaran Period, \_\_\_\_\_, was when the first soft-bodied multicellular creatures appeared.

Tissues, \_\_\_\_\_, allow a multicellular organism to perform tasks no single cell could manage.

Cell specialization, \_\_\_\_\_, is the key step that made complex multicellular life possible.

## Think and Write

1. Use an analogy to explain why multicellular life was such an important step. Compare it to working alone versus working as a team, and explain how each part of the analogy connects to what happened in early life.

# Lesson 14: The Cambrian Explosion

Imagine an ocean that has spent hundreds of millions of years nearly empty, with just a few soft, drifting mats of life, nothing with eyes or legs or armor. Then, in what amounts to a blink of geological time, the ocean fills with an astonishing variety of complex animals. Creatures with compound eyes that can see in every direction. Creatures with jointed legs and grasping claws. Creatures protected by hard shells called **exoskeletons**. Scientists call this the **Cambrian Explosion**, and it remains one of the most dramatic and mysterious events in the entire history of life.

It happened about 541 million years ago, and scientists still debate exactly why it unfolded so quickly. Rising oxygen levels may have given organisms enough energy to build large, complex bodies. The appearance of the first true **predators**, animals that hunted and ate other animals, likely triggered an arms race: prey animals that developed better armor or faster movement survived more often and passed those traits on. **Natural selection**, the process by which traits that help survival spread through populations, drove this explosion of new body plans. Among the most successful of the new animals was the **trilobite**: an armored creature with a segmented body and compound eyes, and one of the first animals we know of that could truly see.

Fossils from a site in Canada called the Burgess Shale preserve some of these creatures in astonishing detail. Anomalocaris, nearly a meter long with circular grasping claws, was the ocean's top predator. Hallucigenia was so bizarre that scientists originally studied it upside down. Opabinia had five eyes and a clawed trunk. The **biodiversity** on display in the Burgess Shale, the extraordinary variety of life forms, is staggering even today. Each of these animals represents a completely new experiment in what a body could be.

The Cambrian Explosion matters more than almost any other event in the story of life, because it gave us ours. The ancestors of every major group of animals alive today, including fish, insects, worms, starfish, mollusks, and eventually humans, appeared during this brief window. The basic body plans were set. Life had discovered the animal, and a world of extraordinary diversity had begun.

# The Cambrian Explosion: 541 Million Years Ago

Draw a crowded Cambrian seafloor bursting with life: trilobites, the alien-looking Anomalocaris, five-eyed Opabinia, and Hallucigenia with its legs and spines.

# Lesson 14: The Cambrian Explosion

Make a list of creatures that would fossilize well and which wouldn't. Add an explanation on why or why not.

Would Fossilize Well

Would Not Fossilize Well

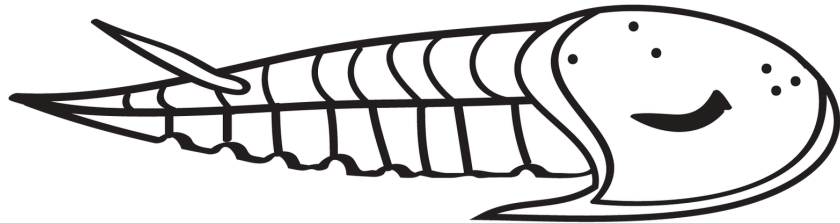
Would Fossilize Well	Would Not Fossilize Well

# Lesson 14: The Cambrian Explosion

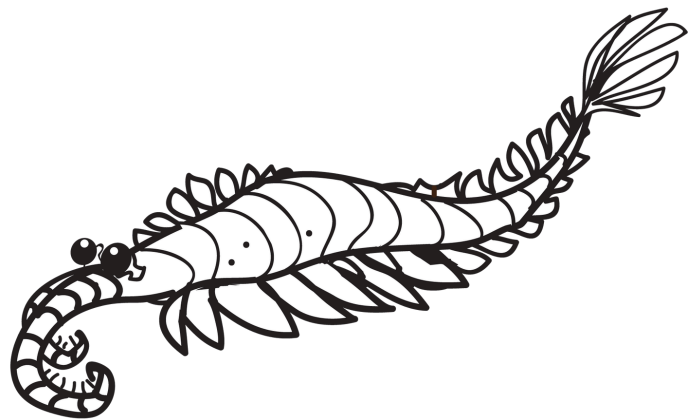
Write some key words or facts about what made each of these Cambrian species unique.

Redlichia

Trilobite



Anomalocaris



Opabinia



# Lesson 14: The Cambrian Explosion

## Because / But / So

Complete each sentence using the connector word shown.

The Cambrian Explosion happened about 541 million years ago **because**

\_\_\_\_\_

The Cambrian Explosion happened about 541 million years ago, **but**

\_\_\_\_\_

The Cambrian Explosion happened about 541 million years ago, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

Animals with hard shells survived predators more successfully **because**

\_\_\_\_\_.

**When** \_\_\_\_\_, other animals were under pressure to develop better defenses.

**Although** \_\_\_\_\_, it still took millions of years to unfold.

## Think and Write

1. Why is the Cambrian Explosion so important to us today? Connect it to animals that are alive right now, including humans.

## Lesson 15: Ordovician and Silurian Seas

After the burst of life in the Cambrian, the oceans of Earth kept growing richer and stranger. The Ordovician Period, from about 485 to 444 million years ago, was a time of astonishing **marine** biodiversity. Sea scorpions prowled the depths. Ancient **invertebrates**, including cephalopods with long cone-shaped shells, glided through the water. Trilobites flourished in spectacular variety. And for the first time, **coral reefs** appeared for the first time, living underwater cities built by tiny animals, creating complex structures that offered shelter, hiding places, and feeding grounds for enormous numbers of creatures. A coral reef is not just a habitat. It is an **ecosystem**, a whole community of living things interacting with each other and their environment, and the Ordovician reefs were the first of their kind on Earth.

Among the most significant animals of the Ordovician seas were the first **vertebrates**, animals with backbones. The earliest were small, jawless fish that filtered food from the water. Having a backbone gave these creatures a strong internal support structure that allowed for more controlled, powerful movement than anything an invertebrate could manage. It was a revolutionary design, and it would eventually produce every fish, amphibian, reptile, bird, and mammal that ever lived, including us.

Then, near the end of the Ordovician, disaster struck. Ice sheets spread across the southern continents. Sea levels dropped. The oceans cooled dramatically. Much of the marine life that had flourished for millions of years was wiped away in one of Earth's great mass extinctions. But life endured. A few lineages survived, and the seas bloomed again during the Silurian Period that followed, from about 444 to 419 million years ago.

The Silurian brought something new and important: some fish developed jaws for the first time. A jaw is a seemingly small invention, but it transformed what an animal could do. A jawed fish could bite, grip, and process a far wider range of food than its jawless ancestors. Predators became more effective. Competition intensified. And on the land at the edges of those seas, the first small vascular plants were tentatively taking root, quietly beginning to turn the barren rock green for the very first time.

# Life Fills the Seas [The Ordovician Period] 485 Million Years Ago

Draw an Ordovician coral reef packed with brachiopods, crinoids, and jawless fish like *Arandaspis* swimming above the reef in the shallow sea.

# Lesson 15: Ordovician and Silurian Seas

Make a list of creatures that would fossilize well and which wouldn't. Add an explanation on why or why not.



Jawless Fish

Jawed Fish



# Lesson 15: Ordovician and Silurian Seas

## Sentence Expansion

Each sentence below is a bare fact. Rewrite it on the lines, adding details that answer the question in parentheses.

Fish developed jaws. *(When did this happen, why did it matter, and what could jawed fish do that earlier fish could not?)*

A mass extinction struck at the end of the Ordovician. *(What caused it, how severe was it, and what happened afterward?)*

## Because / But / So

Complete each sentence using the connector word shown.

The evolution of jaws was a turning point for vertebrates **because**

---

The evolution of jaws was a turning point for vertebrates, **but**

---

The evolution of jaws was a turning point for vertebrates, **so**

---

# Lesson 16: The Devonian Period

The **Devonian** Period, from about 419 to 359 million years ago, is called the Age of Fishes for good reason. Fish diversified into an extraordinary variety of forms, including armored fish, early sharks, and ray-finned fish, and a group called **lobe-finned fish** whose strong, fleshy fins were supported by bones arranged like the bones in your arm. At the time, those fins were used to navigate shallow, weedy swamps. But something far more remarkable was beginning at the water's edge.

Some lobe-finned fish began using their fins to push through very shallow water or briefly across mudflats. Over many generations, those fins became more limb-like. One of the most extraordinary fossils ever found captures this transformation: **Tiktaalik**, discovered in the Canadian Arctic, had the scales and gills of a fish but also a neck it could turn, ribs strong enough to support its weight, and fins that worked almost like arms. Tiktaalik is sometimes called a fishapod, neither fully fish nor fully land animal, a snapshot of life in the act of reinventing itself. From creatures like Tiktaalik, the first **tetrapods** evolved: four-limbed vertebrates that could move on land, ancestors of every **amphibian**, reptile, bird, and mammal alive today.

While animals were testing the land, plants were already claiming it. **Vascular plants**, meaning plants with internal tubes to carry water and nutrients upward, had been growing since the Silurian. In the Devonian, they grew tall for the first time, forming the first forests on Earth. These forests produced soil, changed the climate, and pulled carbon from the air. They also evolved **seeds**, protective packages enclosing a plant embryo that could survive dry conditions and germinate later, a remarkable adaptation that freed plants from needing to stay near water.

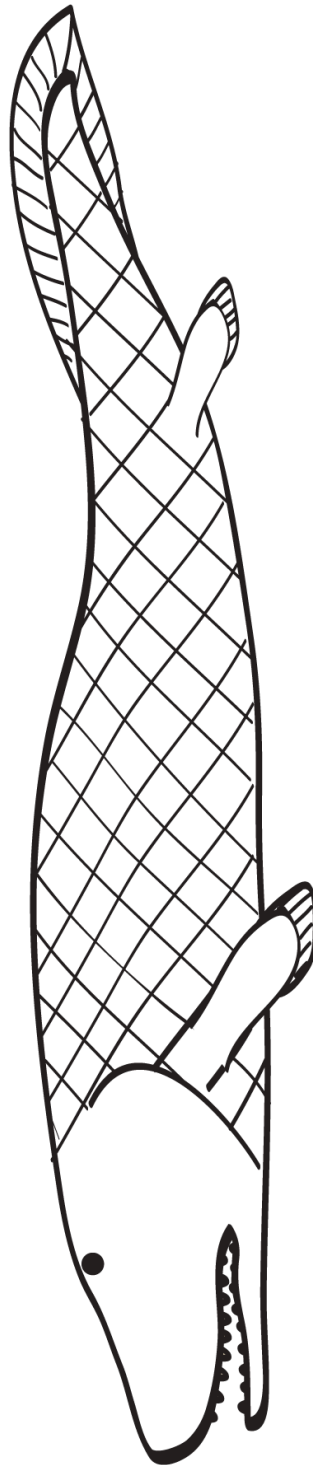
The Devonian was a period of firsts that changed the planet permanently: first tall forests, first seeds, first four-legged land animals. In geological terms, it happened quickly. And the world on the far side of the Devonian looked nothing like the world before it.

# The Age of Fishes [The Devonian Period]: 419 Million Years Ago

Draw Tiktaalik hauling itself out of a Devonian swamp on its stumpy fins, with the first fern forests rising behind it on the shore.

# Lesson 16: The Devonian Period

Label three features of Tikaalik that make it a unique species.



# Lesson 16: The Devonian Period

## Because / But / So

Complete each sentence using the connector word shown.

Tiktaalik was a transitional species between fish and land animals **because**

\_\_\_\_\_

Tiktaalik was a transitional species between fish and land animals, **but**

\_\_\_\_\_

Tiktaalik was a transitional species between fish and land animals, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun. Use information from the reading.

Tiktaalik, \_\_\_\_\_, is one of the most important fossils ever discovered.

Seeds, \_\_\_\_\_, allowed plants to spread across dry land for the first time.

The Devonian Period, \_\_\_\_\_, is often called the Age of Fishes.

# Lesson 17: Carboniferous

Land was waiting, full of opportunity. Plants were spreading. Sunlight was available everywhere. There were almost no competitors, no predators, no rivals at all. But moving onto land required solving problems that water had always solved invisibly. Water holds you up. Water keeps you moist. Water carries your eggs safely. On land, you have to do all of those things yourself, which required an entirely new set of inventions, accumulated over millions of years.

The first vertebrates to walk on land were **amphibians**, descendants of those lobe-finned fish. They could breathe air, move on four limbs, and feed on land insects and plants. But they remained tied to water for reproduction: their eggs had to stay moist, so they could never venture far from rivers, lakes, or pools. The next great invention changed everything. The amniotic egg is an egg with its own sealed water supply inside a leathery or hard shell. It allowed animals to reproduce anywhere on dry land, without any standing water at all. Animals with amniotic eggs could go everywhere.

The animals that evolved the amniotic egg were the first **reptiles**, and they spread rapidly across the land during the **Carboniferous Period**, from about 359 to 299 million years ago. The Carboniferous world was dominated by vast, warm, swampy forests. Giant tree ferns, towering club mosses, and enormous horsetail plants reached into a sky thick with oxygen. That rich oxygen allowed insects to grow to sizes never seen before or since, dragonflies with wingspans wider than your outstretched arms.

Those ancient forests also left behind something we use to this day. When the great Carboniferous trees died, they fell into warm swampy water where there was not enough oxygen for them to fully rot. Instead, layer upon layer of plant matter built up, compressing under its own weight over millions of years. Heat and pressure deep underground slowly transformed it into coal, a black rock packed with the stored energy of ancient sunlight. When we burn coal today, we are releasing energy that those trees captured from the sun more than 300 million years ago. The Carboniferous forests are gone, but their remains still heat our homes and power our cities. It is one of the strangest and most thought-provoking connections between the deep past and the world we live in now.

