

Educator's Guide



The Zula Patrol[®]
**DOWN TO
EARTH**

www.zula.com

Dear Educator,

As a scientist, I am keenly aware of the critical void in early science literacy throughout the United States. A recent report of The New Commission on the Skills of the American Workforce stated that “high-quality early childhood education is one of the best investments ... in (our) young people” – and science is a key component.

The fulldome show *The Zula Patrol*®: Down to Earth and accompanying Educator’s Guide were created to help fill that critical void. Zula addresses the national call for science literacy education by targeting preschool and early elementary students. Research shows that these are the most effective and age-appropriate developmental stages for introducing basic science concepts. By reaching the receptive preschool and early elementary age groups, *The Zula Patrol*®: Down to Earth show and Educator’s Guide provide a foundation for developing critical thinking skills – skills that are necessary for life-long success!

This Educator’s Guide is comprised of standards-driven, inquiry-based science, math, and language arts activities and lesson plans for students in preschool through third grade.

I hope that you find *The Zula Patrol*®: Down to Earth fulldome show and Educator’s Guide compelling and beneficial in your efforts to help address the need for early science education with your students. Together we can provide our young children with the skills necessary to compete in a global economy and help this great nation of ours regain the leading position in science literacy that it once had!

Sincerely,



Deborah M. Manchester, Ph.D.
CEO, Zula International

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How to Use This Guide

Within the Educator's Guide, you'll find the Mission Wheel highlighting the current stage in the mission and identifying the instructional strategies to be employed during that stage. There are five stages to the Educator's Guide.

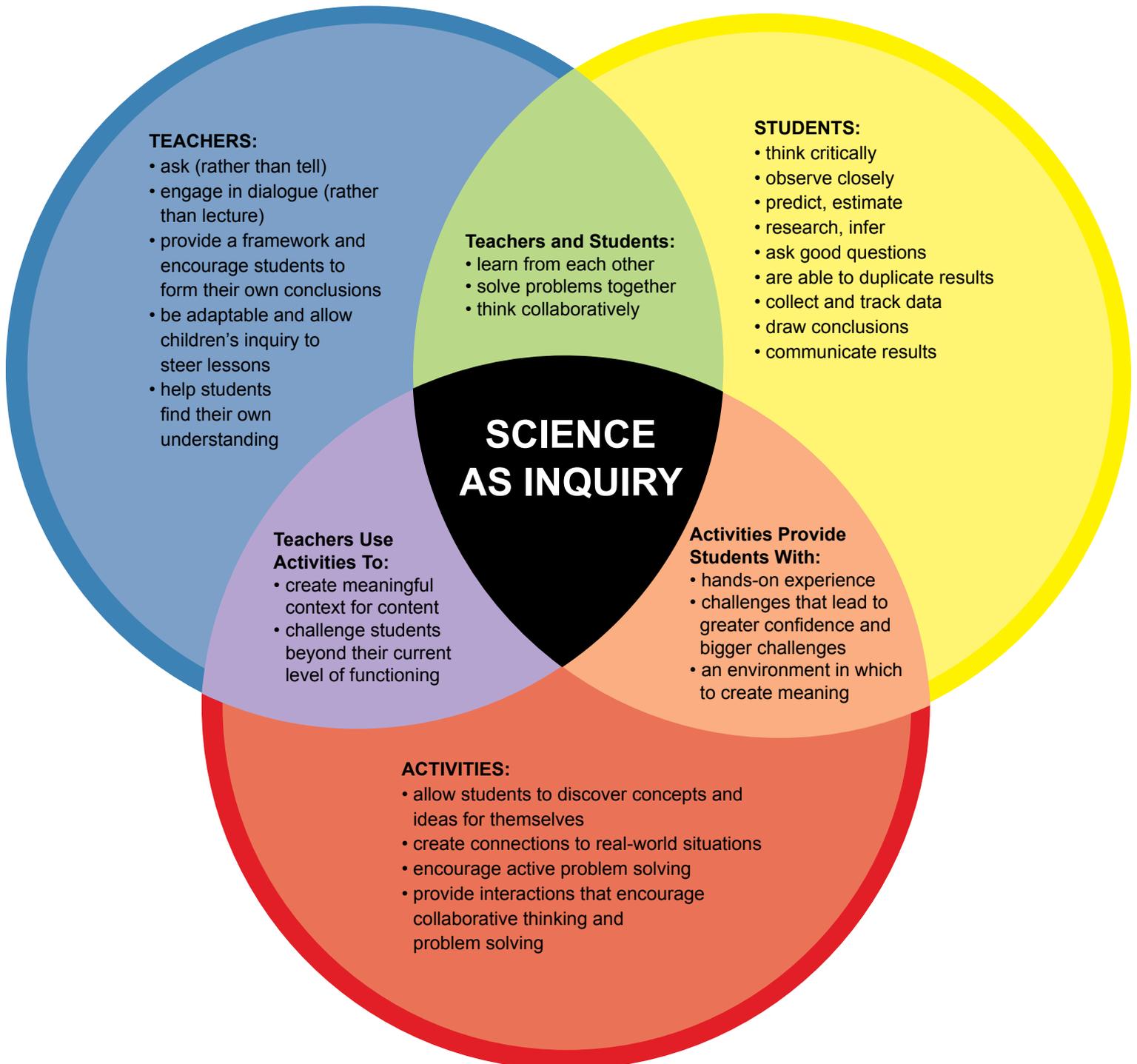
- **MISSION IGNITION** activities can be done prior to viewing the fulldome show, *The Zula Patrol*®: Down to Earth. These activities are designed to stimulate curiosity and introduce some of the topics that will be presented, and are accompanied by Student Sheets and journaling opportunities (identified by an icon).
- **CREW BRIEFING** exposes children to the topic with the fulldome show itself. We also recommend reading a related book of your choice as a way of deepening your students' understanding of the topic.
- **MISSION BLASTOFF** activities are designed to be completed after viewing *The Zula Patrol*®: Down to Earth. These activities allow students to further explore the topics covered in the fulldome show, and are accompanied by Student Sheets and journaling opportunities.
- **MISSION SPIN-OFFS** are cross-curricular activities created to extend your students' learning to other subject areas. Each subject area is identified with an icon.
- **MISSION ACCOMPLISHED** provides opportunities to gauge student progress through the use of class charts, journals, and other materials.

About Student Learning

Questioning and exploration are second nature to students of this age, but they need guidance to develop communication, science process, and critical thinking skills, as well as encouragement to deepen their desire to continue exploring science. With the help and support of Zula, students and teachers can discover together the fun and wonder of science and math.



SCIENCE AS INQUIRY



MISSION:

Down to Earth



FULLDOME SHOW:

Down to Earth: While on a routine fossil-hunting expedition, *The Zula Patrol*® turns up evidence that the villainous Deliria Delight has been traveling back in time to Earth's prehistoric past to illegally dump her company's toxic trash. The Zula Patrollers must find and catch her, before her actions cause catastrophic consequences. In the process, our heroes learn all about the formation and development of Earth, and the life forms who call it home.



MISSION GOALS AND OBJECTIVES:

FUNDamental Goal: Students will dig up facts about fossils, throw down space rocks, and float a continent!

Big Idea: Earth is constantly changing over time.

Students will:

- create timelines of their lives and Earth's history
- explore how different fossils are formed
- discover the process of planet formation
- build models representing Earth's layers and features



NATIONAL SCIENCE EDUCATION STANDARDS:

Science as Inquiry: understanding about scientific inquiry

Physical Science: properties of objects and materials, position and motion of objects

Life Science: the characteristics of organisms, life cycles of organisms, organisms and environments

Earth and Space Science: properties of earth materials, objects in the sky, changes in earth and sky

Zula Patrol Mission Map Page

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Standards for the English Language Arts

- Students apply a wide range of strategies to comprehend [and] interpret ... texts.
- Students employ a wide range of strategies as they write.
- Students conduct research ... by generating ideas and questions, and by posing problems.



National Council of Teachers of Mathematics, Curriculum Focal Points

Numbers and Operations:

- PreK-K – Count with understanding and recognize “how many” in sets of objects
- K-Grade 1 – Connect number words and numerals to the quantities they represent, using various physical models and representations
- Grade 2 – Use multiple models to develop initial understandings of place value and the base-ten number system
- Grade 3 – Understand the place-value structure of the base-ten number system and be able to represent and compare whole numbers and decimals

Algebra:

- PreK-K – Sort, classify, and order objects by size, number, and other properties
- PreK-K – Describe qualitative change, such as a student's growing taller
- Grades 1-2 – Describe quantitative change, such as a student's growing two inches in one year
- Grade 3 – Describe, extend, and make generalizations about geometric and numeric patterns

Science and Technology: understanding about science and technology, abilities to distinguish between natural objects and objects made by humans

Science in Personal and Social Perspectives: characteristics and changes in populations, types of resources, changes in environments

History and Nature of Science: science as a human endeavor



Geometry:

- PreK-K – Describe, name, and interpret relative positions in space and apply ideas about relative position
- PreK-2 – Describe, name, and interpret direction and distance in navigating space and apply ideas about direction and distance
- PreK-K – Find and name locations with simple relationships such as “near to” and in coordinate systems such as maps
- Grade 1 – Investigate and predict the results of putting together and taking apart two- and three-dimensional shapes
- Grade 1 – Recognize and represent shapes from different perspectives
- Grade 3 – Investigate, describe, and reason about the results of subdividing, combining, and transforming shapes

Measurement:

- PreK-2 – Recognize the attributes of length, volume, weight, area, and time
- PreK-K – Compare and order objects according to these attributes
- Grade 3 – Select and apply appropriate standard units and tools to measure length, area, volume, weight, time, temperature, and the size of angles





Mission Sessions

This mission can be divided into several shorter sessions of exploring, discussing, reading, viewing, and experimenting. Sessions are intended to last approximately 20 minutes and are designed for playful exploration with active sharing of ideas and discoveries. They can be combined for longer instruction times. Mission Ignition activities may be done in the weeks leading up to your visit; Mission Blastoff activities after.

Mission Ignition:

- Journal It!
- Chart It!
- Relatively Speaking...
- It's Absolutely You
- Fossil Formation
- Traces of Life
- Lay It Down
- Dig It Up!

Crew Briefing

Mission Blastoff:

- Which Came First?
- When Did *That* Happen?
- Static Makes It Stick
- Crashing to Earth
- Layer Upon Layer
- Drifting Apart
- Puzzle It Out

Mission Accomplished



Recommended Reading

If You Find a Rock by Peggy Christian and Barbara Hirsch Lember

Fossils Tell of Long Ago by Aiki

Dino IQ (Smart Kids) by Roger Priddy

Life on Earth: The Story of Evolution by Steve Jenkins

Harmony Children's Edition: A Vision for Our Future by HRH The Prince of Wales

UNIFYING CONCEPTS:

Systems, Order, and Organization:

- Students will order and organize events from Earth's history and their own lives, creating systems to keep track of large time scales.

