Lesson 4: Convection in the Earth

Earthquake damage from 1989 Loma Prieta Earthquake, San Francisco Bay Area; California Department of Transportation (Caltrans)

Students explore conditions that might change the density of a substance, resulting in movement. They observe convection and use this information to infer how movement occurs inside the Earth.

Main Lesson Concept:
The interior of the Earth is hot. The heating and cooling of the mantle result in convection cells and movement inside the Earth.

Scientific Question:
How does the inside of the Earth move?

Objectives	Standards
• Students will use the inquiry process to identify temperatur as a condition that can change the density of a substance and affect movement. • Students will illustrate and describe how a change in density can cause movement inside the Earth. • Students will explain convection cells.	**Meets:** NSES B (5-8) #3.2 **Partially meets:** 2061: 4C (6-8) #1 2061: 4E (6-8) #3 2061: 4E (3-5) #2

Assessment	Abstract of Lesson
Convection Cell Drawing, inquiry write-ups, and answers to questions in Astro Journal.	Students use the inquiry process to determine what causes a substance to change density, and thus cause movement. They heat glittered water and observe that an increase in temperature causes a substance to be less dense and rise above denser substances, then cool and become denser, causing it to sink. This creates convection currents. Students use this knowledge to draw and explain how movement occurs in the Earth's mantle.

Prerequisite Concepts	Major Concepts
• Heating and cooling may cause changes in the properties of materials. Many kinds of changes occur faster under hotter conditions. (2061: 4D (3-5) #1) • Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated. (2061: 4D (6-8) #3, Astronomy Lessons 4 and 5) • Humans need the following geologic conditions (Geology Lesson 1): – Liquid outer core (coupled with the planet's rotation) and a thick atmosphere – Viscous mantle (slow motion) – Slow motion of crust and upper mantle (lithosphere) of 3 to 5 centimeters per year • Density is the amount of matter in a certain unit of volume or space and, it is the measure of how tightly packed molecules are within a substance. (Geology Lesson 3) • Substances of greater density will sink below those of lesser density. (Geology Lesson 3) • As you go deeper into the Earth, the density of the materials increases. (Geology Lesson 3) • A change in density can affect the movement of matter. (Geology Lesson 3)	• Convection is the transfer of heat through a substance (solid, liquid, or gas) caused by molecular motion. • The density of a substance can change with pressure and temperature. • As temperature is increased, substances become less dense and thus rise. • When warmer things are put with cooler ones, the warm ones lose heat and the cool ones gain it until they are the same temperature. • When a substance heats up and rises, it comes into contact with cooler substances that cool it down. • When the substance cools, it becomes denser and sinks. • If the gas or liquid sinks toward a heat source, it will warm up and rise again. • This rising and sinking creates currents or convection cells that transfer heat. • High temperatures deep inside the Earth heat up the mantle, decreasing density and causing lower mantle material to rise. • Mantle material near the crust cools as it comes in contact with cooler material, causing it to become denser and sink. • The crust and top part of the mantle that is solid are called the lithosphere (sphere of rock). • The lower part of the upper mantle composed of some molten rock is called the asthenosphere. • Below the asthenosphere is the rest of the mantle, which extends all the way to the outer core.

Suggested Timeline (45-minute periods):

Day 1: Engage and Explore – Part 1, Day 1 sections
Day 2: Explore – Part 1, Day 2 section
Day 3: Explain – Part 1, Explore – Part 2, and Explain – Part 2 sections
Day 4: Extend section
Day 5: Evaluate section (approximately 20 minutes)

Materials and Equipment:

- A class set of Astro Journal Lesson 4
- Earth Structure Transparency
- Markers or crayons
- Chart paper

Density Inquiry Activity materials may include the following for each group:

- 2 or more of the following liquids: oil, water, molasses, conditioner and vinegar
- Cups
- Thermometer
- Hot plate or other heat source
- 2 beakers or glass containers that can be heated (made of material similar to Pyrex®)
- Food coloring
- Other materials will depend on the experimental designs students come up with (Make a list after Explore – Part 1, Day 1.)

Materials for Convection Currents Demonstration (teacher demo or each group will need the following):

- Hot plate or other heat source
- 2 beakers or glass containers that can be heated (made of material similar to Pyrex®)
- Water
- Glitter
- Alternatively, you could use a lava lamp
- Another alternative is to use two aluminum pie-pans, tap water, food coloring or other dye, liquid hand soap that contains glycol stearate, glycol distearate or glycerol stearate, and a hot plate.