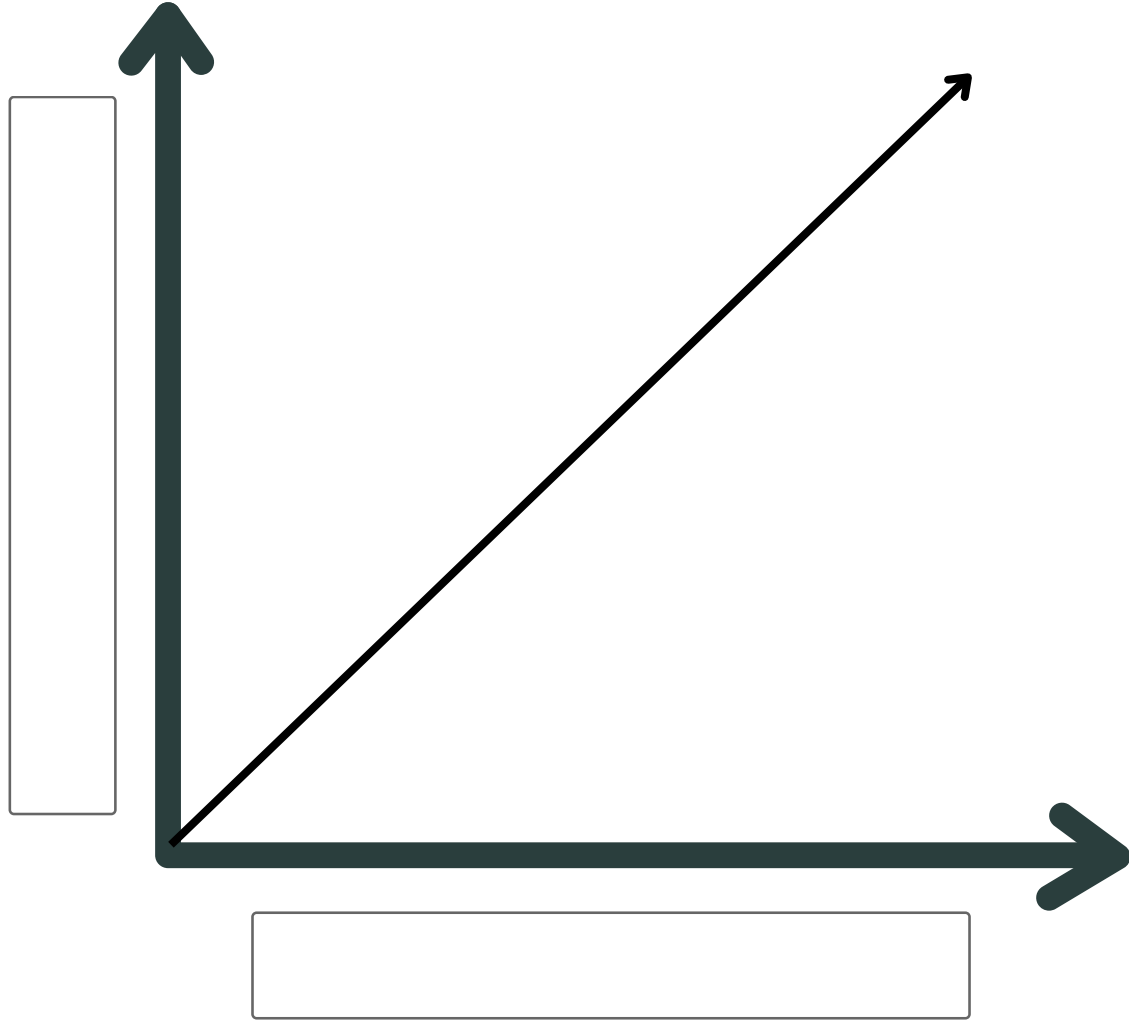
Life on land required countless **adaptations**, features shaped by evolution over many generations to meet new challenges. Waterproof skin to prevent drying out. Stronger limbs to bear body weight. More efficient lungs. Each adaptation was a problem solved, another step in life's extraordinary ability to find new ways to survive in new places. The land was being claimed, slowly and completely, by life.

## The Carboniferous Period: 320 Million Years Ago

Draw a Devonian tetrapod crawling out of the water into a dense Carboniferous coal forest. Consider adding towering club mosses, giant ferns, and enormous dragonflies filling the air above.

# Lesson 17: Carboniferous

What could we label the x and y axes that would make sense for the Carboniferous period? Hint: Think about the insects during this period.



As \_\_\_\_\_ increased,

\_\_\_\_\_ also increased.

# Lesson 17: Carboniferous

## Vocabulary: Fill in the Blank

**Word Bank:** *amphibian amniotic egg reptile arthropod adaptation Carboniferous*

1. A vertebrate that can walk on land but must return to water to reproduce is called an \_\_\_\_\_.
2. An egg with membranes and a shell that allows reproduction away from water is called an \_\_\_\_\_.
3. A vertebrate with waterproof skin that can reproduce fully on land is called a \_\_\_\_\_.
4. An invertebrate with a hard exoskeleton and jointed legs, like an insect or spider, is called an \_\_\_\_\_.
5. A trait that helps an organism survive and reproduce in its environment is called an \_\_\_\_\_.
6. The period (359-299 million years ago) known for vast swamp forests and giant insects is the \_\_\_\_\_ Period.

## Because / But / So

Complete each sentence using the connector word shown.

The amniotic egg was one of evolution's most important inventions **because**

\_\_\_\_\_

The amniotic egg was one of evolution's most important inventions, **but**

\_\_\_\_\_

The amniotic egg was one of evolution's most important inventions, **so**

\_\_\_\_\_

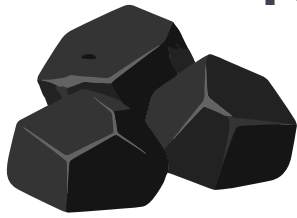
## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

**Before** \_\_\_\_\_, all vertebrates had to stay near water to reproduce.

**Although** \_\_\_\_\_, moving there required solving many serious problems.

**After** \_\_\_\_\_, reptiles could spread into every habitat on dry land.



# FORMATION OF COAL

FLIP BOOK

GLUE OR STAPLE HERE

**1**

**First**

GLUE OR STAPLE HERE

**2**

**Next**

GLUE OR STAPLE HERE

**3**

**Then**

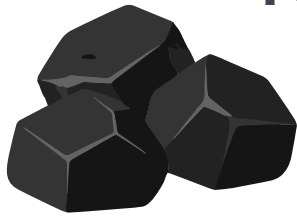
GLUE OR STAPLE HERE

**4**

**Last**

**1** Complete with the steps of formation of coal (draw/write).

**2** Cut the boxes and glue them in order.



# FORMATION OF COAL

FLIP BOOK

GLUE OR STAPLE HERE

Vast, swampy forests  
grew, absorbing energy  
from the sun.

**1**

**First**

GLUE OR STAPLE HERE

Plants died and fell into  
oxygen-poor water,  
forming thick layers of  
peat.

**2**

**Next**

GLUE OR STAPLE HERE

Over time, layers of  
sediment and sand buried  
the peat deep  
underground, protecting it  
from air.

**3**

**Then**

GLUE OR STAPLE HERE

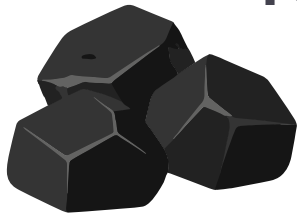
Extreme heat and weight  
from the Earth crushed  
the buried peat, slowly  
transforming it into solid  
coal.

**4**

**Last**

**1** Complete with the steps of formation of coal (draw/write).

**2** Cut the boxes and glue them in order.



# FORMATION OF COAL

FLIP BOOK

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underground,  
protecting it from

**3**

air.  
**Then**

GLUE OR STAPLE HERE

Extreme heat and  
weight from the  
Earth crushed the  
buried peat, slowly  
transforming it into  
solid coal.

**4**

**Last**

**1** Complete with the steps of formation of coal (draw/write).

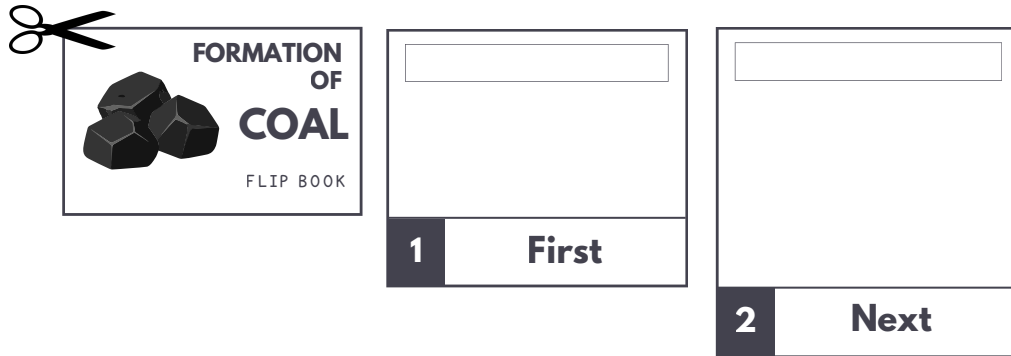
**2** Cut the boxes and glue them in order.

# FORMATION OF COAL

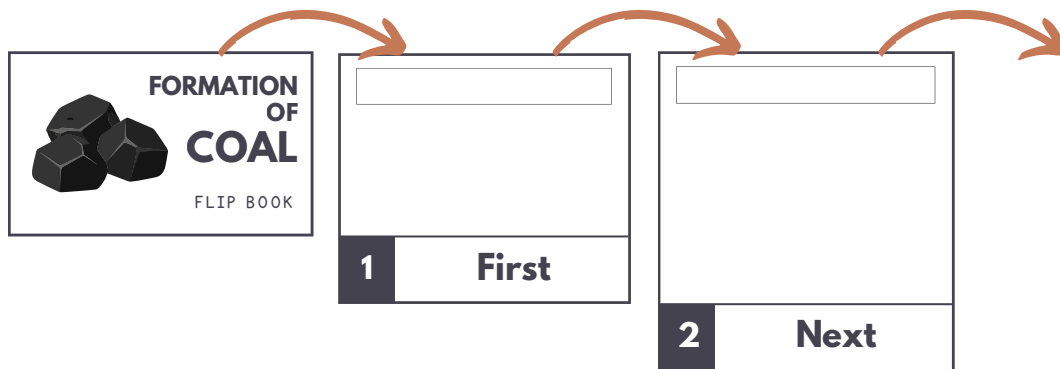
## FLIP BOOK

**1** Ask learners to complete the steps to Formation of Coal (write and/or draw)

**2** When they finish ask them to cut the 5 boxes (pages) of the Flip Book.



**3** Tell students to glue or staple the pages together, one onto the other, following the numbers.



**4** The Flip Book will look like this:



# Lesson 18: The Permian Period

Long before any dinosaur walked the Earth, back in the **Permian** Period from about 299 to 252 million years ago, the land was ruled by a group of animals called **synapsids**. They were not quite reptiles in the modern sense and not yet true mammals. They were something in between, a living bridge between the two groups, and they were the direct ancestors of every mammal alive today, including you. They can be distinguished by a particular opening in the skull behind each eye that is also found in all mammals. Their legs were also positioned more directly beneath their bodies, not splayed to the sides like a lizard's, which made movement more efficient and less tiring. Many had differentiated teeth, with cutting teeth at the front and crushing teeth further back, just like our own. Some may have had fur, and there is even evidence that suggests some may have cared for their young.

The most mammal-like of all the synapsids were the cynodonts. Looking at a cynodont skull, you can almost see the mammal emerging, the different tooth types, the enlarged brain case, the posture. Unlike typical **cold-blooded** reptiles that relied on the sun to warm them, therapsids were likely becoming **warm-blooded**, generating their own body heat internally. This gave them an enormous advantage: they could stay active in cool weather when cold-blooded competitors became sluggish.

The **fossil record**, the collection of all known fossils arranged in rock layers, tells us that synapsids were spectacularly successful. They filled every ecological role from small insect-eaters to large predators. They spread across Pangea. For a time, they truly ruled the land. But the end of the Permian Period was approaching, and it would bring something that no amount of warm blood or good teeth could prepare them for.

# The Permian Period: 320 Million Years Ago

Draw a sail-backed Dimetrodon basking in the Permian sun.

# Lesson 18: The Permian Period

Make a list of vertebrates and invertebrates. For each type of organism think about why their body structure helps them.

Vertebrates

Invertebrates

Vertebrates	Invertebrates

# Lesson 18: The Permian Period

## Because / But / So

Complete each sentence using the connector word shown.

Therapsids were the ancestors of all mammals alive today **because**

\_\_\_\_\_

Therapsids were the ancestors of all mammals alive today, **but**

\_\_\_\_\_

Therapsids were the ancestors of all mammals alive today, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun.

Cynodonts, \_\_\_\_\_, were the most mammal-like of all the therapsids.

The Permian Period, \_\_\_\_\_, was the time when therapsids ruled the land.

Warm-bloodedness, \_\_\_\_\_, gave therapsids a real advantage over cold-blooded competitors.

# Lesson 19: The Great Dying

About 252 million years ago, life on Earth nearly ended. Not in a day, not in a century, but over thousands of years, conditions on Earth became so hostile that creature after creature, species after species, ecosystem after ecosystem, collapsed. By the time it was over, about 96 percent of all marine species and 70 percent of all land species were gone. Scientists call this catastrophe the **Great Dying**, and it was the worst **mass extinction** in the history of life, far more devastating than the asteroid that later killed the dinosaurs.

The cause was volcanic. In what is now Siberia, a region of Earth called the Siberian Traps erupted in pulses for hundreds of thousands of years, releasing staggering amounts of carbon dioxide into the atmosphere. As **carbon dioxide** built up, Earth's temperature rose rapidly in a runaway **greenhouse effect**. The oceans warmed and lost oxygen. They also absorbed carbon dioxide and became more acidic, a process called **ocean acidification**, which dissolved the shells of marine creatures and collapsed reef ecosystems that had taken millions of years to build. The combination of heat, low oxygen, and acid was devastating.