Evidence, Models, and Explanation:

- Students will view evidence of a changing Earth, create models of rock strata and planets, and theorize about how and why Earth continues to change.

Change, Constancy, and Measurement:

- Students will measure change over time by creating timelines of Earth's history and experimenting with plate tectonics.

Evolution and Equilibrium:

- Students will observe that living things can change form over time.

Form and Function:

- Students will create models of Earth and its geologic processes.

TEACHER-PROVIDED MATERIALS:*

- Chart paper
- Markers, crayons, paper, and scissors
- Sponges, trays or pie pans, and dental floss
- Clay or salt dough
- Sand, flour, salt, and cocoa
- Balloons
- Corn syrup, vegetable oil, or dish soap
- Reading selection (*see Recommended Reading*)

* Materials can be purchased at Zula.com or by calling Toll Free: (877) 328-9414 Ext. 27

LESSON PREPARATION:

- Prepare class charts:
 - Chart title: What We Know About the Changing Earth
 - Chart title: What We NOW Know About the Changing Earth
- Prepare saturated solution
- Prepare salt dough (if required)
- Invite students to bring in yogurt cups and fossil-digging tools

MISSION VOCABULARY

A Starter List:

- Dinosaur
- Earth
- Land
- Layer
- Ocean
- Rock
- Solar System
- Space
- Timeline

Science Words:

- **Continent** – one of Earth's gigantic landmasses
- **Core** – the innermost layer of Earth, made up of a solid inner core and liquid outer core
- **Crater** – a pit or hole in a surface; can be caused by impacts of meteors or other objects, or by volcanoes
- **Crust** – Earth's outermost solid layer, making up Earth's land surfaces and ocean floors
- **Erosion** – when water or wind carries away the loose surface materials created by weathering; can happen quickly or over hundreds, thousands, or millions of years
- **Fossil** – the preserved remains or evidence of a living thing – such as a plant or animal – that lived on Earth long ago
- **Magma** – molten rock inside a volcano or underground
- **Mantle** – the middle layers of Earth's interior, between the crust and the core
- **Mineral** – a nonliving, naturally occurring substance with a crystalline structure; minerals can be identified by their color, hardness, and luster
- **Molten** – melted by heat
- **Sediment** – a natural material that has been broken down and may be moved by wind, water, or gravity
- **Strata** – layers in a rock formation
- **Tectonic plates** – the top layer of Earth's interior is broken up into pieces that fit together like a jigsaw puzzle; these pieces are called *tectonic plates*

MISSION VOCABULARY

Preparing for the Future:

- **Accretion** – the process by which small particles come together to form a much larger body
- **Body fossil** – a fossil formed when part or all of an animal or other organism is preserved
- **Core sample** – a cylinder of rock or sediment that allows scientists to observe the layers beneath Earth's surface
- **Dissolve** – in a mixture, when the parts of a solute spread out evenly into the solvent to create a solution
- **Evaporation** – the process of a liquid turning into a gas
- **Lithosphere** – the combined layer of crust and upper mantle that makes up the tectonic plates
- **Pangaea** – the single supercontinent formed when Earth's landmasses came together 250 million years ago; it broke apart to create today's continents
- **Saturated** – when a solvent holds as much of a solute as possible
- **Solute** – the part of a solution that gets dissolved
- **Solution** – a special mixture formed when one or more materials dissolve in another
- **Solvent** – the part of a solution that does the dissolving
- **Trace fossil** – the preserved evidence of an animal's (or other organism's) existence; imprints, tracks, and even fossilized droppings are trace fossils



FICTION VS. FACT!

Fiction: Earth has always been the same as it is today.

Fact: The only thing constant about Earth is that it is always changing! From the time of Earth's formation, it has been going through a series of changes, both in its composition and on its surface. Today, phenomena such as weather, erosion, tectonic activity, and even impacts of rocks from space contribute to changes on Earth.

MISSION IGNITION!

Organization:

- **Journal It!:** Students work individually, share resources
- **Chart It!:** Whole group
- **Gauge Your Age**
 - Relatively Speaking: Individual
 - It's Absolutely You: Individual
- **Fossil Frenzy**
 - Fossil Formation: Space Patrol teams of four students
 - Traces of Life: Whole group and individual
 - Lay It Down: Space Patrol teams of four students
 - Dig It Up!: Space Patrol teams of four students

Materials for Classroom Use:

- Chart paper
- Markers and crayons
- Small objects that can be used as fossils (twigs, leaves, shells, animal toys)

Materials per Space Patrol Team:

For Activity 4A) Fossil Formation:

- 2 sponges, cut in half
- Scissors
- 4 small containers
- 1 container (lid optional) of saturated salt solution
- Marker for labeling

For Activity 4B) Traces of Life:

- Salt dough or clay
- Tools for marking in clay (pencils, toothpicks, etc.)

For Activity 4C) Lay It Down:

- 4 small objects for creating "fossils"
- Salt dough or clay in five different colors
- 1 clear cup

For Activity 4D) Dig It Up!:

- 1 cup with layered fossils (from another team)
- Fossil-digging tools: popsicle sticks, toothbrushes, paint brushes

Materials per Student:

- Blank paper
- Markers or crayons
- 1 small object for creating a "trace fossil"
- Salt dough or clay
- Student Sheet 1: Gauge Your Age
- Student Sheet 2: Fossil Frenzy (2 pages)
- *Zula Science Journal* cover

Preparation:

- Make one copy of the Zula Science Journal cover (front and back, found at the end of this guide) for each student.
- Prepare class chart:
 - Chart title: What We Know About the Changing Earth
- Ask students to bring in old yogurt or cottage cheese cups.
- Ask students to bring in old toothbrushes or small paint brushes.
- For Fossil Formation, prepare a saturated salt solution using the directions below.
- For Traces of Life and Lay It Down, prepare salt dough using the recipe below (*optional*).
- Make one copy of Student Sheet 1 and Student Sheets 2a and 2b for each student.



Teachers: *Mission Ignition activities can be done before viewing Down to Earth. Use these activities to assess students' prior knowledge and experiences. Introduce the new mission.*

Students: *Students share the experiences, ideas, and prior knowledge they bring to this mission. Students will create their own Zula Science Journal, build a timeline of their lives, and discover how fossils are formed and found.*

DIRECTIONS FOR TEACHERS

1) Journal It!

Teacher: Distribute copies of the Zula Science Journal covers (front and back), several sheets of blank paper, and markers or crayons to each student. Explain to your class that scientists record their observations, ideas, and discoveries.

Ask:

- Why do you think scientists use journals?
- What types of things would you like to record in your journal?

Encourage students to decorate the outside of their journals, but to keep the inside blank for now, leaving room to draw, dictate, and write about the observations and discoveries they will make during their mission with *The Zula Patrol*.[®] You may wish to staple their journals, or bind them in some way.

2) Chart It!

Teacher: Prepare the class chart (see Figure 1, write title and date only). Engage your students in an active discussion about how Earth has changed over time and how it continues to change. You may wish to use the following questions as a starting point.

- Chart title: What We Know About the Changing Earth

Ask:

- What do you know about changes on Earth?
- What do you know about Earth's history?
- What do you know about how old Earth is?
- What do you *want* to know about the changing Earth?

Teacher: Record students' responses on the class chart.

Teacher's Note: *This is the time for teachers to begin exploration by encouraging students to share experiences, ideas, and prior knowledge (including misconceptions) they bring to this mission.*

Teacher: Help students compare the changing Earth to other things in their lives that change.

Ask:

- Earth isn't the only thing that's changing. What else can you think of that has changed?
- How has your neighborhood changed? Your school?
- How have your parents changed? Your brothers or sisters? Your dog or cat?
- How have you changed?

The image shows a sample class chart. It is a rectangular piece of paper with a double-line border. At the top, there are two small circles, one on the left and one on the right. The title "What We Know About the Changing Earth" is written in a bold, sans-serif font across the top. Below the title are five horizontal lines for writing. At the bottom right corner, there is a label "Today's Date" with a line next to it for writing the date.

Figure 1, Example, class chart



JOURNALING OPPORTUNITY:

Encourage students to draw, dictate, or write their ideas about the changing Earth in their *Zula Science Journal*.

Teacher's Note: Throughout the lesson, teachers have the option of recording children's responses and observations on a class chart rather than making individual journal entries.

3) Gauge Your Age

Teacher: Students will discover the value of using timelines to organize information, and will create a frame of reference for understanding the age of Earth.

Teacher's Note: *Student Sheet 1: Gauge Your Age* offers background information both for you and your students' reference.

Part A: Relatively Speaking...

Teacher: Provide each student with a copy of Student Sheet 1: Gauge Your Age. Ask them to number the events listed in Part A from 1 to 8, with 1 being the first thing that happened in their lives and 8 being the most recent, to create a *relative* timeline of their lives. Encourage them to share their timelines with other students. If they are uncertain about the order of some events, they can take a guess at it now, and then take their Student Sheet home to get help from their parents.

Ask:

- Did you start crawling before you started walking?
- Did you eat breakfast *before* or *after* you got dressed this morning?

Teacher: Discuss *relative* timelines with your class. While it is useful to know when an event in history took place, like the formation of Earth or the Moon, or when the first life forms appeared in our oceans, it is not always necessary. Sometimes just knowing the order of events can give scientists the information they need.

Part B: It's Absolutely You

Teacher: Ask students to create an *absolute* timeline of their lives, using the ordered events from Part A. It might be easiest for students to start with number 1, which should be "I was born" for everyone – and work forward from that point. For example, a student who is 6-1/2 years old would place a dot (labeled "1") halfway between 6 years ago and 7 years ago on their timeline. From there, they would count 5 years "up," placing a dot with the corresponding number for "I turned 5 years old" halfway between 1 year ago and 2 years ago. Remind your students that some of the dots may be very close together or overlapping.

Ask:

- How old are you? How many years ago were you born?
- How old were you when you started crawling? Walking?
- How old were you when you started kindergarten?

Teacher: Allow students to share their completed timelines with other students. Students should feel free to add other events to their timelines.



JOURNALING OPPORTUNITY:

Journal prompt:

- Draw, write, or dictate the story of another event in your life that you can add to your timeline. Share the story with some of your fellow students.

4) Fossil Frenzy

Teacher: Some parts of Activity 4) Fossil Frenzy require either clay or salt dough. You may choose to use materials you already have in your classroom, but if you wish to make salt dough, we have included a recipe below. We have also included directions for creating a saturated solution, which will be needed for activity 4A) Fossil Formation.