Preparation:

- Duplicate a class set of Astro Journal Lesson 4.
- Prepare Earth Structure Transparency.
- Gather materials for demonstrations and activities.
- Make sure there is enough room for the Heat Transfer Kinesthetic Activity in the Explain – Part 2 section.
- Prepare chart paper with major concept of the lesson to post at the end of the lesson.

Differentiation

Accommodations

For students who may have special needs:

Have them work with a partner on their Astro Journal writing or report orally to the teacher.

Advanced Extensions

For students who have mastered this concept:

Have students who have already mastered this concept research and report on the importance of convection in our oceans or in the atmosphere. How does convection affect our weather and temperature? What would happen if these convection currents changed? What would the temperature be like in Great Britain if there were no convection currents in the Atlantic Ocean?

Engage

(approximately 10 minutes)

Skiff cleaning up oil spill in Sydney Harbor, Australian Maritime Safety Authority

1. Draw on students' prior knowledge of density, how density causes movement of substances, and how density affects the composition of Earth's layers (from Geology Lesson 3).

- Question: How would you describe density?
- *Answer: Density is the amount of matter in a certain unit of volume or space.*

- Say: In Geology Lesson 3, you poured two liquids into a beaker. The liquids that were available were oil, water, molasses, conditioner, and vinegar.

- Question: Did the liquids have different densities? How did you know?
- *Answer: The liquids did have different densities. We knew this by first observing differences in the thickness of the liquids. Then the difference in densities was confirmed by pouring two liquids into a beaker. The thicker liquid sank to the bottom while the thinner liquid rose to the top.*

- Question: What movement did you observe that was caused by density?
- *Answer: Less dense substances moved to the top, while denser substances sunk to the bottom.*

- Question: How would you describe the molecules in a substance with low density?
- *Answer: The molecules in a substance with low density are sparsely packed.*

- Question: What affects the movement of molecules?
- *Answer: Temperature affects the movement of molecules.*

- Question: When the temperature of a substance is increased, what happens to the movement of the molecules?
- *Answer: The movement of the molecules increases when the temperature of a substance is increased.*

- Question: How would an increase in temperature affect the density of a substance? Explain your answer.
- *Answer: An increase in temperature causes the molecules to move around more quickly. This movement of the molecules will result in a decrease in density because the number of molecules in a certain unit of space or volume would decrease.*

- Question: Which layer of the Earth has the lowest density?
- *Answer: The crust has the lowest density.*

- Question: Which layer of the Earth has the highest density?
- *Answer: The core has the highest density.*

- Question: How would you describe the packing of molecules in the core compared to the molecules in the crust?
- *Answer: The molecules in the core are tightly packed together compared to the molecules in the crust.*

- Question: Why is the core the densest layer of the Earth?
- *Answer: The core is the densest because as the Earth formed the densest materials moved towards the center forming the core.*

---

2. Bridge to this lesson and introduce the purpose and Scientific Question.

- Say: In the Geology Training module, you saw that movement inside the Earth causes the surface of the Earth to be habitable. Today, we are going to use our knowledge of temperature, pressure, and density to learn how the inside of the Earth moves.

- Say: The Scientific Question we will be exploring is: How does the inside of the Earth move?

- Ask students to share their hypotheses/predictions about the Scientific Question.

Explore – Part 1, Day 1

(approximately 35 minutes)

Researcher using high-temperature probe for earthquake studies; Sandia National Laboratories, USDOE

1. Bridge to inquiry activity.

- Say: In Geology Lesson 3, we learned that the layers of the Earth are arranged in order of increasing density starting at the crust and moving towards the core. In this activity, you are going to design an experiment to help you explore the question:
  – Is it possible to change the density of a substance in order to cause movement?

- Students record their hypothesis to this question in the Hypothesis/Prediction section of their Astro Journals.

Note to Teacher: Based on your experience with your class, there are at least three ways to proceed from here. Students who would benefit from the opportunity to design their own experiment should do so. If the class is not ready as a whole, you can also do this as a whole class project in which everyone contributes to one hypothesis and test. You could also work with a group who needs more assistance while allowing those who benefit from working on their own to do so.