The world that emerged from the Great Dying was almost unrecognizable. The rich Permian forests were gone. The therapsids were mostly gone. The complex marine ecosystems, trilobites, coral reefs, ancient fish, were gone. Earth was nearly silent. But a few survivors remained, huddled in whatever corners of the world had been spared the worst: some reptiles, some early mammal relatives, some insects, some plants. And from those survivors, over millions of years, life would rebuild itself. Different, but alive.

The Great Dying is perhaps the most powerful reminder in the entire story of life of how connected living things are to the chemistry and climate of the planet. Earth's living systems are resilient, but they are not invincible. When the conditions that support life change drastically and quickly, life changes with them, or it disappears. And in the silence left behind, something new begins.

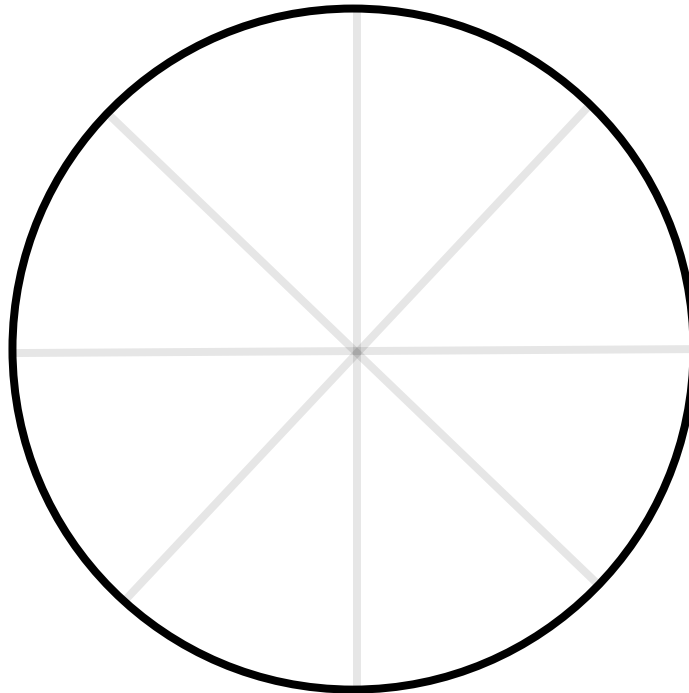
# The Great Dying 252 Million Years Ago

Draw a barren, ash-covered landscape with a massive volcano on the horizon and a few lonely, bony creatures surviving among the dead trees.

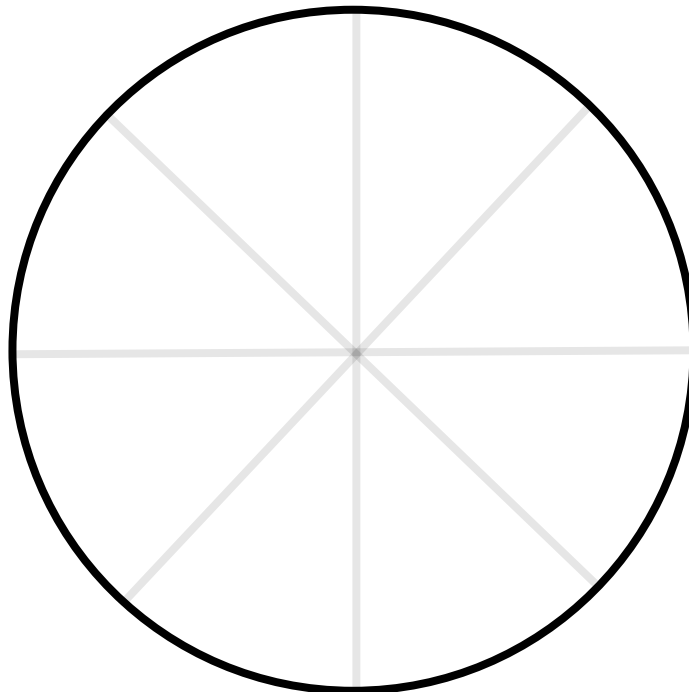
# Lesson 19: The Great Dying

Create a pie graph for what percentage of species went extinct during the Great Dying.

Land Species



Ocean Species



# Lesson 19: The Great Dying

Create a cause-and-effect chain for the Great Dying. For each step, write one sentence explaining what happened or create a drawing.

A vertical flowchart template for a cause-and-effect chain. It consists of six empty rectangular boxes stacked vertically. Each box is connected to the one below it by a vertical line with a downward-pointing arrowhead at the bottom. The top box has a line extending downwards from its bottom center, and the subsequent boxes have lines extending downwards from their top centers, each ending in an arrowhead pointing down.

# Lesson 19: The Great Dying

## Because / But / So

Complete each sentence using the connector word shown.

The Great Dying wiped out 96 percent of all marine species **because**

\_\_\_\_\_

The Great Dying wiped out 96 percent of all marine species, **but**

\_\_\_\_\_

The Great Dying wiped out 96 percent of all marine species, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

The Siberian Traps volcanoes erupted for hundreds of thousands of years **because**

\_\_\_\_\_.

**Although** \_\_\_\_\_, a few survivors remained and eventually rebuilt the living world.

**Since** \_\_\_\_\_, an entirely new group of animals was able to rise and take their place.

# Lesson 20: The Triassic

After the Great Dying, Earth was quiet. Most of the Permian world was gone. But the planet was not dead. A few survivors remained in a devastated landscape, and over millions of years, those survivors would rebuild a living world, different from what came before, and in some ways more extraordinary. The **Triassic** Period, from about 252 to 201 million years ago, was the age of recovery. And out of that recovery rose an animal that would dominate the next 160 million years: the dinosaur.

The survivors of the Great Dying included a group of reptiles called **archosaurs**. From this group, two great lineages would eventually emerge: pterosaurs, the first flying vertebrates, and **dinosaurs**. The earliest dinosaurs were small and quick, nothing like the giants that would follow. Their key advantage was posture. A dinosaur's legs were positioned directly beneath its body, like a dog's or a bird's. This made them **bipedal** in many cases, walking upright on two legs, freeing the arms, and gave them a more efficient, less tiring stride. In a recovering world where efficiency mattered, this was a decisive edge.

Each species fills a **niche**, a role in the ecosystem defined by what it eats, where it lives, and how it interacts with other species. After the Great Dying, countless niches were empty. Dinosaurs, with their efficient bodies and adaptable diets, filled niche after niche as the world recovered. Early mammals also appeared during the Triassic, tiny, fur-covered, nocturnal creatures that hid carefully in the dinosaurs' shadow. They would wait a very long time for their opportunity.

The Triassic was the opening chapter of the **Mesozoic Era**, the Age of Reptiles, which would last for nearly 190 million years. It was a time of rebirth and reinvention. The survivors of catastrophe had inherited a changed world, and they were making it their own. The stage was being set for something spectacular.

# Dinosaurs Appear [The Triassic Period] 251 Million Years Ago

Draw a small, upright early dinosaur like Eoraptor standing tall on two legs in a dry Triassic landscape, maybe with a tiny shrew-like mammal hiding in the rocks nearby.

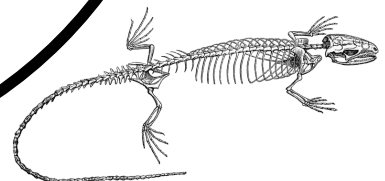
# Lesson 20: The Triassic

Compare and contrast dinosaurs and lizards.



Dinosaurs

Lizards



Hopley, Catherine Cooper, CCO, via Wikimedia Common

# Lesson 20: The Triassic

## Because / But / So

Complete each sentence using the connector word shown.

The Great Dying left the world full of empty ecological roles **because**

\_\_\_\_\_

The Great Dying left the world full of empty ecological roles, **but**

\_\_\_\_\_

The Great Dying left the world full of empty ecological roles, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun.

Archosaurs, \_\_\_\_\_, were the group of reptiles from which dinosaurs and pterosaurs evolved.

The Mesozoic Era, \_\_\_\_\_, lasted for nearly 190 million years and is known as the Age of Reptiles.

Early mammals, \_\_\_\_\_, were small, nocturnal creatures that lived in the shadow of the dinosaurs.

## Think and Write

1. How did the aftermath of the Great Dying actually help the first dinosaurs succeed? Explain the connection between extinction and opportunity.

# Lesson 21: Jurassic Period

The **Jurassic** Period, from about 201 to 145 million years ago, was Earth at its most extravagant. Pangea had been splitting apart, and the new inland seas brought warm, wet weather to the continents. Plants grew in abundance everywhere. And the more plants there were, the more food was available, and the larger the animals that ate those plants could grow. In the Jurassic, life pushed the boundaries of size in ways that have never been equaled since.

The giants of this world were the **sauropods**, the enormous long-necked plant-eating dinosaurs. Brachiosaurus, Apatosaurus, Diplodocus: these animals reached lengths of 30 meters or more, and their weight made the ground shake with every step. They were the largest land animals that have ever existed. Their long necks allowed them to browse foliage high in the treetops that no other **herbivore** could reach, effectively giving them a food supply all to themselves. Meanwhile, **carnivores** like Allosaurus stalked the Jurassic landscape, powerful predators in a world of giants.

But land was not the only stage. In the oceans, enormous **marine reptiles** ruled the seas, ichthyosaurs with streamlined, dolphin-shaped bodies, and long-necked plesiosaurs that patrolled near the surface. In the air, **pterosaurs** of many sizes soared on leathery wings. Life had filled every available space, air, land, sea, in a complex interlocking web of relationships. Who ate whom, who depended on whom, who kept whom in check: this is what scientists call a **food web**, and the Jurassic's was one of the most intricate the world had ever seen.

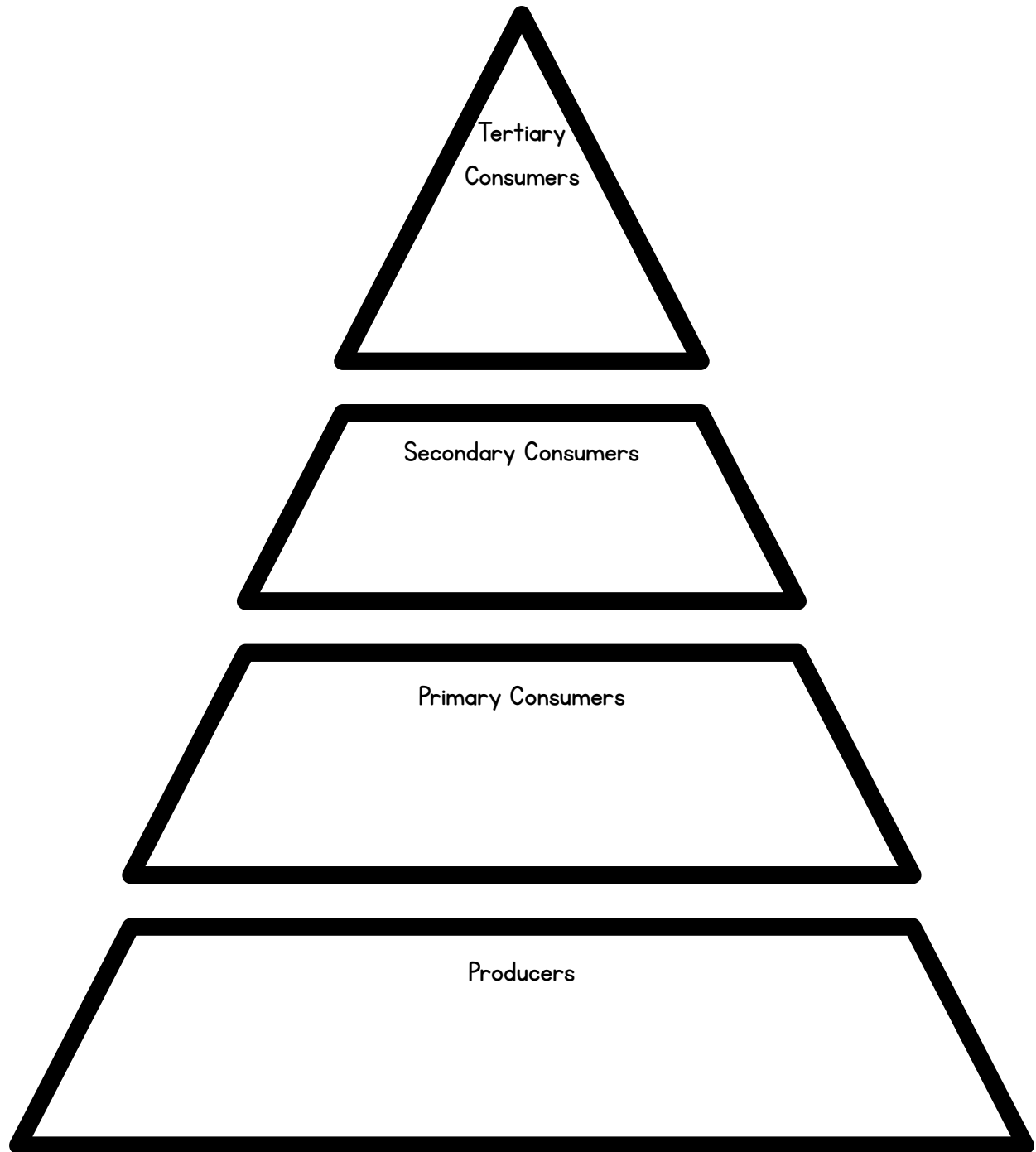
And something almost invisible was happening in the Jurassic that would prove to be among the most important events in life's history. Among some small theropod dinosaurs, the two-legged predators in the shadow of the giants, feathers were appearing. At first perhaps for warmth, perhaps for display, perhaps both. But over generations, some feathered theropods began to glide, and then to fly. The first birds were quietly taking shape in the Jurassic forests, descended from dinosaurs, and they would outlast every giant that ever walked beneath them.

# The Age of Giants [The Jurassic Period] 201 Million Years Ago

Draw a massive Brachiosaurus stretching its neck into the treetops of a lush Jurassic forest, with a tiny Archaeopteryx gliding between the branches above.