Teacher's Note: *Student Sheet 2: Fossil Frenzy offers background information both for you and your students' reference.*

Background Information:

Saturated Solutions

A *saturated* solution is one that is "full." This means that the solvent (the water, in this case) has as much solute (the salt, in this case) as it can hold. Adding more solute will not make a saturated solution any more concentrated; the solute will just sit on the bottom of the container or float around in the solution, but it will not dissolve into the solvent.

Making a Saturated Solution

(Kosher, table, sea, or Epsom salt)

Materials for Making a Saturated Solution:

- 2 cups of water
- 1 appropriate heat-proof container (soup pot or glass measuring cup)
- Salt (Kosher, table, sea, or Epsom salt will work)
- 1 spoon
- Heat source (microwave or stovetop)

Directions:

1. Heat 2 cups of water to boiling or near boiling on the stovetop or in the microwave.
2. When the water is hot, add desired salt (kosher or Epsom) a spoonful at a time. Stir to dissolve after each addition.
3. Continue to add salt to the water little by little until no more will dissolve. When salt remains in the bottom of the container and will not become part of the solution no matter how much it is stirred, the solution is saturated.
4. Allow the solution to cool.

Teacher's Note: *Depending on your students and classroom, preparing the saturated solution may be done in class as a collaborative demonstration. Students can help measure the salt into the water and can make predictions about how much salt will be needed to saturate the solution. SAFETY FIRST! Remind students to take care around hot water and to keep away from heat sources.*

Salt Dough Recipe

1 cup warm water	2 cups flour
1 cup salt	1/2 cup dry tempera paint

Mix the salt, flour, and dry tempera paint together. Add about half the water and mix well. Add more water a spoonful at a time until you achieve the desired consistency.

Although the ingredients in salt dough are edible, it is not meant to be ingested. The salt content is very high and children should be discouraged from eating it.

Part A: Fossil Formation

Teacher: Provide each team with four copies each of Student Sheets 2a and 2b. Introduce students to the topic of **fossils**. A **fossil** is the preserved remains or evidence of a living thing – such as a plant or animal – that lived on Earth long ago. **Fossils** are formed when all or part of an organism is preserved in something like ice, tree resin (amber), or rock. Sometimes, when an animal dies, its body is buried in mud and the soft parts decompose, leaving behind the hard parts, such as teeth, bones, or shell. Over time, **minerals** in the ground fill in the empty spaces and may even replace the hard parts, leaving behind a tooth-, bone-, or shell-shaped rock that we call a **fossil**.

Ask:

- What do you know about **fossils**?
- From what are **fossils** made?
- How do you think **fossils** are formed?

Teacher: Provide each team with sponges, scissors, a marker, and four empty (yogurt) containers. Have students cut their sponges into **fossil** shapes, such as an animal, a bone, or a shell. (Collect the leftover bits of sponge for comparison to the “fossilized” sponges later.) Each student should place their **fossil** in the bottom of a container (it's okay if they have to squash it in) and write their name on the outside of the container. Explain to your students that you have created a solution by dissolving salt in water. A *saturated* solution is one that is “full” – no more salt will dissolve in the water. When this solution is left in a warm, dry place, the water will evaporate, leaving behind the salt. Salt is a **mineral** and can seep into the holes of a sponge just like **minerals** seep into the empty spaces in bones or shells, creating a **fossil**.

Ask: What do you think will happen if you place your sponge **fossil** in a salt solution?

Teacher: Provide each team with a container of saturated salt solution. Allow students to carefully pour the salt solution over their **fossils**, soaking the sponges but leaving just a small amount of liquid in the bottom of their containers. Put the containers in a warm, dry area of the room. Have students observe their **fossils** daily until the water has completely evaporated. They may then take them out of their cups and investigate the changes that have occurred.



JOURNALING OPPORTUNITY:

Describe your “**fossil**” sponge before you poured the salt solution over it. You may draw, dictate, or write your description. Describe your sponge after it “fossilized.” What do you think has happened to it?

- *Student Sheet 2a: Fossil Frenzy*

Part B: Traces of Life

Teacher: Fossils that are formed when part or all of an animal is preserved are called *body fossils*. But a **fossil** can also be created when evidence of an animal's existence (like an imprint, track, or even poop!) is left behind and preserved. These are called *trace fossils*, because they are a record of a living thing, rather than the organism itself.

Ask:

- What kinds of things might an animal leave behind that could be preserved and fossilized?
- What could you learn from the discovery of a trace fossil?
- What might today's humans leave behind to be discovered as trace fossils in the future?

Teacher: Take your students on a **fossil** hunt around the classroom or school grounds. Have each student collect a small object that could be used to create a **fossil**, such as a leaf, stick, shell, or

animal toy. When they are back at their tables, distribute salt dough or clay. Students should make a 1/2 inch thick “pancake” out of a small amount of clay or dough. Tell them to use their found object to create a trace fossil by pressing it into the pancake and then removing it, leaving behind an imprint. Students can write their names in the clay or dough as well, using a pencil, toothpick, or other tool. The clay or dough will dry if left to air out for a few days, helping to preserve their trace fossils. (Students can take their trace fossils home, but they will need to save their found objects for the next activity, Lay It Down.)



JOURNALING OPPORTUNITY:

Draw a picture of your trace fossil.

- *Student Sheet 2a: Fossil Frenzy*

Part C: Lay It Down

Teacher: Engage students in a class discussion about how rock formations can be created from layers of **sediment** being deposited over time, and how **fossils** can be found buried in these layers.

Ask:

- Why do many rocks, and many rock faces, have stripes?
- How are the stripes – or layers (**strata**) – at the top of a rock formation different from those at the bottom?
- What might happen to the bones of a dinosaur whose body was buried in mud?

Teacher: Provide each Space Patrol team with a clear plastic cup and clay or dough in five different colors. Ask each team to “bury” their found **fossils** (from Traces of Life) in layers of “rock.” Students should first place one color of clay or dough at the bottom of their cup. They can then choose one **fossil** to be their “oldest” **fossil**, and press it into the bottom layer of clay. They should simulate the action of that **fossil** being buried in **sediment** by placing a second layer of clay (in a different color) on top of the **fossil**, and continue (fossil – clay – fossil – clay) until they have placed all of their team’s **fossils** between different layers of clay.

Ask:

- Which layer of rock in your cup is the oldest? Which is the youngest?
- Which **fossil** in your team’s cup is the oldest? Which is the youngest?



JOURNALING OPPORTUNITY:

Draw your team’s cup with all of its layers, and indicate which color represents the oldest layer of rock, and which represents the youngest layer of rock. Draw each of your team’s **fossils**, labeling them from oldest to youngest, or indicate where they can be found on the drawing of the cup.

- *Student Sheet 2b: Fossil Frenzy*

Part D: Dig It Up!

Teacher: Collect cups from Lay It Down (students may label them with their team name if they choose) and redistribute them among the teams. Give teams time to examine the cups while you discuss *how* scientists use rock layers to learn about Earth’s history. Sometimes layers are exposed, like in a canyon wall; other times, scientists drill into the earth to retrieve a *core sample* – a cylinder

of rock or **sediment** that allows them to see the layers hidden beneath Earth's surface. In both cases, scientists are able to look back in time by observing and analyzing the layers of rock.

Ask:

- A. What do you think scientists can learn from studying layers of rock?
- B. How is your cup like a core sample?
- C. If your cup were a core sample, which layer of clay or dough would be the oldest? Which is the youngest?

Teacher: Distribute fossil-digging tools to Space Patrol teams. Instruct them to carefully excavate – or dig up – the **fossils** in their cup – or “core sample” – keeping careful notes on the relative ages of their **fossils** (which are youngest, and which are oldest). As they remove the **fossils** from the clay or dough, they should gently and carefully clean their **fossils**.



JOURNALING OPPORTUNITY:

Draw your “core sample” in your journal. Note which layers of “rock” (clay or dough) were oldest and which were youngest. Draw the **fossils** you uncovered and note their relative ages.

- *Student Sheet 2b: Fossil Frenzy*



CREW BRIEFING

Organization: Whole group

Materials for Classroom Use:

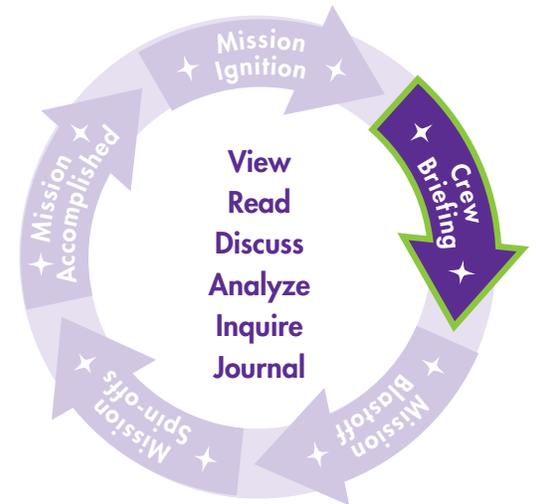
- Book chosen by the teacher
(see *Recommended Reading*)
- *The Zula Patrol*®: Down to Earth fulldome show

Materials per Student:

- *Zula Science Journal*

Preparation:

- Select a book about fossils, geology, or the changing Earth to read aloud.



Teachers: *Share a book about the changing Earth. Watch The Zula Patrol®: Down to Earth. Guide students to actively discuss the mission.*

Students: *Listen to the story. Watch the fulldome show. Share reactions, ideas, and questions about the book and movie.*



DIRECTIONS FOR TEACHERS



- Read and discuss a book about the changing Earth with the students.
- View and discuss *The Zula Patrol*®: Down to Earth. Encourage the students not only to watch, but also to think about this movie through active viewing – by thinking and questioning. Use the phrase “I wonder why” when discussing the mission.



JOURNALING OPPORTUNITY:

- Students are encouraged to draw something they remember from viewing the fulldome show.
- Students write or dictate words, phrases, or sentences that help explain their drawings.
- This is also a good place for students to write/dictate an idea they have about the changing Earth.

Teacher’s Note: *Writing/dictating a student-generated idea or question after viewing the fulldome show is a good springboard into the exploration phase of the lesson (Mission Blastoff!).*

DIRECTIONS FOR TEACHERS

1) Class Discussion

Let's talk about The Zula Patrol's mission!

Teacher: Guide the children to talk about *The Zula Patrol*® and the changing Earth. Follow the students' lead, and discuss the ideas and concepts that interest your young scientists.

Ask:

- A. What did Gorga discover in the wall of the canyon?
- B. Why did Deliria go back in time?
- C. How has Earth looked at different times in its history? How is that different from today?
- D. How has life on Earth changed over time?

Teacher's Note: *When discussing the topic with your students, use their responses to steer the discussion toward a meaningful dialogue. When a child offers an answer that includes a vocabulary word, take the opportunity to build on their answer by repeating and defining that word again while asking a question that promotes deeper thinking and inquiry. Use topic-specific vocabulary words in your questions as often as possible. A good open-ended question should create the possibility of multiple right answers.*

Teacher's Note: *The goal is not necessarily to teach specific science vocabulary, although that would be a great outcome. The goal is for the children to think about and interpret new words that are spoken in meaningful context. The practice of asking "How has Earth changed?" helps children develop a scientific way of thinking that encourages them to infer, "If this, then what?"*



MISSION BLASTOFF!

Organization:

Exploration:

• Gauge Earth's Age::

- Which Came First?: Space Patrol teams of four students (using individual Student Sheets)
- When Did *That* Happen?: Individual

• Building a Planet:

- Static Makes It Stick: Space Patrol teams of four students
- Crashing to Earth: Space Patrol teams of four students
- Layer Upon Layer: Space Patrol teams of four students
- Drifting Apart: Space Patrol teams of four students
- Puzzle It Out: Space Patrol teams of four students

Materials for Classroom Use:

- Balloons
- Sand
- Flour
- Cocoa
- Thick liquid such as corn syrup, vegetable oil, or dish soap

Materials per Space Patrol Team:

For Activity 1) Gauge Earth's Age:

- Crayons or markers

For Activity 2A) Static Makes It Stick:

- 1 small tray or pie pan
- 1 scoop of sand

For Activity 2B) Crashing to Earth:

- 1 small tray or pie pan (containing flour and cocoa)

For Activity 2C) Layer Upon Layer:

- 1 small tray or pie pan
- 4 lumps (lime-sized) of clay or salt dough (each a different color)

For Activity 2D) Drifting Apart:

- 1 tray or pie pan 1/4 full with corn syrup or other thick liquid

For Activity 2E) Puzzle It Out:

- 1 copy of the tectonic map from Student Sheet 4b

Materials per Student:

- Student Sheet 3: Gauge Earth's Age (2 pages)
- Student Sheet 4: Building a Planet (2 pages)

Preparation:

- For Activity 2A) Static Makes It Stick, inflate one balloon for each Space Patrol team.
- For Activity 2B) Crashing to Earth, prepare pie plates 2/3 full with flour and sprinkle a light dusting of cocoa powder on top (afterward, the flour can be re-used to make salt dough, if desired).
- Make one copy of Student Sheets 3a & 3b, Student Sheets 4a & 4b, and Student Sheet 5 for each student.
- Make an extra copy of Student Sheet 4b for each Space Patrol team.
- Make copies of Teacher Observation Guidelines (*optional*).



- Teacher Observation Guidelines: Hands-on Performance-based Activity

- 1 inflated balloon
- 1 lump of clay or salt dough

- Newsprint or paper towel
- 1 piece of dental floss (approx. 6 inches)

- 2 sponges
- Scissors

- Scissors

- Student Sheet 5: Wonder Sheet
- *Zula Science Journal*

Teachers: *Mission Blastoff activities can be done after viewing Down to Earth. Support and facilitate student experimentation. Introduce and reinforce mission vocabulary after students describe concepts in their own words.*

Students: *Experience the concepts. Discover, observe, and experiment.*

DIRECTIONS FOR TEACHERS

Exploration:

1) Gauge Earth's Age

Teacher: By comparing the span of Earth's history to their own lives, students may better comprehend the events of a geologic time scale.

Teacher's Note: *Student Sheet 3: Gauge Earth's Age offers background information both for you and your students' reference.*

Part A: Which Came First?

Teacher: Provide each student with a copy of Student Sheets 3a and 3b (Gauge Earth's Age). Discuss Earth's history and the events witnessed by the Zula Patrollers when they went back in time.

Ask:

- What are some big events that have happened on Earth over the past 4-1/2 billion years?
- Which events in Earth's history happened right after it was formed?
- Which events happened more recently?

Teacher: Ask students to work with members of their Space Patrol team to create a *relative* timeline of the events listed in Part A: Which Came First. Although students should work together to order the events, each student should record their results on their own Student Sheet.

Ask:

- Did the "Age of Dinosaurs" end before or after the last "Ice Age"?
- Were the first living things already on Earth during the millions of years of rain?

Teacher: Ask students to prepare their "Age Gauge" using different colors to represent Precambrian time, the Paleozoic Era, the Mesozoic Era, and the Cenozoic Era. Students will need to save their Student Sheets for the rest of the Mission Blastoff activities.

Teacher's Note: *An answer key to Which Came First is located on the Teacher Observation Guidelines sheet.*

Part B: When Did That Happen?

Teacher: In *Down to Earth*, Zeeter used an Age Gauge in the Patrollers' time machine to tell her "when" in history they were. Discuss with your class the usefulness of a timeline of events.

Ask:

- Can you name some significant events that occurred in Earth's history?
- Do you know how long ago any of these events happened?
- Why do you think it might be useful to know when these events took place?

Teacher: Using the timeline (now in color) on Student Sheet 3b, ask students to create their own Age Gauge – an *absolute* timeline. Guide students to plot the events listed in Part A on their timeline and label each event with its corresponding number. Then have them compare Earth's timeline to the timeline of their own lives.

Ask:

- Compare Earth's timeline to the timeline of your life. Do you notice any similarities?
- Which events seem to fall at the same places on the two timelines?

Teacher's Note: Encourage your students to bring out their newly created Age Gauge for each of the following activities, and place an arrow or other marker at the time in Earth's history that corresponds to the activity.

**JOURNALING OPPORTUNITY:**

Students complete Student Sheet 3 and draw/dictate/write about how Earth's timelines and their own individual timelines (from Mission Ignition) are both similar and different.

- Student Sheet 3: Gauge Earth's Age

Journal prompts:

- Which events on the two different timelines happen to fall at approximately the same places?
- How are the events in your life like events in Earth's history?

2) Building a Planet

Teacher's Note: Keep in mind that scientists must use clues to puzzle out Earth's history because none of us were actually there to see it happen! These clues come in many forms – fossils, rocks, even air bubbles trapped in ice – and it's up to scientists to come up with their best guesses as to when things happened. Scientists share their ideas, called theories, with other scientists, which often leads to agreement on an idea: what we call a "widely accepted theory." Sometimes, scientists disagree with one another and "competing theories" arise. And other times, a widely accepted theory is proven to be incorrect, and then another round of new theories begins. That's one of the wonderful things about science: we are always discovering and exploring new ideas!

Part A: Static Makes It Stick

Teacher: In *Down to Earth*, the Zula Patrollers witnessed the formation of Earth. Engage your students in a discussion about this time in Earth's history.

Ask:

- Earth was formed a very long time ago. What do you know about how it happened?
- Earth was formed from bits of rock and dust crashing into each other. What do you think might have held these pieces together?

Teacher: Give each team an inflated latex balloon and a tray or pie pan containing the grains of sand. Have one student rub the balloon on their hair (or a sweater or scarf) to build up a charge of static electricity. Students should observe the grains of sand as they place the balloon above the tray.

Ask:

- Move the balloon closer to the dish. What happens to the grains of sand?
- How is what you're seeing with the balloon and sand similar to how Earth was formed?

**JOURNALING OPPORTUNITY:****Journal prompts:**

- Draw your observations in your science journal.
- Draw a picture of what you think the Solar System might have looked like before Earth was formed.

SUPPORT FOR TEACHERS

Background Information:

Scientific evidence supports the theory that Earth – and the entire Solar System – was formed around 4.6 billion years ago from a large cloud of gas and dust in space, called a *solar nebula*. As the nebula began to spin, or rotate, most of the gas and dust was pulled into the center, which eventually became our Sun. The rest of the gas and dust flattened out in a disc surrounding the Sun, and over time, formed the planets, moons, and other bodies in our Solar System.

While the exact manner of Earth's formation is unknown, most scientists think that in the earliest stages, bits of dust and other particles in the solar nebula were attracted to one another and held together by static electricity. Eventually, the proto-Earth became large enough that gravitational forces could draw in and hold onto more bits of dust and larger pieces of rock. This process, in which small particles come together to form a much larger body, is called *accretion*.

Part B: Crashing to Earth

Teacher: Discuss Earth's formation with your students. As Earth grew, the pieces of rock and dust that accumulated were held together by gravity, and gravity helped attract larger pieces of rock and dust that were floating around in space. When a piece of space rock lands on Earth, we call it a *meteorite*. Today, most of these pieces burn up in Earth's atmosphere before reaching the ground, but at times in Earth's early history, Earth had little or no atmosphere to protect it from hurtling space rocks. This, combined with the fact that there were a lot more rocks floating around the Solar System during that time, means that the early Earth was regularly hit by space rocks. Sometimes these impacts were significant enough to change not only Earth's surface, but also the layers in Earth's interior.

Ask:

- In the early days of Earth's formation, there were many pieces of rock floating around in space. What do you think happened when these pieces got close to Earth?
- What do you think would happen if a large enough piece of rock crashed into Earth?

Teacher: Distribute clay or dough to the Space Patrol teams. Ask students to create different sized pieces of "space rocks" out of their clay or dough. While they are doing this, give each team a pie pan containing flour and cocoa. Ask students to create "craters" by dropping their clay "space rocks" (one at a time) onto the surface of their flour and cocoa "planet," observing and recording the results in their Zula Science Journals.



JOURNALING OPPORTUNITY:

Students record their observations. Students draw/dictate/write about their experiment.

Journal prompts:

- What did the surface look like before you dropped the bits of clay?
- What did the surface look like after?
- How did it change?

Part C: Layer Upon Layer

Teacher: Provide students with one copy each of Student Sheets 4a and 4b. Provide each Space Patrol team with four scoops of clay or dough (placed on newsprint or paper towels) and a tray.

Teacher's Note: *Student Sheet 4: Building a Planet offers background information both for you and your students' reference.*

Explain to the students that they are going to build a planet from the inside out. They will start by taking a small (grape-sized) chunk of clay or dough from one of their lumps. Students should break up this chunk into tiny bits (pea-sized and smaller) and scatter them on the tray. Have one team member roll their hand lightly back and forth over the tiny bits. The bits will begin to stick together and form a larger piece of clay. This is called *accretion*. Once they've accreted – or collected – all of the bits of the first color, they can pick it up and roll it between their hands, making a ball, or sphere. This is their planet's inner core.

Next, the students should take a slightly larger chunk from a different color of clay or dough (the size of a large strawberry). Again, students will break up the chunk into tiny bits and scatter them on the tray. Another student should take the inner core and roll it around a second tray, picking up bits of clay or dough of the new color. They should try to cover the entire ball. Once they've accreted this new layer, they should again roll the ball in their hands to pack it tightly and smooth it out.

For the third layer, students can use an entire lump of clay or dough in a third color. They should accrete this layer in the same way. *For the final, or fourth layer, students should use only a small amount of clay (smaller than the first layer!).* It should be enough to completely cover the ball, but the layer should be very thin, because Earth's **crust** is very, very thin in comparison to the other layers.