# Lesson 21: Jurassic Period

Label the energy pyramid with examples from the Jurassic Period.



Where is the original energy coming from?

# Lesson 21: Jurassic Period

## Sentence Expansion

Each sentence below is a bare fact. Rewrite it on the lines, adding details that answer the question in parentheses.

Sauropods were enormous. *(How large were they, what did they eat, and why could they grow so big during the Jurassic?)*

Feathers appeared on some dinosaurs. *(Which group had them, what might they have been used for at first, and why does this matter?)*

## Because / But / So

Complete each sentence using the connector word shown.

The Jurassic Period was the most lush and productive time in Earth's history **because**

---

The Jurassic Period was the most lush and productive time in Earth's history, **but**

---

The Jurassic Period was the most lush and productive time in Earth's history, **so**

---

# Lesson 23: Cretaceous Period

The **Cretaceous** Period, from about 145 to 66 million years ago, was the last and most spectacular chapter of the dinosaur age. Tyrannosaurus rex, Triceratops, and Velociraptor all lived during this time, in a world that was warm, largely ice-free, and extraordinarily diverse. The continents had drifted further apart, so dinosaurs on different landmasses evolved in different directions, producing the richest variety of dinosaur life the world had ever seen.

But the most transformative event of the Cretaceous had nothing to do with dinosaurs. It was botanical: the rise of the **angiosperm**, the flowering plant. For most of Earth's history, plants reproduced using spores or cones, relying on wind to carry pollen. Flowers changed everything. A flower offers a reward, nectar, pollen, to any creature that visits it. In return, that creature carries pollen from flower to flower, far more reliably than wind ever could. This partnership between plants and their **pollinators**, the insects and other animals that carry pollen, is one of evolution's greatest relationships, and it worked so well that flowering plants spread and diversified faster than any plant group before them.

This is called **coevolution**, when two species shape each other's evolution as they adapt to each other over millions of years. Flowers became more elaborate to attract the pollinators that served them best. Bees and beetles evolved to be better at finding and using flowers. Each drove the other forward. Fruits evolved too, nutritious packages around seeds, designed to be eaten by animals that would carry the seeds somewhere new in their digestive systems. The relationship between flowering plants and animals reshaped entire **ecosystems**, making them richer and more interconnected than anything that had existed before.

The Cretaceous world was, in many ways, the most complex and interconnected Earth had ever produced. New flowers everywhere. New insects. Dinosaurs evolving alongside the new plant life. And in the undergrowth, small fur-covered mammals watching, waiting, living carefully. They had been waiting for a very long time. Their moment was coming.

# The 1st Flowers Bloom [Cretaceous Period] 125 Million Years Ago

Draw the first small flowering plants blooming among ferns and cycads in a Cretaceous landscape, with a bee or early pollinating insect hovering nearby.

# Lesson 23: Cretaceous Period

Label the angiosperm (flower) with the appropriate terms below

Petal

Sepal

Anther

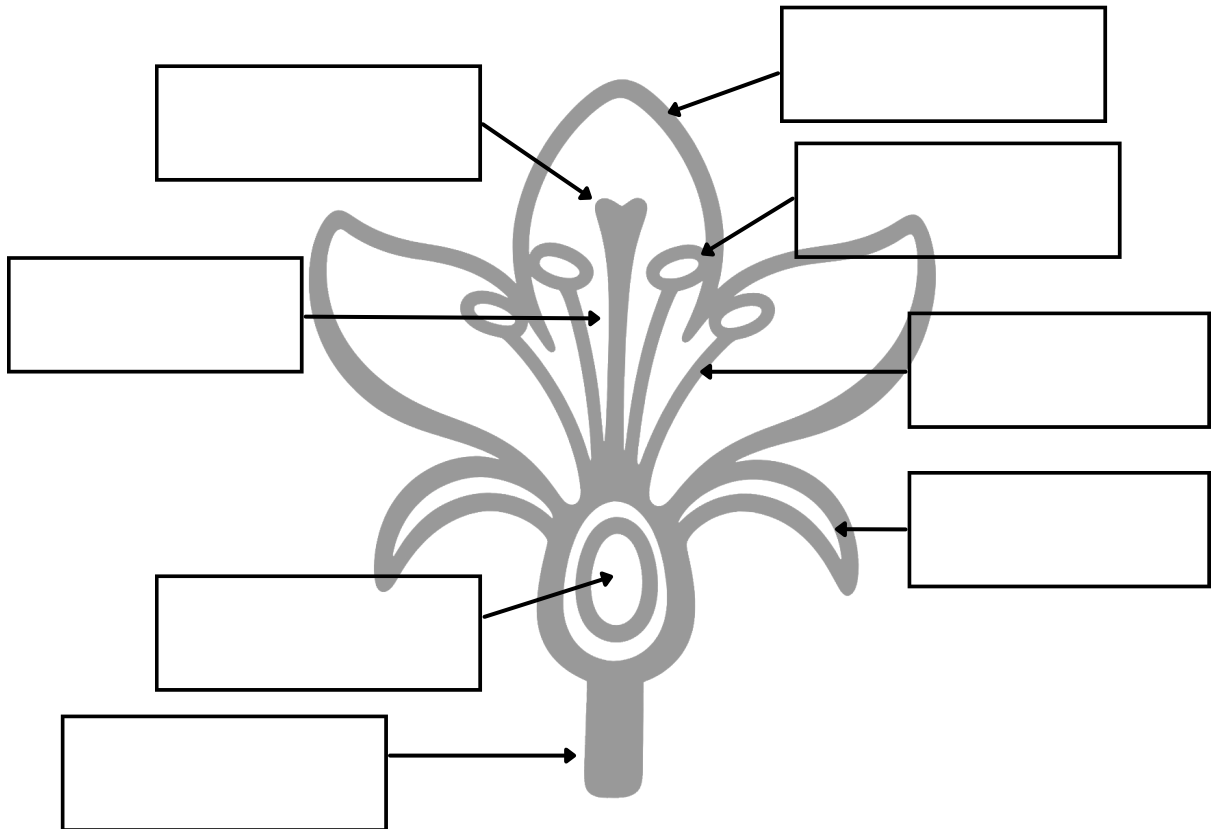
Ovary

Stigma

Filament

Style

Stem



Why was the development of angiosperm (flowers) a significant milestone?

# Lesson 23: Cretaceous Period

## Because / But / So

Complete each sentence using the connector word shown.

Flowering plants changed the way plants reproduce **because**

\_\_\_\_\_

Flowering plants changed the way plants reproduce, **but**

\_\_\_\_\_

Flowering plants changed the way plants reproduce, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

Flowers offered nectar and pollen to insects **because**

\_\_\_\_\_.

**After** \_\_\_\_\_, they spread and diversified faster than any plant group before them.

**Although** \_\_\_\_\_, their partnership with pollinators was one of evolution's most successful inventions.

## Think and Write

1. What is coevolution? Give a specific example from the reading and explain exactly how each partner in the relationship affected the other.

# Lesson 24: End of the Dinosaurs

Sixty-six million years ago, a rock from space ended an era. It was roughly 10 kilometers across, about the size of a city, and it struck Earth at tens of kilometers per second near what is now Mexico's Yucatan Peninsula. The energy released was billions of times greater than any nuclear weapon ever built. The ground shook across the entire planet. Enormous fires erupted across the continents. A cloud of vaporized rock, dust, and debris was blasted into the upper atmosphere and spread around the world within days.

What followed was a period called **nuclear winter**, months or years of darkness and cold, as the debris cloud blocked sunlight across the globe. Plants could not photosynthesize. Food chains built on plant life fell apart. Animals that depended on those food chains starved. The oceans were affected too. About 75 percent of all species on Earth went extinct, including every **non-avian dinosaur**: every T. rex, every Triceratops, every sauropod. This catastrophe is called the **K-Pg Extinction**, named for the boundary between the Cretaceous and the Paleogene periods in the rock record.

How do scientists know an **asteroid** caused this? The evidence is multiple and mutually confirming. A worldwide layer of rock, exactly 66 million years old, contains high concentrations of **iridium**, a metal rare at Earth's surface but common in asteroids. The same layer contains minerals that could only form under the pressure of a massive impact. And buried beneath the Gulf of Mexico is the **impact crater** itself, the Chicxulub Crater, over 150 kilometers across, the scar left in Earth's crust by the end of the dinosaurs.

But not everything died. Small mammals, hiding in burrows and eating seeds and insects, survived. Crocodylians survived in rivers and lakes. And birds, the avian descendants of theropod dinosaurs, survived too, meaning the dinosaurs are not entirely gone. With the giants erased, the survivors found themselves in a world of empty opportunities. And the age that followed would belong to them.

# The End of the Dinosaurs [K-Pg Extinction] 66 Million Years Ago

Draw the Chicxulub asteroid streaking toward Earth with a fiery trail across the sky, and silhouettes of dinosaurs on the horizon below.

# Lesson 24: End of the Dinosaurs

Think of examples of animals that survived and ones that did not survive the KG extinction event. Think of some reasons why the ones who survived were successful.

Survived K-Pg Extinction

Did NOT Survive K-Pg Extinction

Survived K-Pg Extinction	Did NOT Survive K-Pg Extinction

# Lesson 24: End of the Dinosaurs

## Vocabulary: Fill in the Blank

**Word Bank:** *non-avian dinosaurs K-Pg Extinction asteroid iridium impact crater avian*

1. All dinosaurs except the lineage that evolved into birds are called \_\_\_\_\_ dinosaurs.
2. The mass extinction 66 million years ago that ended the dinosaur age is called the \_\_\_\_\_ Extinction.
3. A rocky body from space that struck Earth and triggered the extinction is called an \_\_\_\_\_.
4. A rare metal found worldwide in rock from 66 million years ago, evidence of the strike, is \_\_\_\_\_.
5. The circular scar left by the strike, buried under the Gulf of Mexico, is called an \_\_\_\_\_ crater.
6. Birds are \_\_\_\_\_ dinosaurs because they are the only surviving members of the dinosaur lineage.

## Because / But / So

Complete each sentence using the connector word shown.

The asteroid that struck Earth 66 million years ago changed the history of life forever **because**

\_\_\_\_\_

The asteroid that struck Earth 66 million years ago changed the history of life forever, **but**

\_\_\_\_\_

The asteroid that struck Earth 66 million years ago changed the history of life forever, **so**

\_\_\_\_\_

**Subordinating Conjunctions**

Complete each sentence using the conjunction shown.

**Although** \_\_\_\_\_, small mammals and birds managed to survive.

dust and soot blocked sunlight after the impact **because**

\_\_\_\_\_.

**Since** \_\_\_\_\_, mammals have been able to diversify and eventually produce humans.

# Lesson 25: Rise of Mammals

For 160 million years, mammals had lived small and careful in the shadow of the dinosaurs. They were mostly nocturnal, hiding in burrows, eating insects and seeds, staying invisible. They had warm blood, fur, and milk to feed their young, remarkable traits, but not enough to compete with the giants above them. Then the asteroid struck, the dinosaurs vanished, and for the first time in the history of mammals, the world was open.

The result was one of the most spectacular diversifications in the history of life. With countless ecological roles left empty by the dinosaurs, mammals moved in. This rapid spread of one group into many different forms to fill many different roles is called **adaptive radiation**. Some mammals grew large. Some returned to the sea and eventually became whales and dolphins. Some took to the trees. Some evolved into swift grassland runners. In the space of a few million years, extraordinarily fast in geological terms, mammals transformed from a collection of small, cautious survivors into the dominant large animals of the planet.

Three great groups of mammals diversified during this time. **Placental mammals** carry their young inside the body until they are fully developed, nourished through an organ called a placenta. This group includes almost every mammal you have ever heard of: dogs, horses, elephants, bats, whales, and humans. **Marsupials** give birth to very undeveloped young that continue growing in a pouch, kangaroos and koalas are living examples. And **monotremes** are the ancient egg-laying mammals, represented today only by the platypus and echidna, extraordinary animals that remind us how diverse mammalian life once was.

The **Cenozoic Era**, the age of mammals, stretching from 66 million years ago to the present, was just beginning. And within it, one particular lineage of small, sharp-eyed, tree-dwelling mammals was setting the stage for something that had never happened before in the history of life on Earth.

# Age of Mammals Begins [Paleocene Epoch] 66 Million Years Ago

Draw a Paleocene forest floor with small, fuzzy early mammals – in all different shapes – exploring the ferns and fallen logs left behind by the dinosaurs.

# Lesson 25: Rise of Mammals

Draw an example of each type of mammals and write 1-2 sentences explaining how each strategy helped mammals survive after the dinosaurs.

Placentals

Monotremes

Marsupials

# Lesson 25: Rise of Mammals

## Because / But / So

Complete each sentence using the connector word shown.

Birds are the only living descendants of the dinosaurs **because**

\_\_\_\_\_

Birds are the only living descendants of the dinosaurs, **but**

\_\_\_\_\_

Birds are the only living descendants of the dinosaurs, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun.

Archaeopteryx, \_\_\_\_\_, had feathers like a bird but claws and teeth like a dinosaur.

Crocodylians, \_\_\_\_\_, are among the most successful survivors of the K-Pg extinction.

Theropods, \_\_\_\_\_, were the group of dinosaurs from which modern birds evolved.

## Think and Write

1. What specific evidence proves that birds really are living dinosaurs? List at least three pieces of evidence from the reading and explain each one.

# Lesson 26: Crocodiles & Birds

The next time you see a bird, any bird, even a sparrow on a wire, look at it carefully. The hollow bones. The three-toed feet. The wishbone. The way it lays eggs in a nest and tends them carefully. You are looking at a dinosaur. Not a creature that resembles a dinosaur, not a distant cousin: an actual, living dinosaur. Birds evolved directly from **theropods**, the two-legged predatory dinosaurs, and they carry their dinosaurian heritage in every structure of their bodies.

The connection became undeniable when fossils like Archaeopteryx were discovered: a creature with beautiful **feathers** like a bird but the teeth, claws, and long tail of a theropod. Since then, hundreds of feathered dinosaur fossils have been found, tracing the gradual transition step by step. The evidence of **common ancestor** is written in shared DNA, in bone structure, in behavior, in the way birds breathe, a rapid, efficient respiratory system inherited from their dinosaur ancestors. Calling birds dinosaurs is not a metaphor. It is scientific precision. **Hollow bones** evolved in theropods millions of years before flight, originally perhaps for efficient breathing, and birds inherited them. They belong to the larger group **archosaurs**, along with crocodilians and pterosaurs.

Crocodilians, crocodiles, alligators, gharials, have a completely different story. They are not descended from dinosaurs; instead, they share an ancient common ancestor with them from back in the Triassic Period. What is remarkable about **crocodilians** is how little they have changed. They survived the K-Pg extinction because they were exceptional ambush predators that could go months without food, hide in rivers and lakes, and eat virtually anything. And then they essentially stopped changing. The crocodile on a riverbank today is almost identical to crocodiles that lived alongside the dinosaurs.

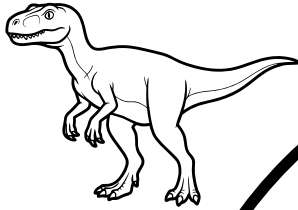
When you see a heron and a crocodile at the same river's edge, you are watching two utterly different kinds of survival. The heron, light, warm-blooded, feathered, descended from theropods, represents one path through deep time. The crocodile, cold, patient, ancient beyond imagining, represents another. The past is still alive, if you know where to look for it.

# Birds & Crocodylians Survive 66 Million Years Ago

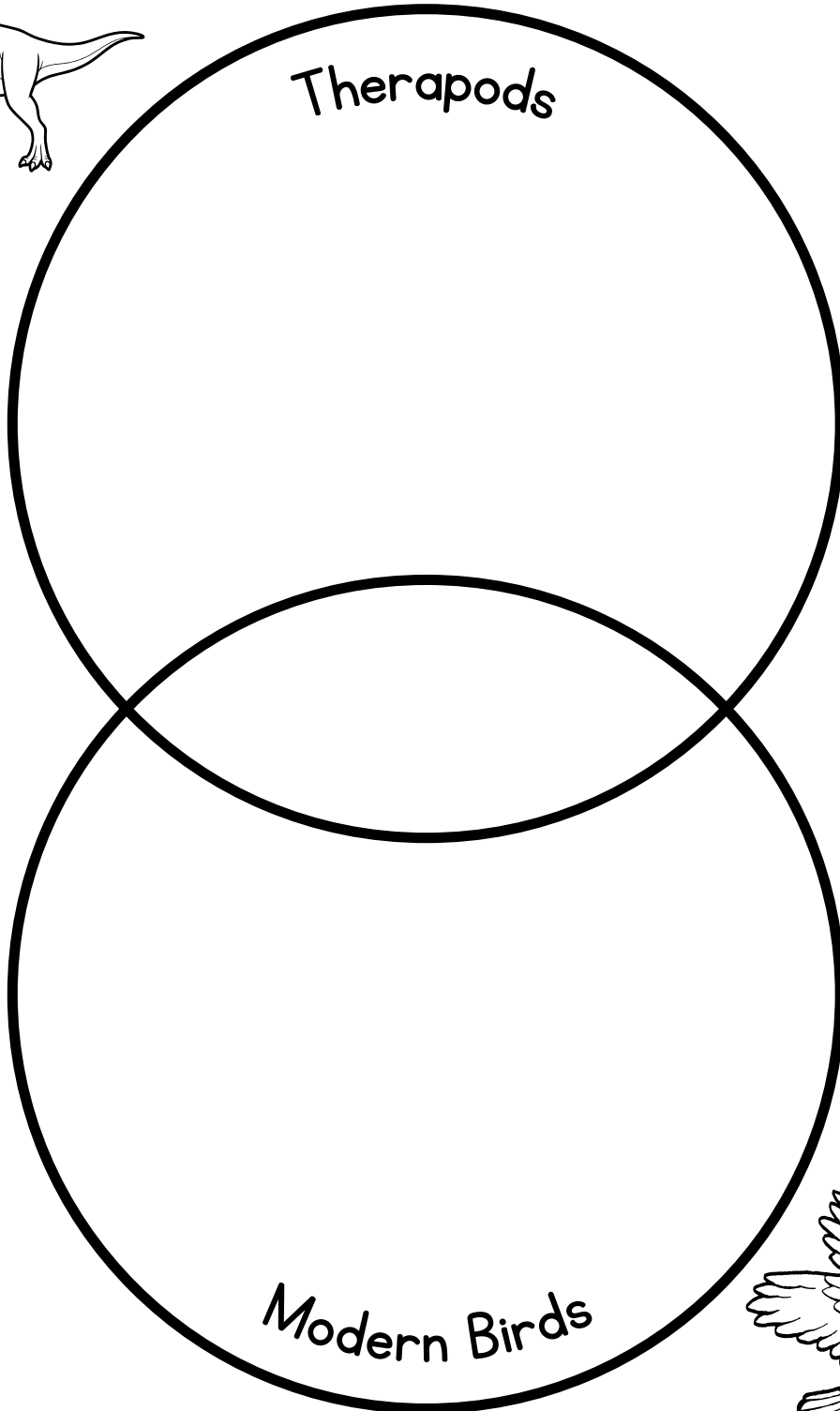
Draw a crocodylian lurking in a shallow river beside a colorful early bird perched on a branch, with the K-Pg boundary layer of ash visible in the rock cliff behind them.

# Lesson 26: Dinosaur Descendents

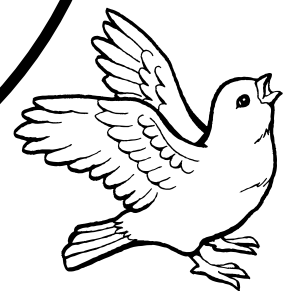
Compare and contrast a theropod dinosaur with a modern day bird.



Theropods



Modern Birds



# Lesson 26: Crocodiles & Birds

## Because / But / So

Complete each sentence using the connector word shown.

Many megafauna went extinct at the end of the last Ice Age **because**

\_\_\_\_\_

Many megafauna went extinct at the end of the last Ice Age, **but**

\_\_\_\_\_

Many megafauna went extinct at the end of the last Ice Age, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

South America was isolated from other continents for millions of years **because**

\_\_\_\_\_.

**Although** \_\_\_\_\_, they disappeared relatively quickly at the end of the Pleistocene.

**Since** \_\_\_\_\_, no land animals as large as woolly mammoths or giant ground sloths have existed on Earth.

## Think and Write

1. Scientists debate whether climate change or human hunting caused the megafauna extinctions. Using evidence from the reading, describe both arguments and explain which you find more convincing.

# Lesson 26: Mega Mammals

After the dinosaurs disappeared, mammals stepped into an open world and filled it with extraordinary variety. Over tens of millions of years, some lineages grew to sizes that rival or surpass the largest dinosaurs. For a long time, Earth was home to **megafauna**, truly enormous mammals. **Woolly mammoths** had tusks three meters long and thick shaggy fur roamed the frozen grasslands of the northern world. Giant ground sloths the size of elephants lumbered through South American forests. Cave bears stood over two meters at the shoulder. Saber-toothed cats stalked prey with canine teeth as long as daggers.

Why did some mammals grow so large during the **Ice Age**? In cold climates, large bodies conserve heat more efficiently than small ones, a pattern called **Bergmann's Rule**. A mammoth loses heat from its surface relative to its volume more slowly than a small mammal does, so large size was genuinely useful in an arctic world. Thick fur, dense fat, and enormous size together made these animals formidable survivors of extreme cold. The woolly mammoth was not just a novelty, it was a supremely well-adapted creature, perfectly suited to its world.

But that world did not last. As the Ice Ages came to an end and the climate warmed, something happened to the megafauna. Species after species disappeared: mammoths, giant sloths, cave bears, woolly rhinoceroses, mastodons. Scientists still debate the exact cause. Climate change disrupted the grassland ecosystems these animals depended on. And something else was happening at the same time: humans had arrived. Early human hunters were skilled and cooperative, and some researchers believe overhunting accelerated or caused the **extinction** of many megafauna species, especially in the Americas and Australia where animals had never seen human hunters before.

The great animals of the Ice Ages left their bones in tar pits in California, their frozen bodies in Siberian permafrost, and their images in the paintings of the humans who lived alongside them. They were real, they were spectacular, and their loss reshaped every ecosystem they had once inhabited. An **adaptation** that made an animal perfect for one world could do nothing to save it when the world changed.

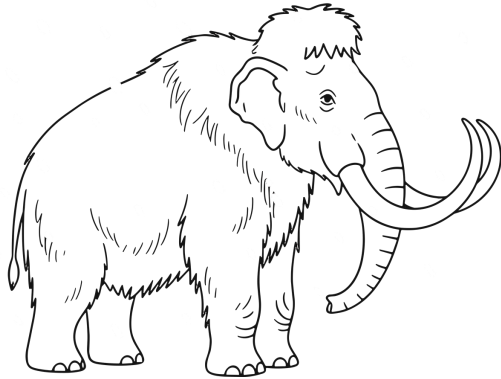
# Age of Mega Mammals (Pleistocene Epoch) 2.5 Million Years Ago

Draw a shaggy woolly mammoth with massive curved tusks standing in a snowy Pleistocene steppe, with a saber-toothed Smilodon prowling in the background.

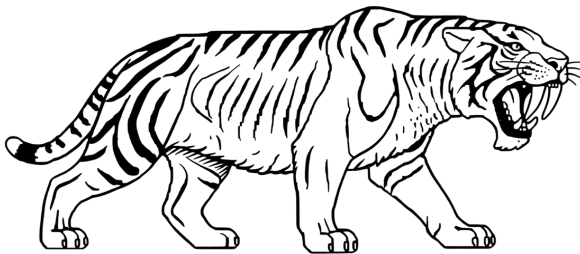
# Lesson 26: Mega Mammals

What survival strategy would each of these mammals use to survive the ice age?

Mammoth

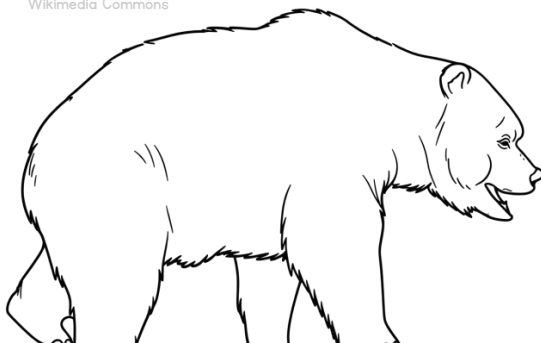


Sabertooth



Cave Bear

Sergiodlarosa, CC BY-SA 3.0  
<<http://creativecommons.org/licenses/by-sa/3.0/>>, via  
Wikimedia Commons



# Lesson 26: Mega Mammals

## Because / But / So

Complete each sentence using the connector word shown.

Many megafauna went extinct at the end of the last Ice Age **because**

\_\_\_\_\_

Many megafauna went extinct at the end of the last Ice Age, **but**

\_\_\_\_\_

Many megafauna went extinct at the end of the last Ice Age, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

South America was isolated from other continents for millions of years **because**

\_\_\_\_\_.

**Although** \_\_\_\_\_, they disappeared relatively quickly at the end of the Pleistocene.

**Since** \_\_\_\_\_, no land animals as large as woolly mammoths or giant ground sloths have existed on Earth.

## Think and Write

1. Scientists debate whether climate change or human hunting caused the megafauna extinctions. Using evidence from the reading, describe both arguments and explain which you find more convincing.

# Lesson 27: Glaciers and Iceages

The Great Lakes of North America, some of the largest freshwater lakes on the planet, did not exist a million years ago. They were not carved by rivers or formed by volcanoes. They were scooped out of the bedrock by ice. Enormous sheets of glacial ice, in some places more than two kilometers thick, ground slowly southward across the continent, scooping up rock and soil as they went. When the ice eventually melted, the basins it had carved filled with meltwater. This is the power of **glaciers**: patient, relentless, reshaping landscapes in ways that last for millions of years.

A glacier forms when snow accumulates in cold regions faster than it melts. Year after year, new snow presses down on old snow, compressing it into dense ice. When enough ice builds up, it begins to flow under its own weight, a slow river of ice moving a few meters a day, grinding over everything beneath it. This is one of the most powerful forces of **erosion** on Earth. Glaciers can flatten mountains, carve deep U-shaped valleys, and carry boulders the size of houses hundreds of kilometers from where they started. The classic mountain valleys of Norway and the Alps were shaped entirely by glaciers that retreated thousands of years ago.

Earth's **climate** has cycled in and out of **Ice Ages** many times throughout its history, driven by subtle, predictable wobbles in Earth's orbit around the Sun. During the **Pleistocene** Epoch, from about 2.6 million to 11,700 years ago, ice sheets advanced and retreated repeatedly across the northern continents. During the coldest periods, **sea level** dropped by more than 100 meters as enormous quantities of water were locked up in ice. That exposed vast areas of the continental shelves, land that is now underwater, and created bridges between continents that allowed animals and people to walk to places they could not otherwise reach.

The last Ice Age ended about 11,700 years ago. As the glaciers melted and retreated, colossal floods of meltwater carved new channels, built new deltas, and filled new lakes. The world's coastlines shifted as the sea returned. The landscape of every continent was reshaped. The world we recognize today, its river systems, its lake districts, its valleys and plains, was largely built by ice.

# Ice Ages & Glaciers [Pleistocene Ice Age] 115,000 Years Ago

Draw a massive glacier pushing across a landscape, scraping boulders, carving a valley, and leaving a moraine ridge of rocks and gravel at its edge.

# Lesson 27: Glaciers and Iceages

Draw a simple diagram showing a glacier moving across land. Label what happens: rock being pushed, valleys being carved, sediment being deposited.