Once they've finished accreting their "crust," students should observe their planets.

Ask:

- What do you think your clay or dough planet looks like on the inside?
- What do you think Earth looks like on the inside?

Teacher: Provide each team with one 6-inch length of dental floss. Have students use the floss to carefully slice their planet in half. They are now looking at a *cross section* of their planet. Have them observe the layers and describe what they see.

Ask:

- Which layer represents the inner core? What color is it?
- Which layer represents the outer core? The **mantle**? The **crust**?

Teacher's Note: *Remind students that Earth's interior is divided into many layers. For the purposes of this exercise, they are creating four of Earth's layers: inner core, outer core, mantle, and crust.*



JOURNALING OPPORTUNITY:

Students draw the interior of their planet.

- *Student Sheet 4a: Building a Planet*

Part D: Drifting Apart

Teacher: Discuss the differences in Earth's layers with your students. The outer layer is cracked into sections – called **tectonic plates** – that float around on top of the layer underneath (like ice floating on top of a drink). Provide each team with scissors, sponges, and a pan with corn syrup (or other thick liquid). Encourage students to cut their sponges into different shapes and then lay them atop the layer of syrup.

Ask:

- A. What happens if you push the pieces of the sponges together? Can you fit them back together?
- B. What happens if you pull the pieces apart?
- C. What happens if you gently tilt the pan?
- D. Do you think the sponges would move faster or slower if they were floating on water instead of syrup?

Teacher: Explain to students that Earth's **tectonic plates** move very, very slowly, but that over time, their movement can rearrange the look of Earth's surface.



JOURNALING OPPORTUNITY:

Students observe the movement of the sponges and draw/dictate/write about what they saw.

Part E: Puzzle It Out

Teacher: Provide each Space Patrol team with scissors and one extra copy of Student Sheet 4b. As students are examining the map, remind them that Earth's **crust** is broken into pieces called **tectonic plates**. The major plates are identified on the map. The **tectonic plates** are floating on top of the layer below. In some places, the plates are spreading apart, and in other places, they are being pushed together.

Ask:

- A. Earth's **continents** move with Earth's **tectonic plates**. What do you think happens to the **continents** when the plates move?
- B. Looking at the map, what do you notice about the shape of the plates? What do you notice about the shape of the **continents**?

Teacher: Ask students to cut out the major plates on their maps. (Smaller plates, such as the Scotia plate or the Caribbean plate, can be grouped in with a nearby larger plate.) When they are done, ask them to mix up the pieces and take turns putting the tectonic puzzle back together.

Ask:

- A. What do you remember from *Down to Earth* about the movement of the **continents**?
- B. Do any of the **continents** look like puzzle pieces?

Teacher: Ask students to take their plate puzzle pieces and cut out the **continents**. Let students try to arrange their new puzzle pieces into one giant landmass. Remind them about *Pangaea* – the supercontinent that began to break up around 175 million years ago (Ma). After they've put the pieces together to create a supercontinent, have them slowly push them apart to re-create today's Earth.

Ask:

- A. How do you think the **continents** fit together in the past?
- B. Based on how the **continents** moved from Pangaea to today's Earth, where do you think the plates are spreading apart? Where are they being pushed together?



JOURNALING OPPORTUNITY:

Students draw/dictate/write about their experience puzzling out Earth's **tectonic plates**.



JOURNALING OPPORTUNITY:

Students draw, dictate, or write to record their observations and discoveries. Encourage students to record a question extending their experiences.

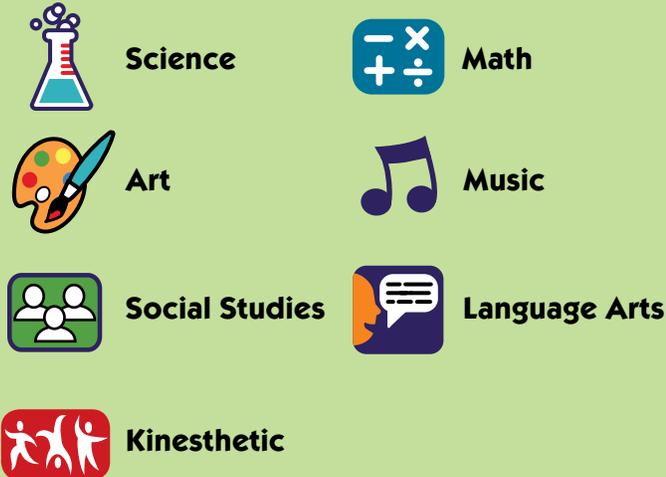
Journal prompts:

- I discovered _____.
- Now I wonder _____.
- *Student Sheet 5: Wonder Sheet*



MISSION SPIN-OFFS AND CONNECTIONS

Use this key to identify additional curriculum areas found in the MISSION SPIN-OFFS.



Teachers: *Spin-offs are optional and include cross-curricular activities. Choose activities that are applicable to your young scientists and individual classroom.*

Students: *Students create stories about Earth's history, sing and dance, make a class timeline, and sort and order fossils. Students take The Zula Patrol® on a home mission.*

DIRECTIONS FOR TEACHERS



1) HIS- or HER- Story

Directions for Teachers: Distribute blank paper and crayons or markers. Ask students to choose a time from Earth's history and create a picture book that tells a story about that time period. Is their story from the point of view of Earth? Or from a creature that lived during that time? Or is the author going back in time to witness an event? Students can draw, write, or dictate their story.



2) Fossil Figures

Directions for Teachers: Find photographs, images, or even models of plants and animals that we know only from the fossil record (mastodons, dinosaurs, petrified wood, trilobites, saber-toothed tigers, giant dragonflies, etc.) and print the fossil's age or the time period in which it lived on the back of the image. Show the images to your students and discuss the various ages of the fossils and what Earth was like when these fossils were living. Distribute the fossil examples among the Space Patrol teams. Each team of four students will need three or four examples, each from a different time period. Have students work together to order their examples from oldest to youngest. Then have teams trade some or all of their images and re-order the images or group plants and animals from the same time period together.





3) Zula Sing-a-Long

Directions for Teachers: With your students, learn the words and tune to “A Cute Little Planet” from the Zula fulldome show *Down to Earth*. Sing the song while letting students dance around a “maypole” with ribbons or crepe paper.



A Cute Little Planet

Lyrics by Cydne Clark and Steve Granat, ASCAP

Destroying the Earth, for what it’s worth,
Is not the result that I’d choose,
It’s a cute little planet of iron and granite,
And a wonderful place to buy shoes.

But where else can I stash all this nasty old trash?
Besides, no one will know what I’ve done –
Before humans evolve, Earth may just dissolve,
And a girl’s just gotta have fun!

La-la la-la la LAAAAAAAAA!

The trash that you dump is not just a lump,
It may turn into something much finer,
Perhaps a rare fossil, a statue colossal,
Or a theme park in North Carolina!

Exactly, my friend, so there’s really no end
To the good that I’m doing mankind,
I’ll save them the trouble and make lots of rubble,
So they won’t feel they’re falling behind!

La-la la-la la LAAAAAAAAA!



4) Timeline Mural

Directions for Teachers: Create a classroom timeline, starting with the first day of school and marking significant dates or special events (such as seeing the Zula fulldome show *Down to Earth!*). Create a moveable marker that indicates “Today” or “Right Now” and have students move it as needed. Let your students decorate the timeline with drawings, photographs, or other objects that represent the events depicted on the timeline. Leave extra space so your students can add to the timeline as the school year progresses. You may find that your timeline wraps around the room!



5) Home Mission (Take-home Letter)

Parent letter provides an opportunity for parents/guardians to help their child learn more about the changing Earth.

- *Home Mission: Down to Earth*



Parents can copilot their children’s exploration of the changing Earth by discovering changes in their region or community.

MISSION ACCOMPLISHED!

Organization:

- **Class Chart:** Whole group
- **Mission Accomplished Badge:** Individual

Materials for Classroom Use:

- Chart paper
- Markers
- Crayons

Materials per Student:

- *Zula Science Journal*
- Mission Accomplished Badge

Preparation:

- Prepare class chart:
 - Chart title: What We NOW Know About the Changing Earth
- Copy one Mission Accomplished Badge for each student.



Teachers: *Assess students' progress and distribute the Mission Accomplished Badges for students to color and add to their science journals.*

Students: *Participate in a matched pre-post assessment opportunity using the class chart and/or journal entries.*

DIRECTIONS FOR TEACHERS

1) Class Chart

Teacher: Prepare the class chart (see Figure 2, write title and date only). Ask the students what they now know about the changing Earth. Record the students' responses on the chart. Ask what more they would like to know about how Earth and its living things continue to change.

- Chart title: What We NOW Know About the Changing Earth



JOURNALING OPPORTUNITY:

Journal prompt:

- Write/dictate/draw what you've discovered about changes on Earth.

○ **What We NOW Know**
About the Changing Earth

Today's Date

Figure 2, Example, class chart



2) Mission Accomplished Badge

Celebrate a mission accomplished! Distribute the badges for children to color and wear or glue into their science journals.

- Mission Accomplished Badge

Congratulations on a mission well done. Keep exploring!

SUPPORT FOR TEACHERS

Assessment

Assessment is intended to be both formative, based on information gathered throughout the lesson, and summative, based on evaluative information gained at the end of the lesson. These two types of assessment will help you determine how well your students understand, use, and apply concepts related to the changing Earth.

Teacher's Note: *Because Zula's lessons are intended to do more than impart science concepts along with the associated vocabulary, you are encouraged to use methods for assessing students' learning that go beyond the standard recall-type test.*

1) Formative assessment provides continuous information for improvement and/or adjustment in learning and instruction. It offers multiple opportunities and sources for collecting information and can be used to help students and teachers think more pointedly about how the teaching and learning processes might be improved.

Formative assessments in this lesson include, but are not limited to:

- KWL Charts
- Class Discussions/Question and Answer
- *Zula Science Journal* Entries
- Home Missions

2) Summative assessment is a more formal type of assessment used to make final judgments about student achievement and instructional effectiveness. Zula provides two types of summative assessments: a *Hands-on Performance-based Activity* and *Student Sheet Activities*. With the *Hands-on Performance-based Activity*, students are given specific module materials and expected to design and conduct an investigation and communicate findings. With the *Student Sheet Activities*, students are required to identify, compare, evaluate, interpret, or depict scientific concepts learned in the lesson.