# Lesson 27: Glaciers and Iceages

## Vocabulary: Fill in the Blank

**Word Bank:** *glacier erosion climate Ice Ages Pleistocene sea level*

1. A large, slow-moving mass of ice formed from accumulated compressed snow is called a \_\_\_\_\_.
2. The wearing away of rock and soil by water, wind, or ice is called \_\_\_\_\_.
3. The long-term patterns of temperature and precipitation in a region are called its \_\_\_\_\_.
4. Long periods when large ice sheets covered much of Earth's surface are called \_\_\_\_\_.
5. The geological epoch from about 2.6 million to 11,700 years ago, marked by repeated glaciations, is the \_\_\_\_\_.
6. The average height of the ocean surface, which drops when water is locked in ice sheets, is called \_\_\_\_\_ level.

## Because / But / So

Complete each sentence using the connector word shown.

Glaciers are one of the most powerful forces that shape Earth's landscape **because**

\_\_\_\_\_

Glaciers are one of the most powerful forces that shape Earth's landscape, **but**

\_\_\_\_\_

Glaciers are one of the most powerful forces that shape Earth's landscape, **so**

\_\_\_\_\_

**Sentence Expansion**

Rewrite each sentence on the lines, adding details that answer the question in parentheses.

Sea levels dropped during the Ice Ages. (*By how much, what was exposed, and how did this affect animals and early humans?*)

# Lesson 28: Primates

About 55 million years ago, in the warm forests of a world still recovering from the end of the dinosaurs, a small warm-blooded animal was making its way through the treetops. It had eyes that faced forward, eyes that worked together to give it precise depth perception. It had hands with fingers that could curl around a branch, and a thumb that could press against those fingers to grip with extraordinary accuracy. Its brain was large for its size. This creature was one of the earliest **primates**, the mammal group that today includes lemurs, monkeys, apes, and humans.

The distinctive features of primates all make sense in the context of life in the trees.

**Binocular vision**, seeing a single, unified image through both forward-facing eyes, gives precise depth perception essential for judging the exact distance to the next branch before leaping. The **opposable thumb** allows precise gripping and object manipulation that no other mammal group can quite match. Large brains allowed for better learning and more flexible responses to complex, ever-changing environments. Primates are, above all else, **arboreal** animals, animals shaped by the demands and opportunities of life in the trees.

Over millions of years, primates diversified into many forms. Some grew larger and more social. About 15 to 20 million years ago, the apes appeared, larger, tailless primates with notably bigger brains and more complex behavior. From the ape lineage, several branches eventually diverged. One became gorillas. One became chimpanzees. One became humans. But it is crucial to understand that humans did not descend from chimpanzees. Instead, humans and chimpanzees share a **common ancestor**, a primate that lived about 6 to 7 million years ago, whose descendants eventually split into two separate lineages that evolved in very different directions.

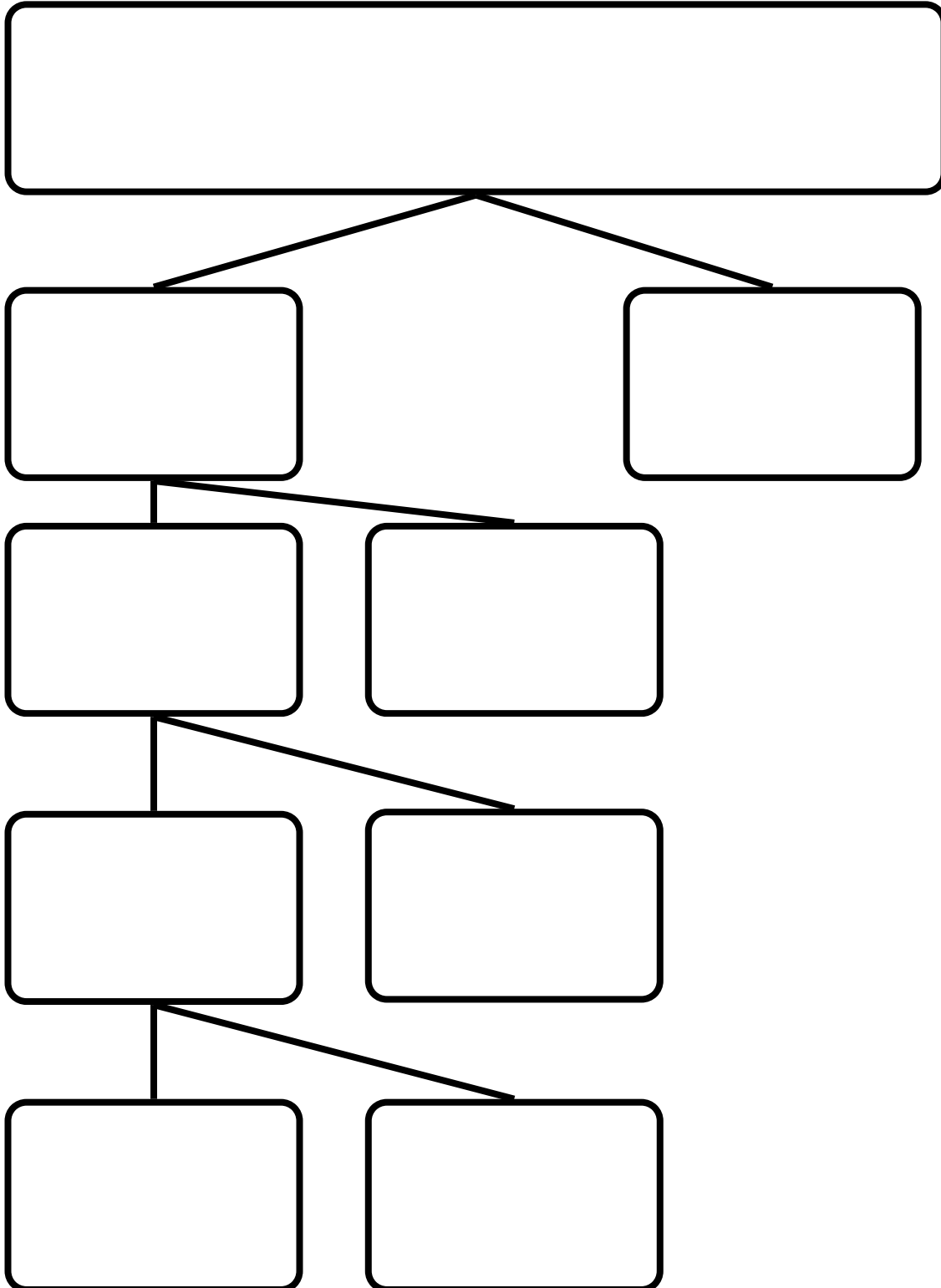
Understanding our primate heritage is not about diminishment. It is about connection. The opposable thumbs that let you hold a pencil, the forward-facing eyes that let you read these words, the large and curious brain that wonders about the world, these are primate gifts, refined over millions of years of **evolution**, shaped by the demands of a life in the trees long before anyone walked on the ground.

# Primate Development [The Miocene Epoch] 15 Million Years Ago

Draw several Miocene primates in the trees. Make sure to show their grasping hands, forward-facing eyes, and one coming down to the ground on two legs.

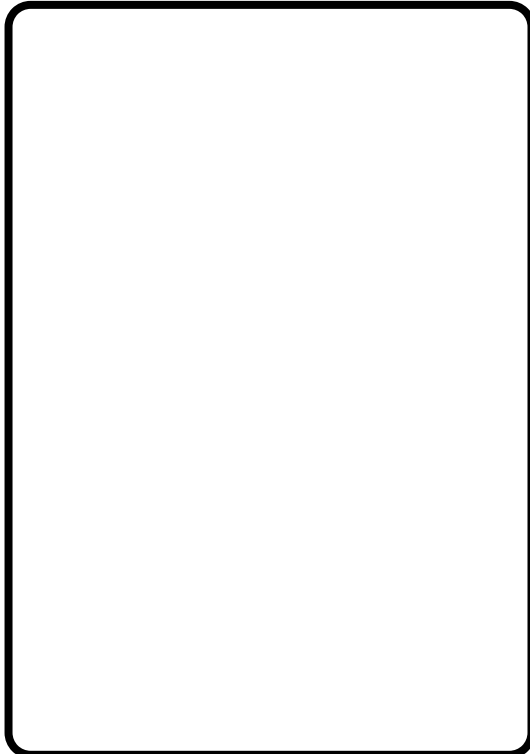
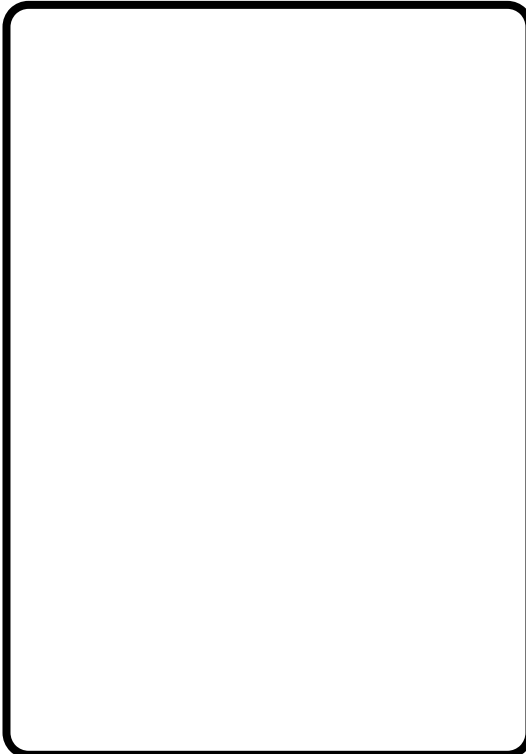
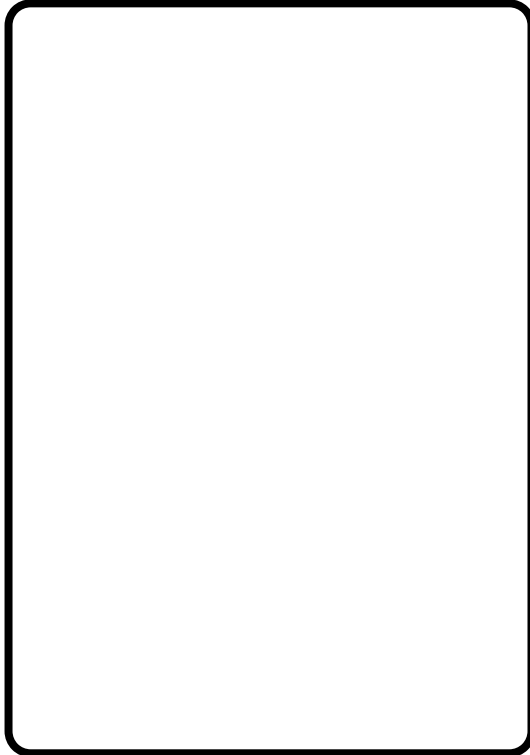
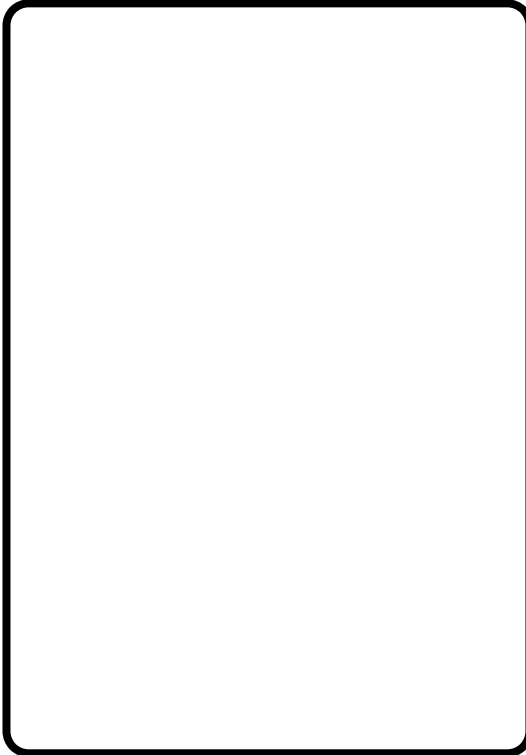
# Lesson 28: Primates

Create a chart of primate development



# Lesson 28: Primates

What are 4 traits that most primates have?



# Lesson 28: Primates

## Because / But / So

Complete each sentence using the connector word shown.

Humans and chimpanzees share a common ancestor **because**

\_\_\_\_\_

Humans and chimpanzees share a common ancestor, **but**

\_\_\_\_\_

Humans and chimpanzees share a common ancestor, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

Early primates lived in trees **because** \_\_\_\_\_.

**Although** \_\_\_\_\_, they share a common ancestor from only 6 to 7 million years ago.

**Since** \_\_\_\_\_, they have been able to judge distances with great accuracy.

## Think and Write

1. Explain how living in trees led to the specific traits that primates have today. Choose two traits and trace each one back to its arboreal origin. Be specific.

# Lesson 29: What Makes Human

What makes you human? You walk upright on two legs, your hands completely free. You have a brain large enough to imagine things that do not exist, to remember the distant past, and to plan for a future you cannot see. You can speak, read, reason, create, and grieve. These traits feel ordinary only because they are all you have ever known, but in the context of life's 3.5-billion-year history, they are extraordinary, built up slowly over millions of years of evolution.

The lineage called **hominins**, which includes modern humans, our direct ancestors, and our closest evolutionary relatives, split from the lineage leading to chimpanzees about 6 to 7 million years ago. One of the very first changes was **bipedalism**, which means walking fully upright on two legs. The early hominin genus **Australopithecus**, which lived in Africa 2 to 4 million years ago, was already walking with a fully upright stride, leaving recognizably human-shaped footprints in volcanic ash. Walking on two legs freed the hands completely, and free hands could do something no other animal had done before: make things deliberately and with precision.

As the hominin **brain** grew larger over many generations, those hands made more and more sophisticated **tools**. And about 2 to 3 million years ago, the genus **Homo** appeared, the group that includes our own species, **Homo sapiens**. Early Homo species were already making stone tools, cooperating in groups, and ranging across Africa in search of food. They were not the strongest or the fastest animals in their world. They were not particularly large. But they were, increasingly, the cleverest, and that, in the end, would make all the difference.

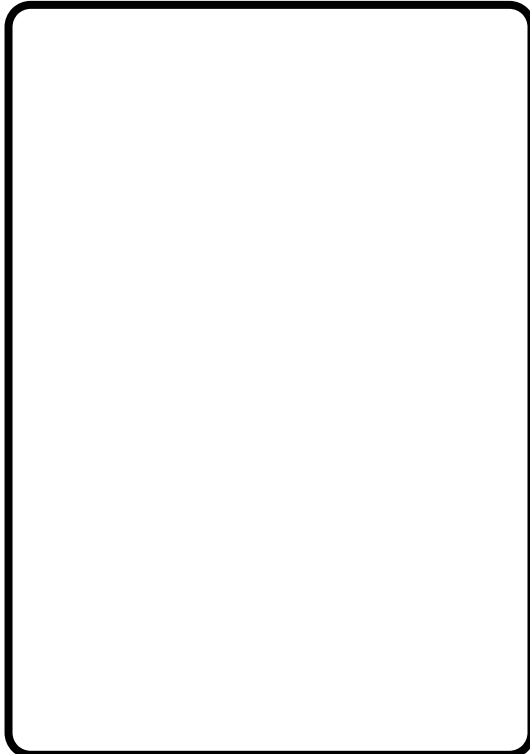
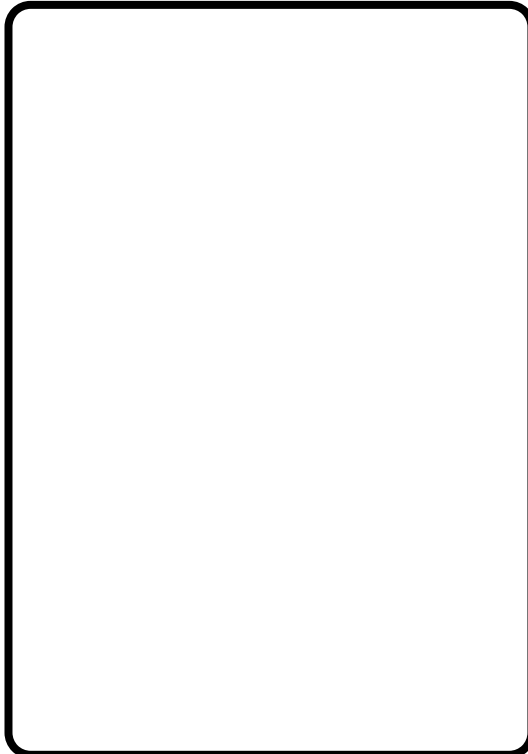
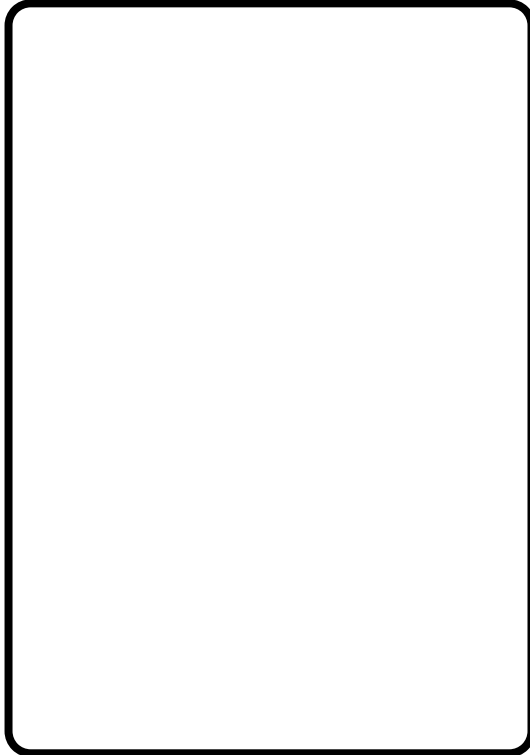
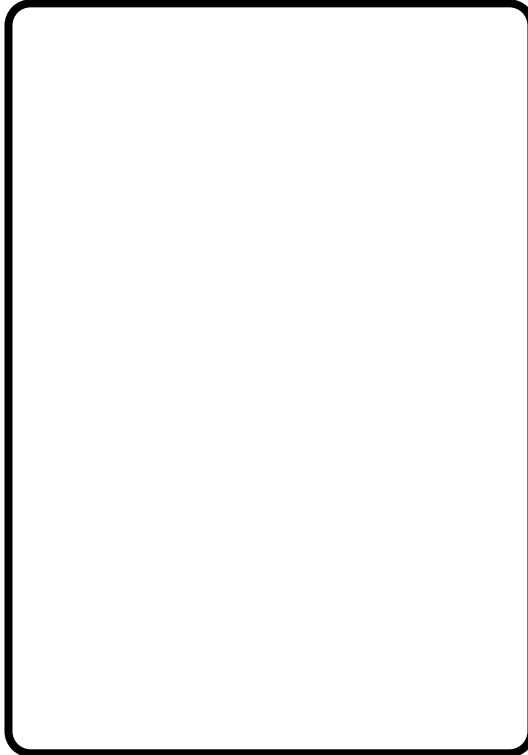
The human lineage is not a story of one dramatic leap. It is a story of gradual accumulation, one trait building on another, one generation passing something on to the next, the biological and the cultural intertwining over millions of years into something that had never existed before in the history of life.

# Walking Upright [The Pliocene Epoch] 4 Million Years Ago

Draw Australopithecus, like Lucy, walking upright across an African savanna.

# Lesson 29: What Makes Human

What are 4 characteristics that make humans...human?



# Lesson 29: What Makes Human

## Because / But / So

Complete each sentence using the connector word shown.

Bipedalism freed the hands of early hominins completely **because**

\_\_\_\_\_

Bipedalism freed the hands of early hominins completely, **but**

\_\_\_\_\_

Bipedalism freed the hands of early hominins completely, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun.

Australopithecus, \_\_\_\_\_, was already walking fully upright 2 to 4 million years ago.

Homo sapiens, \_\_\_\_\_, is the scientific name for modern humans.

Bipedalism, \_\_\_\_\_, was one of the earliest and most important hominin adaptations.

undefined, \_\_\_\_\_, undefined

## Think and Write

1. How did walking upright lead to the development of tools, and how did tools connect to a larger brain? Trace the whole chain of cause and effect.

# Lesson 30: Tools and Fire

Pick up a rock. Pick up another. Strike them together at just the right angle and a sharp-edged flake chips off. You have just made a **stone tool**, a simple one, called an Oldowan tool, the kind our ancestors were crafting nearly 3 million years ago. It does not look like much. But that sharp edge could slice meat from a carcass, scrape fat from a hide, or dig roots from the earth. In a world where getting enough food was everything, a sharp edge was the difference between thriving and starving.

Over hundreds of thousands of years, stone tools became more sophisticated. The species **Homo erectus**, which appeared about 2 million years ago and spread across Africa and into Asia, made hand axes shaped on both sides with careful, deliberate craft, objects that required planning, patience, and a mental image of the finished tool before the first strike. These were not reflexes. They were ideas made physical. And Homo erectus did something even more transformative: it learned to control **fire**.

**Fire** reshaped everything. It kept the darkness away and predators at bay. It provided warmth in environments that would otherwise have been too cold to survive. But most transformingly, it enabled **cooking**. Cooking breaks down food, softening tough fibers, killing parasites, and releasing calories locked in raw starch, making food easier to digest and dramatically more nutritious. Some scientists believe that cooking is one of the reasons the hominin brain grew so large: the body could extract so much more energy from food that more of that energy could be devoted to maintaining the brain's extraordinary metabolic demands.

But tools and fire were more than practical inventions. They were the beginning of **culture**, the practices, knowledge, stories, and techniques that humans pass from one generation to the next, not through DNA but through teaching and imitation. Around campfires, early humans shared food, tended the sick, taught skills, and told stories. Every piece of knowledge that has ever been passed down, every technique, every story, every song, began in exactly this way: one human showing another, in the glow of a shared fire.

# The First Stone Tools (Paleolithic Era) 2.6 Million Years Ago

Draw an early Homo habilis kneeling in East Africa, striking a river stone against a cobble to chip off a sharp Oldowan flake tool, with a small fire glowing nearby.

# Lesson 30: Tools and Fire

How did each of these tools help early humans survive?

Choppers



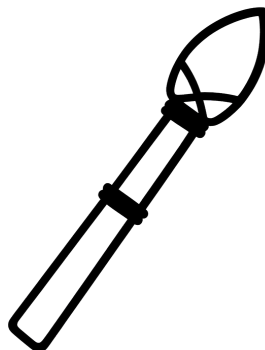
Gary Todd from Xinzheng, China, CC0, via Wikimedia Commons

Scrappers



The Portable Antiquities Scheme/ The Trustees of the British Museum, CC BY-SA 2.0  
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Spears



# Lesson 30: Tools and Fire

## Vocabulary: Match the Term

Write the matching letter on the blank next to each term.

- |                 |  |
|-----------------|--|
| 1. stone tool   | A. Using heat to prepare food; made food easier to digest and may have supported brain growth  |
| 2. Homo erectus | B. The practices, knowledge, and traditions shared and passed down within a group              |
| 3. fire         | C. Humans' control of rapid combustion; a turning point that enabled cooking and warmth        |
| 4. cooking      | D. An object shaped from stone for use; among the earliest evidence of human intelligence      |
| 5. culture      | E. An extinct human species from about 2 million to 100,000 years ago; used fire and hand axes |

## Because / But / So

Complete each sentence using the connector word shown.

Fire was one of the most important discoveries in human history **because**

---

Fire was one of the most important discoveries in human history, **but**

---

Fire was one of the most important discoveries in human history, **so**

---

### Subordinating Conjunctions

Complete each sentence using the conjunction shown.

Cooked food releases more calories and is easier to digest **because**

\_\_\_\_\_.

**Although** \_\_\_\_\_, making them required real planning and skill.

**Since** \_\_\_\_\_, fire has been connected to storytelling, teaching, and community.

# Lesson 31: Human Migration

*Homo sapiens*, our species, first appeared in Africa about 300,000 years ago. For a very long time, our ancestors lived there, learning the land, developing tools, language, and culture. Then, beginning somewhere between 60,000 and 80,000 years ago, small groups of people began to move. Not with a plan, not all at once, just bands of people following animals, following rivers, following the horizon, and generation by generation, over tens of thousands of years, those movements carried **Homo sapiens** to every corner of the Earth.

This was the great human **migration**, and it is one of the most extraordinary journeys in the history of life. What makes it even more remarkable is where humans went. Each new region was a completely different **biome**, a distinct type of environment defined by its climate, plants, and animals. Our ancestors moved from the tropical grasslands and forests of Africa into the scrublands of the Middle East, the temperate forests of Europe, the vast taiga of Siberia, the scorching deserts of Central Asia, and the tropical rainforests of Southeast Asia. Every biome required new knowledge, new clothing, new tools, and new strategies for finding food and staying alive. No other animal has ever colonized so many different biomes so quickly.

They reached Australia more than 50,000 years ago, a journey that required boats and represents one of the most impressive achievements of early human technology. They moved north into Siberia, adapting to the tundra biome with its brutal cold, treeless plains, and frozen ground. And when sea levels dropped during the last Ice Age and exposed **Beringia**, the land bridge between Asia and North America, some crossed into the Americas. Scientists long thought this was the only route into the Americas, but new evidence suggests people may have arrived even earlier, perhaps traveling by boat along the Pacific coast. How exactly the first Americans got there is still one of archaeology's most exciting open questions. From Arctic tundra to tropical rainforest, from open grassland to dense temperate woodland, humans found a way to survive everywhere.

How do we know this happened? **Cultural adaptation** left traces everywhere, tools, hearths, art, and eventually settlements marking the path of human presence across continents and millennia. Climate changes drove much of the movement, as glaciers advanced and retreated, sea levels rose and fell, and available land changed. And scientists can trace the genetic heritage of populations across the world back to African origins, reading migration routes in the code of our DNA. Every human alive today carries in their genome the record of this ancient journey.

No matter where in the world your family comes from, you descend from those first African migrants. Every person alive today is part of one human family, remarkably closely related for a species spread across an entire planet. The diversity of human cultures, languages, and peoples is real and worth celebrating. But the deeper connection is older and more profound: we all share the same ancestors, the same long road out of Africa, the same story.

# Humans Spread Across the Globe 60,000 Years Ago

Draw a small band of Homo sapiens walking along a coastline at sunset, with a world map faintly sketched behind them showing their route out of Africa.