Summative assessments in this lesson include, but are not limited to:

- Hands-on Performance-based Activity
- Student Sheets
- Portfolio Assessment

Assessment Opportunities

The following assessment opportunities are available to the teacher throughout the lesson:

- **Teacher Observation Guidelines: Hands-on Performance-based Activity**
This sheet provides guidelines for teacher observation as students actively collect evidence to begin building the concept of the changing Earth. This "do" part of the lesson also provides opportunities for students to test their ideas of how and why Earth is in a constant state of change.
- Student Sheet 1: Gauge Your Age
- Student Sheet 2: Fossil Frenzy
- Student Sheet 3: Gauge Earth's Age
- Student Sheet 4: Building a Planet

Visit www.zula.com to learn more about Zula International's educational curricula.

Patrol Pyramid

EARLY INVESTIGATOR

Creating Awareness at the "Tip of the Iceberg"

Exploration:

Child explores the properties of the materials

Journaling: Child's entries identify the properties of the materials

Vocabulary: Child uses familiar terms to describe the materials

TRANSITIONAL INVESTIGATOR

Exploring Concepts

Exploration: Child engages in exploring the properties of the materials and central concepts of the lesson

Journaling: Child's entries make connections between the properties of the materials and the central concepts of the lesson

Vocabulary: Child uses some Science Words in discussion and questioning, and while describing his or her actions

MASTER INVESTIGATOR

Deeper Understanding

Exploration and Experimentation: Child tests new ideas that expand on previously learned theories while exploring the materials; child can infer "If this, then that"

Journaling: Child's entries include detailed drawings and/or words and phrases that further explain alternative rationalizations in the entry

Vocabulary: Child uses Science Words in context to create meaning and to respond to terms by demonstrating with the materials

MISSION: Down to Earth

While students are engaged in the mission, circulate throughout the room and observe your young scientists at work. The following list of sample questions can be used as a starting point. Use questions that are appropriate to the play and exploration you encounter. Encourage active discussion and conversation. Space is provided to jot down quick notes on the students' progress, questions, and understanding as you move about the room.



Sample Questions, a starter list:

- How has Earth changed over time?
- What can scientists learn from studying rocks and fossils?
- What are some events that have happened during Earth's history?
- How is Earth continuing to change?

ANSWER KEY for Which Came First?:

- 7 End of the last "ice age" (10,000 years ago)
- 1 Formation of Earth (4.6 bya)
- 8 TODAY
- 5 End of "Age of Dinosaurs" (65.5 Ma)
- 2 Millions of years of rain (4 Ga)
- 3 First living things (3.5 Ga)
- 6 First human-like ancestors (4 Ma)
- 4 Cambrian "Explosion" of life (542 Ma)

---FOLD HERE

Today's Notes

Date:

Class:



My Name: _____

Date: _____

Absolute vs. Relative

Scientists sometimes study... history! Knowing how old an object is (such as a rock or a fossil) or when an important event took place (such as a meteor crashing to Earth) can help us answer questions about what Earth was like at that time. Scientists have different methods for determining exactly how old something is or when something happened. We call this *absolute* dating – which means that we learn the exact – or absolute – date in question. Sometimes, scientists just need to know which of two or more objects is older, or which of two events happened first. We call this *relative* dating, because the objects or events are described in relation to one another.

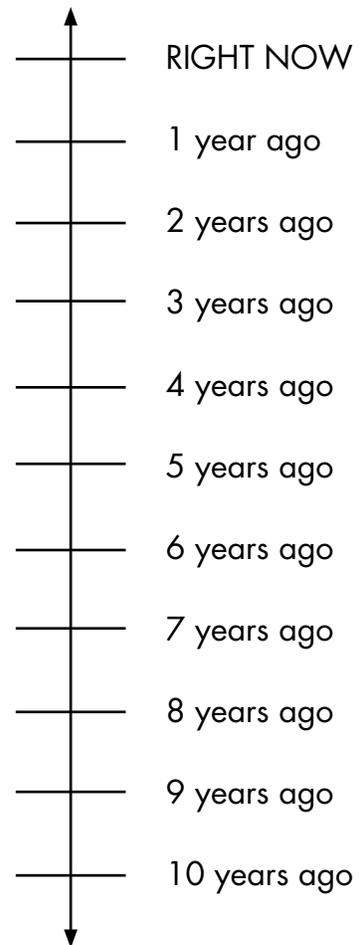
Part A: Relatively Speaking...

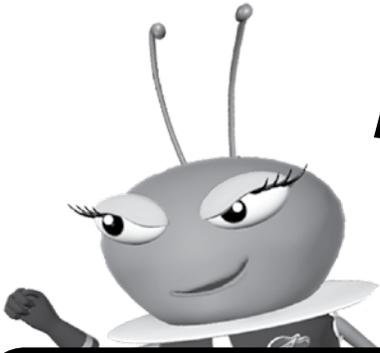
Create a *relative* timeline of your life, by ordering the following events from earliest to most recent. Look over the list below and figure out which event in your lifetime happened first. Label that event with the number 1. What happened next in the timeline of your life? Label that event with the number 2, and so on, until you get to the last thing on the list (number 8).

- _____ I was born
- _____ I started kindergarten
- _____ I learned to crawl
- _____ I ate breakfast today
- _____ I turned 5 years old
- _____ RIGHT NOW
- _____ I learned to walk
- _____ I got dressed this morning

Part B: It's Absolutely You

Now that you know the order of certain events, you can use this information to create an *absolute* timeline of your life. For each of the events listed in Part A, place a dot at the corresponding point on the timeline below. For example, if something happened 6-1/2 years ago, place a dot half-way between 6 years ago and 7 years ago on the timeline. Don't forget to number your dots! Some of your dots may be very, very close together (almost on top of each other!), so you might want to use different colors when you draw them on the timeline.





My Name: _____

Date: _____

Background Information:**Fossil Facts**

It's been billions of years since Earth was formed, but that doesn't mean it's inactive. Earth is in a continuous state of change! One example of change is called **erosion**. It's the process where wind, water, ice, and gravity wear away Earth's surface features, transporting and depositing tiny bits of rock and soil, called **sediment**.

Strata, or layers, in a rock formation are created when **sediment** continues to be deposited in the same area over and over again for many, many years. You can see **strata** in exposed cliffs, road cuts, river banks, and canyons – the rock faces look “striped.” The stripes represent different **strata** formed when a new layer of **sediment** was deposited there. The **strata** near the bottom of a rock formation were deposited earlier than the **strata** above, so lower **strata** are older, higher **strata** are younger. **Geologists** – scientists who study Earth and its processes – can learn a lot about Earth's history by noting the differences in various layers of rock.

Paleontologists and **archaeologists** can, too, by studying **fossils**. A **fossil** is a preserved record of a living thing from the ancient past. *Body fossils* are the remains (either part or whole) of an animal, plant, or other organism. *Trace fossils* show evidence (such as a footprint, an imprint of a leaf, or even fossilized poop!) that a living thing existed many years ago.

Fossils can be formed in many different ways. They can be preserved in ice, or trapped in resin from a plant (called *amber*) which hardens over time. Most **fossils** are from plants or animals that were buried in **sediment**. Over many, many years, the **minerals** in the **sediment** seeped into and replaced the organic material in the organism, turning its parts (often bone, teeth, or shell) into stone. And because **sediment** is deposited in layers, the **fossils** near the bottom of a rock formation tend to be older than those found near the top.

Fossils are of great importance to scientists; they are a way of looking back in time to help determine what life on Earth was like long, long ago.

Part A) Fossil Formation

Draw the body fossil you made from a sponge.

Part B) Traces of Life

Draw your trace fossil.

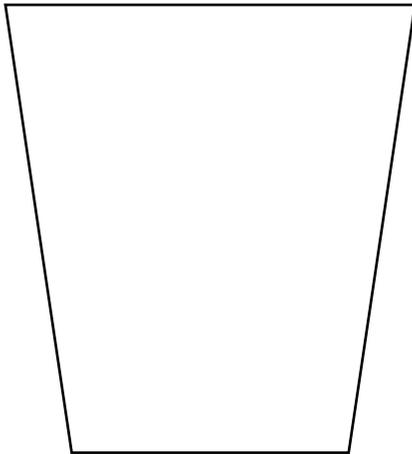


My Name: _____

Date: _____

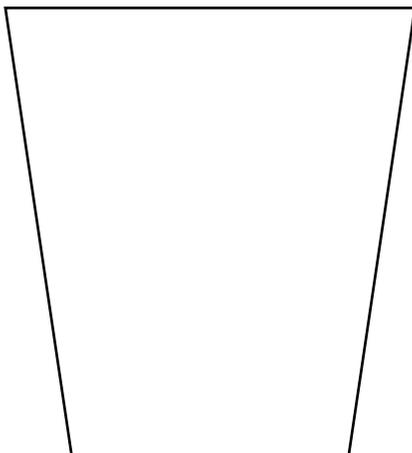
Part C) Lay It Down

Draw your team's cup with all of its layers. Indicate which color represents the oldest layer of rock, and which represents the youngest layer of rock. Draw each of your team's **fossils**, labeling them from oldest to youngest, or indicate where they can be found on the drawing of the cup.



Part D) Dig It Up!

Draw your "core sample" in your journal. Note which layers of "rock" (clay or dough) were oldest and which were youngest. Draw the **fossils** you uncovered and note their relative ages.





My Name: _____

Date: _____

Background Information:

Earth's Long History

In *The Zula Patrol*®: Down to Earth, the Zula Patrollers traveled back in time to witness the birth of Earth, which happened about 4.6 billion years ago. (That's the number 46 written with 8 zeroes after it, like this: 4,600,000,000. We can abbreviate "billion years ago" to bya or Ga – makes it a bit easier to write!) The proto-Earth, or early Earth, was hot and **molten** – kind of like a lava planet! As Earth cooled, the molten surface hardened into a crust. The planet was bombarded by meteors and comets carrying water ice that left behind pits, or **craters**, when they crashed into Earth. This water, combined with steam from volcanoes, condensed into clouds on the cooling planet. By about 4 Ga, Earth was covered with water after millions of years of RAIN!

All that water was important – because all living things need water. **Fossil** evidence shows that life forms could be found on Earth 2.7 Ga, although some research indicates that life may be even older than that – perhaps as old as 3.5 Ga or even 3.9 Ga!

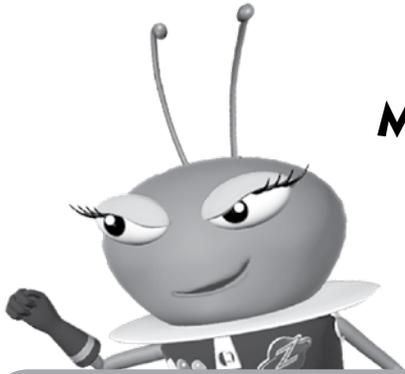
Early life forms were a type of plant-like bacteria. By taking in carbon dioxide and producing oxygen, they drastically changed Earth's environment. At first, these changes may have been detrimental to life on the planet, but eventually, living things adapted and then flourished in the oxygen-rich environment.

This time in Earth's history, from its formation until just over 500 million years ago (mya or Ma), is known as *Precambrian* time. That's most of Earth's existence – in fact, 90% of it, or 4 billion years! Let's look at that time frame a different way: if Earth were 10 years old today, its first 9 years were spent in Precambrian time. Earth itself went through a LOT of changes, but for life on Earth – things have just started getting interesting!

Around 542 million years ago, life really took off, marking the end of Precambrian time and the beginning of the Cambrian Period. Those early life forms gave rise to all kinds of different organisms, at first in the water and then on land. Some people call this the Cambrian Explosion, because during a relatively short period of time, many new life forms evolved. The Cambrian Period represents the first part of the Paleozoic Era (*Paleozoic* means "ancient life"). By the end of this era, land plants and tall trees had developed, as well as large reptiles. The end of the Paleozoic Era was marked by a mass extinction in which most types of living things on the planet died off, caused by environmental and catastrophic changes, such as an impact by a meteor or an increase in volcanic eruptions.

The Paleozoic Era was followed by the Mesozoic Era, also known as the "Age of Reptiles" or "Age of Dinosaurs," which lasted from 251 Ma to 65.5 Ma. Another mass extinction at the end of this era – caused by a huge comet or meteor crashing to Earth – left only a few small species of dinosaurs, from which today's birds are descended.

We are currently in the Cenozoic Era, or "Age of Mammals." After the extinction of the large dinosaurs, the small mammals survived and spread out, eventually evolving into the animals we see today. Our first human-like ancestors evolved over 4 million years ago. Our ancestors have survived – and thrived – despite a cycle of climate changes over the past 2-1/2 million years, taking us from periods of glaciation (sometimes called "ice ages") through warmer times known as interglacial periods. The last period of glaciation, when the glaciers extended far into North America, ended 10,000 years ago.



My Name: _____

Date: _____

Just How Old Is It?

Earth is really, really old. Older than your parents. Older than your grandparents. A LOT older than your great-grandparents. It's a bit hard for us to wrap our heads around just how old it is, so we'll start by ordering some events that happened during the course of Earth's history. Then we'll plot those events on a timeline and compare them to the timeline of our own life, just to give us a basis of comparison.

Part A: Which Came First?

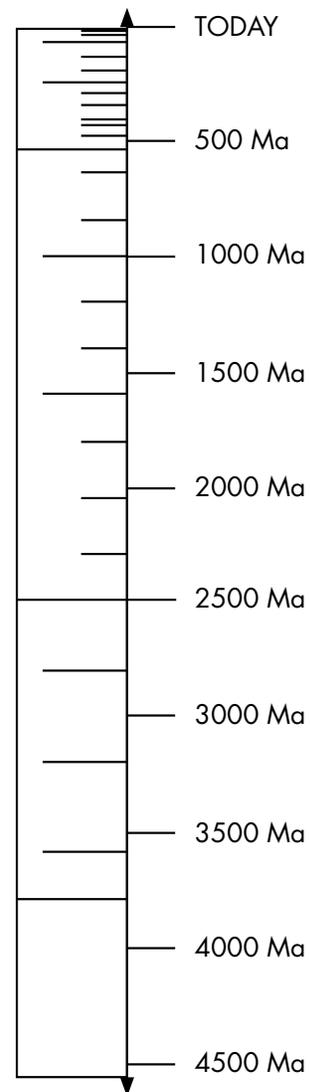
Create a *relative* timeline of Earth's history by ordering the following events. Label the earliest, or oldest event with the number 1, and the most recent with the number 8. Check out the Background Information on the previous page for clues.

- _____ End of the last "ice age"
- _____ Formation of Earth
- _____ TODAY
- _____ End of "Age of Dinosaurs"
- _____ Millions of years of rain
- _____ First living things
- _____ First human-like ancestors
- _____ Cambrian "Explosion" of life

Once you've ordered the events, take a look at the Age Gauge on the right. Choose a color to represent *Precambrian* time, and lightly color in this portion of the timeline. Choose a different color to represent the *Paleozoic Era* and color in this section. Choose two more colors and do the same for the *Mesozoic Era* and the *Cenozoic Era*.

Part B: When Did That Happen?

Create an *absolute* timeline of Earth's history. For each of the events listed in Part A, place a dot at the corresponding point on the timeline below. Don't forget to number your dots! Some of your dots may be very, very close together (almost on top of each other!), so you might want to use different colors when you draw them on the timeline.





My Name: _____

Date: _____

Background Information:

Earth's Layers

Earth's interior can be divided into layers: at the top, where we stand, is the **crust**; the **mantle** makes up the layer underneath the **crust**; and at the center of the planet is the **core**. That's a simple way to break it down, but geologists – scientists who study Earth's history, processes, and materials – get even more detailed when discussing Earth's layers.

For example, the **core** is actually made up of a solid *inner core* and a liquid *outer core*. The **mantle** can be divided into the upper mantle, the transition region (or *mesosphere*), the lower mantle, and the core-mantle boundary layer known as D'' (D-double-prime). There are two types of **crust**: *continental crust* and *oceanic crust*. Oceanic crust – like the sea floor – covers the entire planet, and in some places – like islands and continents – the oceanic crust has continental crust riding on top of it.

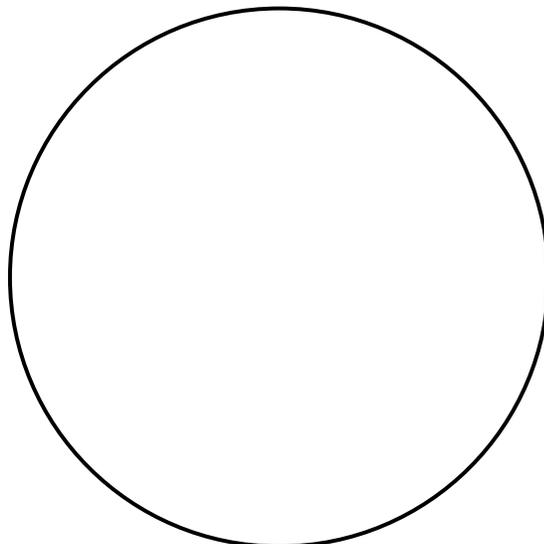
Geologists group the **crust** together with the upper mantle and call this rigid layer the lithosphere. Imagine rolling a hard-boiled egg around – you'd create cracks in the shell. The lithosphere has cracks, too, that create sections known as **tectonic plates**. There are eight large and several smaller plates floating on top of the rest of the **mantle**, which is **molten** – or liquid – rock, known as **magma**. (**Molten** rock is called **magma** when it's inside Earth, and **lava** when it flows out to the surface.) As the **magma** in the **mantle** moves around, the floating plates move, too. In some places the plates are spreading apart, creating new ocean floor as **magma** rises up and cools. In other places, the plates are pushed together, creating mountain ranges or volcanoes, or even a chain of volcanic islands (like Hawaii). Plate movement can cause earthquakes, too.

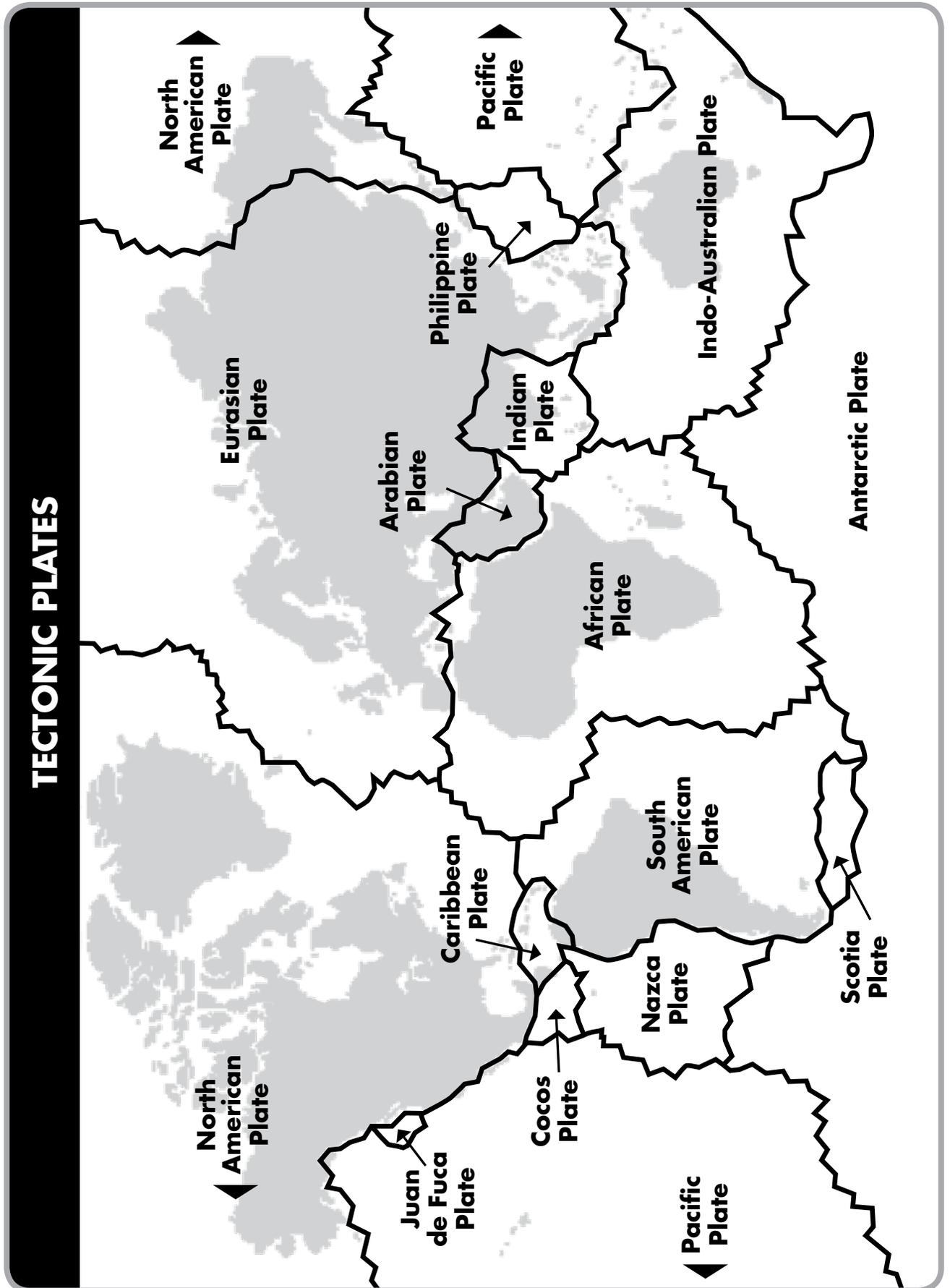
Activity 3C) Layer Upon Layer

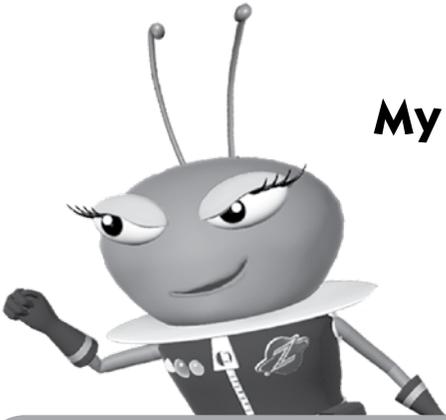
Draw the interior of your planet.