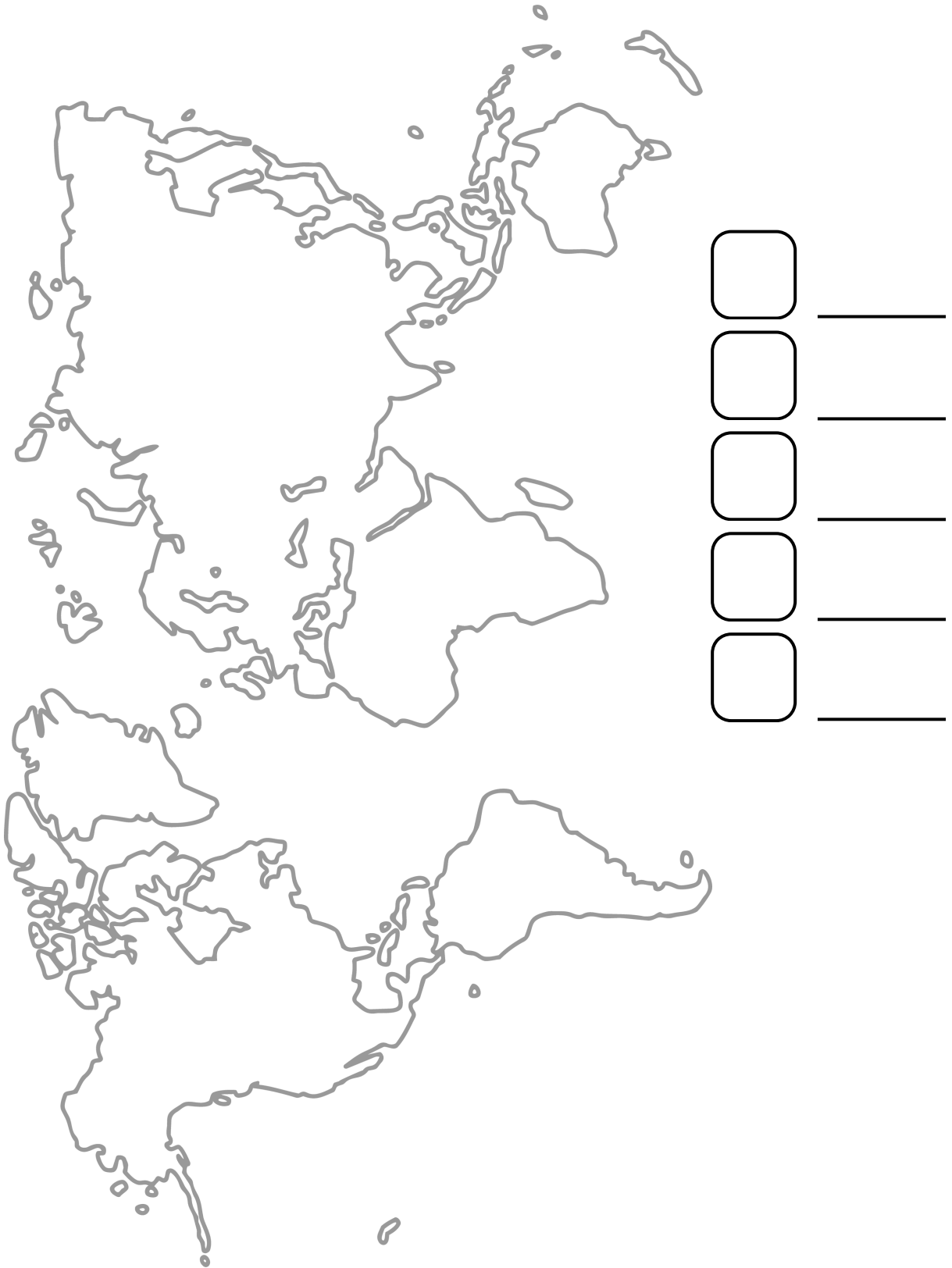
# Lesson 31: Human Migration

Draw the paths human took to migrate out of Africa and into the rest of the world. Label approximately how long ago this happened.



# Lesson 31: Biomes of the World

Label the different major biomes of the world and create a key.



# Lesson 31: Human Migration

## Because / But / So

Complete each sentence using the connector word shown.

Homo sapiens began in Africa and spread across the entire globe **because**

\_\_\_\_\_

Homo sapiens began in Africa and spread across the entire globe, **but**

\_\_\_\_\_

Homo sapiens began in Africa and spread across the entire globe, **so**

\_\_\_\_\_

## Appositives

Fill in the blank with an appositive that describes the noun.

Genetics, \_\_\_\_\_, allows scientists to trace human migration routes through DNA.

Indigenous peoples, \_\_\_\_\_, carry some of the deepest knowledge of the human past that exists.

The land bridge between Asia and the Americas, \_\_\_\_\_, was exposed when sea levels dropped during the last Ice Age.

## Think and Write

1. How do scientists know where and when humans migrated? Describe at least two different types of evidence they use and explain what each one tells us.

# Lesson 32: Before History

History begins with writing. Everything before writing is called **prehistory**, the vast, deep time before anyone left a written record. But do not mistake the absence of writing for the absence of richness. For tens of thousands of years before the first mark was pressed into clay, human beings were living full and complex lives: building communities, raising children, developing language, creating art, caring for the sick and the old, telling stories around fires, and finding meaning in the world around them. They left no words. But they left other things.

For most of human existence, people lived as **hunter-gatherers**, moving through the landscape with the seasons, following herds, gathering plants, fishing rivers, reading weather and terrain with an intimacy that most of us have lost entirely. This was not a simple or primitive life. It required encyclopedic knowledge of hundreds of plants, animals, seasons, and landscapes, passed carefully from one generation to the next through story and practice. Hunter-gatherer peoples had rich languages, complex social structures, ceremonies, art, and relationships with the land that took thousands of years to develop.

About 20,000 years ago, humans created some of the most breathtaking art ever made. Deep inside caves in France and Spain, Lascaux, Chauvet, Altamira, they painted horses, mammoths, bison, lions, and handprints by lamplight. These images are so vivid, so alive, so full of careful observation that they still move people who see them today. This **cave art** is not the work of primitive minds. It is the work of fully modern human intelligence, exercising imagination and craft thousands of years before civilization began.

Then, about 12,000 years ago, something changed. In several places around the world, independently of each other, people began growing their own food, planting seeds, tending animals, staying in one place. This was the birth of **agriculture**, and it changed human life more than any invention before it. Permanent **settlements** grew. Populations increased. People could specialize, some farming, some building, some making pottery or weaving cloth. Villages became towns. Knowledge could accumulate. And eventually, in a few of those settlements, someone pressed a mark into clay, and writing was born. The long extraordinary story of life on Earth had finally produced a creature that could write it down.

# Cave Paintings & the First Storytellers

## The Upper Paleolithic: 40,000 Years Ago

Draw the walls of a cave covered in handprints and painted animals: bison, horses, and mammoths outlined in red and black ochre by firelight, with a human hand silhouette pressed against the stone.

# Lesson 32: Before History

Trace your hand on the paper and then write what you think it could represent.

# Lesson 32: Before History

## Because / But / So

Complete each sentence using the connector word shown.

Agriculture changed human life completely **because**

\_\_\_\_\_

Agriculture changed human life completely, **but**

\_\_\_\_\_

Agriculture changed human life completely, **so**

\_\_\_\_\_

## Subordinating Conjunctions

Complete each sentence using the conjunction shown.

**Although** \_\_\_\_\_, they led rich, complex, and deeply knowledgeable lives.

**When** \_\_\_\_\_, villages grew, populations increased, and specialization became possible.

**Since** \_\_\_\_\_, they tell us that fully modern human minds existed long before written history.

## Think and Write

1. Why should we not think of hunter-gatherer life as 'primitive'? Use at least three specific pieces of evidence from the reading to make your case.

# Creature Trading Card — Instructions

Assign a creature from your current lesson or let kids choose one they find interesting. Complete each section using research, then color and draw! After they fill out the card they can cut it out and fold it on the dotted line. To add stability, they can tape it together or glue it. Once you have several cards, sort them by size, habitat, or diet. Cards from the same time period make a great mini ecosystem display!

## Card Section Guide

**Creature Name & Scientific Name:** Write the common name on the top line and the scientific name on the second line. If you don't know the scientific name, leave it blank or look it up! Optionally, take the time to look up what the names mean.

**Drawing:** Sketch your creature in the box. Try to show its real shape.  
Does it have legs, armor, fins, or tentacles?

**Size:** Fill in the circles from the center out, stopping when you reach your creature's size:

Ring 1 (center only): Microscopic: too tiny to see without a microscope

Ring 2: Tiny: insect or small bug sized

Ring 3: Small: fits in your hand (frog, small fish)

Ring 4: Medium: cat to dog sized

Ring 5: Large: human to bear sized

Ring 6 (all rings filled): Mega: elephant, mammoth, T. rex sized

**Time Period:** When did the creature live?

**Diet:** Circle one: Herbivore (plants only) | Carnivore (animals only) | Omnivore (both).

**Fun Fact:** Write one interesting fact. Examples: "Trilobites had the first compound eyes." or "Anomalocaris could grow up to 3 feet long!"

**Classification:** Circle one option only: If your creature has a backbone, circle its class under VERTEBRATE (Fish, Amphibian, Reptile, Bird, or Mammal).

If it has no backbone, circle its phylum under INVERTEBRATE.

Not sure which phylum? Here's a quick guide:

Arthropoda = insects, spiders, crabs, trilobites

Mollusca = snails, clams, squid, ammonites

Annelida = worms

Echinodermata = starfish, sea urchins

Cnidaria = jellyfish, corals

Porifera = sponges

Note: For single-celled creatures like bacteria, write it in the "other" section in the classification section, they existed long before vertebrates or invertebrates!

**Background Color:** Lightly shade the background of the whole card to show where your creature lived:

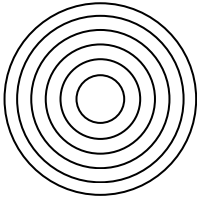
Dark blue = deep ocean

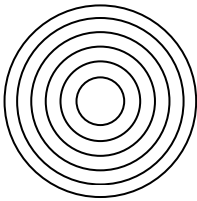
Light blue = freshwater or shallow sea

Green = land

Brown = underground

White/unshaded = sky or air

<p style="text-align: center;">Common Name</p> <hr style="border: 0; border-top: 1px solid black; margin: 10px 0;"/> <p style="text-align: center;">Scientific Name</p> <hr style="border: 0; border-top: 1px solid black; margin: 10px 0;"/> <div style="border: 1px solid black; border-radius: 15px; height: 200px; margin: 10px 0; display: flex; align-items: center; justify-content: center;"> <p style="margin: 0;">Drawing</p> </div>	<p style="text-align: center;"><b>SIZE</b></p> <div style="text-align: center; margin-bottom: 20px;">  </div> <p style="text-align: right;">Time Period _____</p> <p style="text-align: center;"><b>DIET</b></p> <p style="text-align: right;">Herbivore Carnivore Omnivore</p> <div style="border: 1px solid black; border-radius: 15px; padding: 10px; text-align: center; margin: 10px 0;"> <p>Fun Fact</p> </div> <p style="text-align: center;"><b>CLASSIFICATION</b></p> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; vertical-align: top;"><i>VERTEBRATE</i></td> <td style="width: 50%; vertical-align: top;"><i>INVERTEBRATE</i></td> </tr> <tr> <td style="text-align: center;">Fish</td> <td style="text-align: center;">Arthropoda</td> </tr> <tr> <td style="text-align: center;">Amphibian</td> <td style="text-align: center;">Mollusca</td> </tr> <tr> <td style="text-align: center;">Reptile</td> <td style="text-align: center;">Annelida</td> </tr> <tr> <td style="text-align: center;">Bird</td> <td style="text-align: center;">Echinodermata</td> </tr> <tr> <td style="text-align: center;">Mammal</td> <td style="text-align: center;">Cnidaria</td> </tr> <tr> <td></td> <td style="text-align: center;">Porifera</td> </tr> </table> <p style="text-align: right;">Other: _____</p>	<i>VERTEBRATE</i>	<i>INVERTEBRATE</i>	Fish	Arthropoda	Amphibian	Mollusca	Reptile	Annelida	Bird	Echinodermata	Mammal	Cnidaria		Porifera
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# Stardust to Storytellers

## References

APA Format, 7th Edition

The following sources informed the scientific content of this curriculum. Reading passages were written in original language for educational use; this reference list documents the primary and secondary sources consulted for accuracy of facts, dates, and scientific consensus.

### Books

---

#### Cosmology, Earth Science & Deep History

Bryson, B. (2003). *A short history of nearly everything*. Broadway Books.

Hazen, R. M. (2012). *The story of Earth: The first 4.5 billion years, from stardust to living planet*. Viking.

Knoll, A. H. (2021). *A brief history of Earth: Four billion years in eight chapters*. Custom House.

#### Life, Evolution & Paleontology

Lane, N. (2015). *The vital question: Energy, evolution, and the origins of complex life*. W. W. Norton.

Prothero, D. R. (2015). *The story of life in 25 fossils: Tales of intrepid fossil hunters and the wonders of evolution*. Columbia University Press.

Ward, P., & Kirschvink, J. (2015). *A new history of life: The radical new discoveries about the origins and evolution of life on Earth*. Bloomsbury Press.

#### Dinosaurs, Mammals & the Cenozoic

Brusatte, S. (2018). *The rise and fall of the dinosaurs: A new history of a lost world*. William Morrow.

MacLeod, N. (2013). *The great extinctions: What causes them and how they shape life*. Firefly Books.

Switek, B. (2010). *Written in stone: Evolution, the fossil record, and our place in nature*. Bellevue Literary Press.

#### Human Origins, Migration & Prehistory

DeSilva, J. (2021). *First steps: How upright walking made us human*. Harper.

Harari, Y. N. (2015). *Sapiens: A brief history of humankind*. Harper.

Wrangham, R. (2009). *Catching fire: How cooking made us human*. Basic Books.

### Websites & Online Resources

---

#### NASA & Space Science

NASA. (n.d.). *Big Bang*. NASA Science. <https://science.nasa.gov/universe/overview/>

NASA. (n.d.). *WMAP — Cosmic microwave background radiation*. NASA Science. <https://science.nasa.gov/mission/wmap/>

NASA. (n.d.). *Our solar system*. NASA Solar System Exploration. <https://solarsystem.nasa.gov/solar-system/our-solar-system/overview/>

### Smithsonian Institution

Smithsonian National Museum of Natural History. (n.d.). *What does it mean to be human?* <https://humanorigins.si.edu/>

Smithsonian National Museum of Natural History. (n.d.). *Introduction to human evolution*. <https://humanorigins.si.edu/education/introduction-human-evolution>

### Museums & Educational Institutions

University of California Museum of Paleontology. (n.d.). *The Cambrian period*. <https://ucmp.berkeley.edu/cambrian/cambrian.php>

University of California Museum of Paleontology. (n.d.). *Introduction to the Eukaryota*. <https://ucmp.berkeley.edu/allife/eukaryota.html>

### Science Communication & Reference

Khan Academy. (n.d.). *Cosmology and astronomy*. <https://www.khanacademy.org/science/cosmology-and-astronomy/>

National Geographic Society. (n.d.). *Permian extinction*. <https://www.nationalgeographic.com/science/article/permian-extinction>

PBS Eons. (n.d.). *PBS Eons* [YouTube channel]. <https://www.youtube.com/@eons>

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