Label the following layers:

- Inner core
- Outer core
- Mantle
- Crust







My Name: _____

Date: _____

While on a mission with *The Zula Patrol*,[®] I discovered

Now I wonder _____

MISSION:

Down to Earth



Dear Parent/Guardian,

Our class is learning about the changing Earth.

During their mission, *The Zula Patrol*® went back in time and witnessed the dramatic changes that have taken place on Earth during its long history. Some of these changes were geologic, such as the formation and movement of the continents, and some were biological, such as the rise and fall of dinosaurs.

Please help your child find examples of changes that have occurred in your community, neighborhood, or region. You can visit a library and look in the local section, or perhaps there is a nature center in your area with descriptions of the region's geological history. Many quarries offer fossil hunting expeditions or tours. Your child will have the opportunity to share your experiences with classmates.

For more discoveries, read a book about fossils or dinosaurs with your child.

Please help your child complete this sheet and return it to his or her teacher. Thank you.



FULLDOME SHOW:

Down to Earth – While on a routine fossil-hunting expedition, *The Zula Patrol*® turns up evidence that the villainous Deliria Delight has been traveling back in time to Earth's prehistoric past to illegally dump her company's toxic trash. The Zula Patrollers must find and catch her, before her actions cause catastrophic consequences. In the process, our heroes learn all about the formation and development of Earth, and the life forms who call it home.

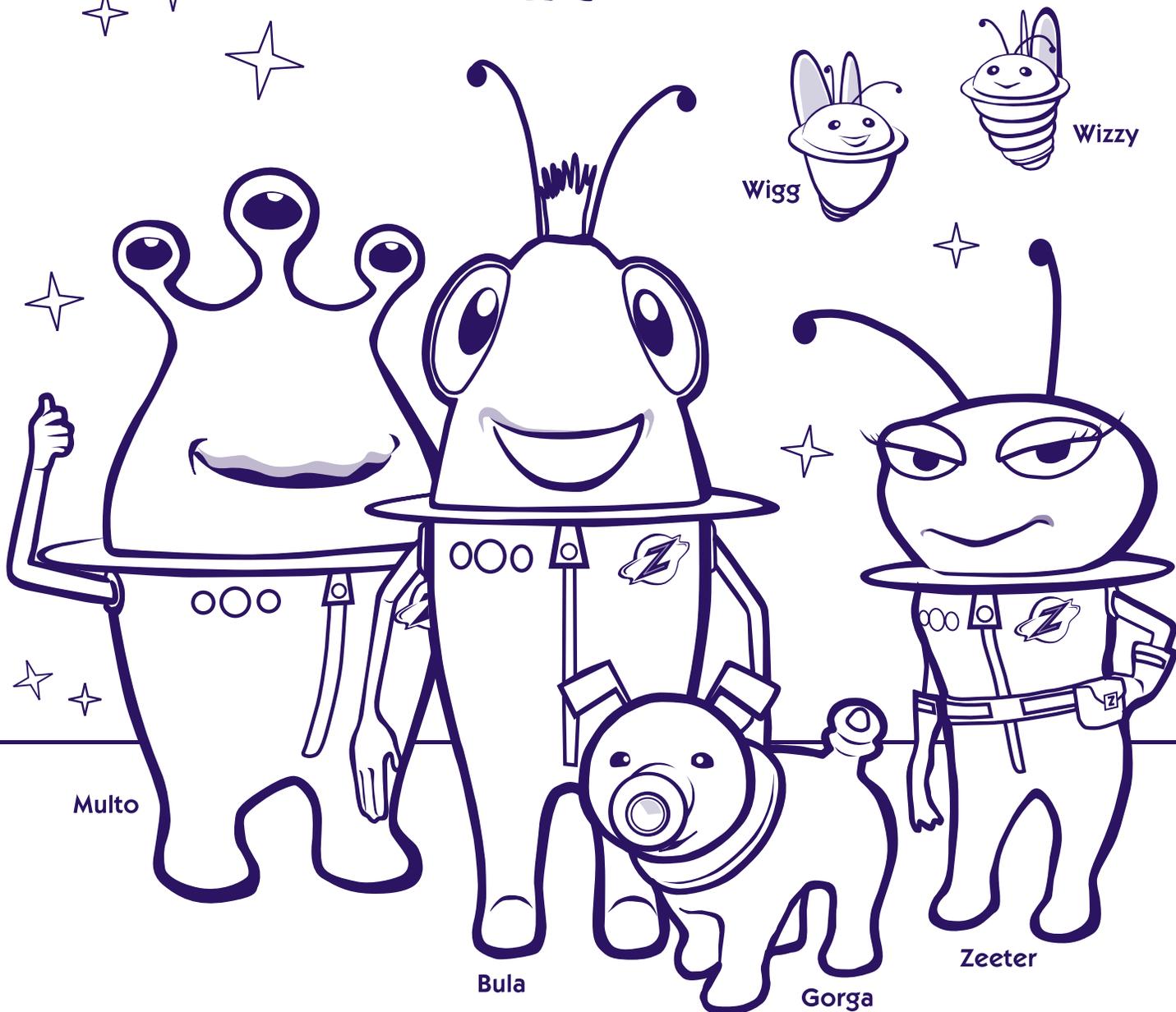
Fossil – *the preserved remains or evidence of a living thing – such as a plant or animal – that lived on Earth long ago*

Visit ZulaWorld.com to explore and discover an Online Virtual Learning Environment for young scientists!

Go to the Zula Patrol HQ in downtown Zulapolis and type in the code: ZulaDownToEarthPrize to redeem your special Down to Earth prize!

Draw a picture or paste a photo of changes that you discovered have taken place around your home.

The *ZULLA*® Patrol

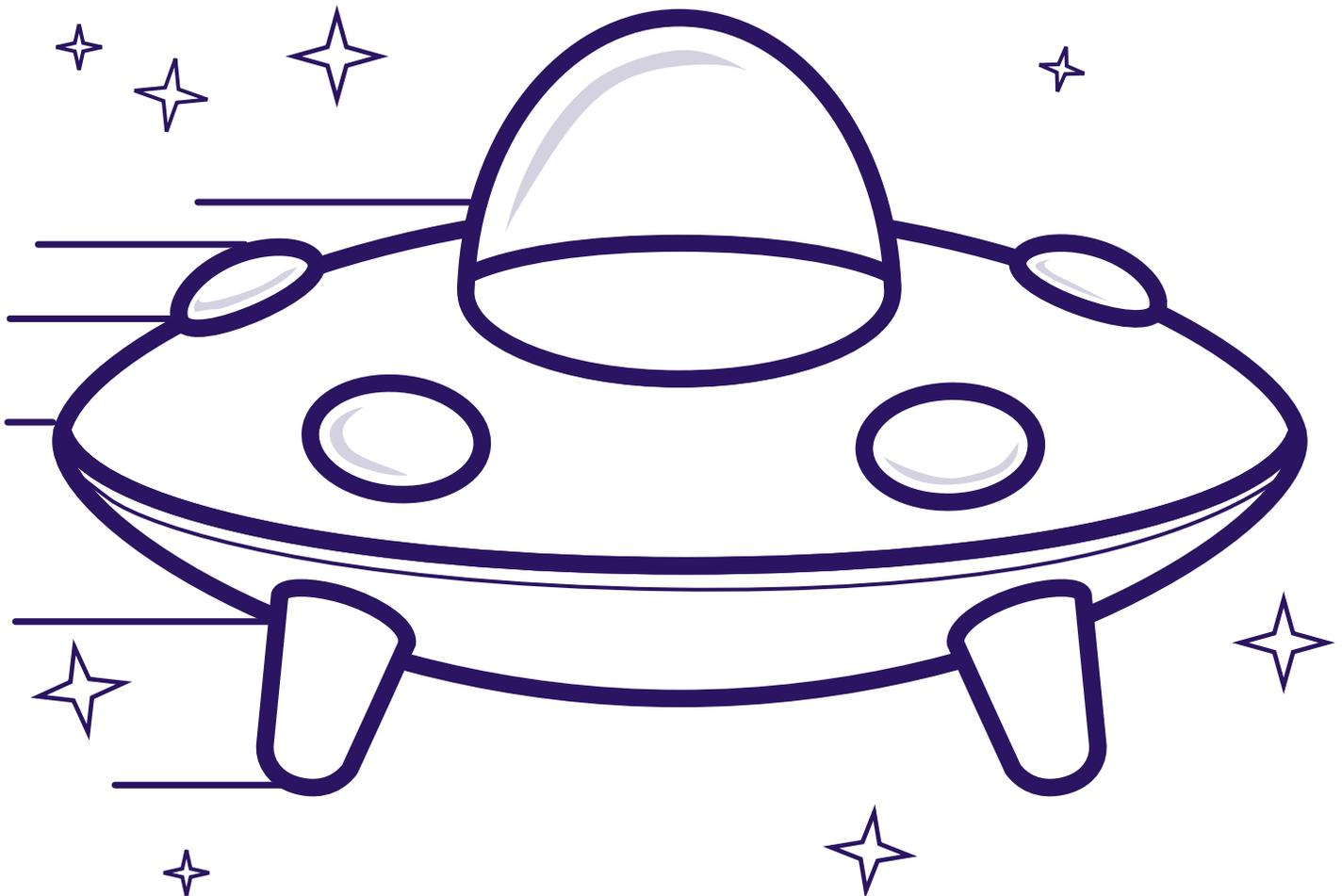


Science Journal

This journal belongs to: _____



**MISSION
Accomplished!**





Educator's Guide



The Zula Patrol® **DOWN TO EARTH**

**For More Exciting Discoveries, Explore
Zula's Curriculum and ZulaWorld.com**

- PreK–3rd Grade Curriculum that exceeds achievement goals with strong standards-based instruction (NAEP, NAEYC, NSTA, NCTM)
- PreK–5th Grade Afterschool Program that exceeds achievement goals with strong standards-based instruction (NAEP, NAEYC, NSTA, NCTM)
- Online Technology Component: ZulaWorld.com is an interactive online virtual learning environment that enhances a teacher's toolkit for enrichment, formal and informal assessment, and customizing learning to meet student needs.

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