---

2. Put students into groups to refine hypotheses and plan experiments to test them.

- Go over expectations for the hypothesis from the inquiry rubric and model how to revise a hypothesis to improve it (i.e., make it clearer, testable, more specific, etc.) in their Astro Journal.
- Demonstrate how the materials, procedures, and data for the test will be recorded in the Astro Journal for this lesson.

Note to Teacher: Make sure that the students are thinking in terms of data — what data they will be collecting, how they will be measuring their data, and how their data is either going to confirm or refute their hypotheses.

3. Give students some time to put together their materials and procedures list in order to figure out what data they will be collecting and how they will measure it.

- Instruct students to fill out the Materials and Procedures sections of their Astro Journal.

4. Have students share their hypotheses and experiment plans.

- Ask questions to help groups clarify aspects of their plan, but try to avoid giving them the answers. Sample questions might include:
  - How does this experiment test your hypothesis?
  - What specific data are you collecting?
  - How will your data confirm or refute your hypothesis?
  - How are you going to measure your data?

Note to Teacher: Corrections should be focused on the science process, not the correctness of the hypothesis. An incorrect hypothesis with a solid experimental plan is fine. A correct hypothesis without a solid experimental plan should be revised.

5. Ask students for a list of materials they will need to conduct their experiments.

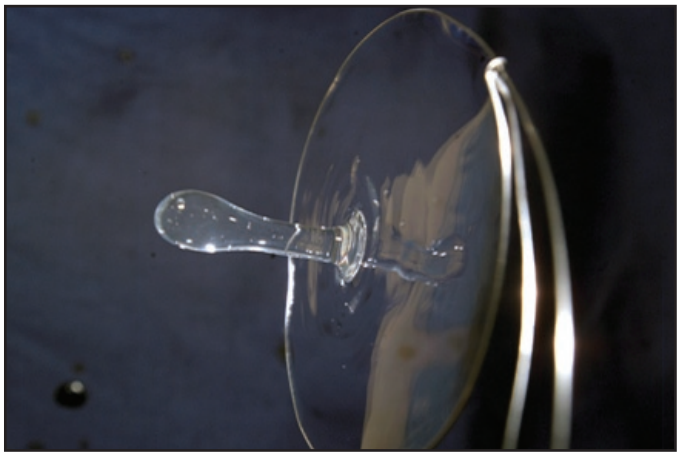
Note to Teacher: Student experiments will vary from group to group. Many students may want to change the temperature of a substance to see how this affects the substance's density. Listed below is a possible idea for an experiment:

Increase in temperature: Students can use two or more of the liquids that were used in Geology Lesson 3 Density Activity. These liquids were oil, water, molasses, conditioner, and vinegar. The students could begin the experiment by having all of the liquids at room temperature. The liquids could then be combined into one cup to determine the order of densities of the liquids. Students could heat one liquid up using a heat source such as a Bunsen burner, a microwave, or setting a beaker of the liquid in hot water. The liquids could all be combined once again. One denser liquid will have an increased temperature, while the other liquids will be at room temperature. Students can record observations about the densities of the substances and whether the heating of one of the liquids causes movement. This experiment could be repeated for each of the liquids.

Encourage your students to be creative and use questioning to lead them to the best choices possible for their experiment. Questions might include: How will you know if density has increased or decreased? How will you isolate the effect on one liquid?

Explore – Part 1, Day 2

(approximately 45 minutes)



Surface tension demonstration on International Space Station (ISS) using water held in place by metal loop; NASA

1. Have students conduct their experiments in which they measure and record data.

- Students record data in the Data section of their Astro Journals.

---

2. Instruct students to fill out their data into a chart or graph in the Charts/Graphs section of their Astro Journal.

Note to Teacher: You may want or need to do a formal introduction or review of graphing.

- **Students may need some assistance in choosing the most appropriate way to graph their data.**
- **Sample Questions:**
  - **How does this graph either support or refute your hypothesis?**
  - **Is there any other kind of graph that might better show what the data demonstrates about your hypothesis?**
  - **What kind of change or comparison are you trying to see? What kind of graph will show this?**

---

3. Have students fill out Results and Conclusions sections of their Astro Journals.

Explain – Part 1

(approximately 10 minutes)

Borehole drilling rig for soil investigation, Louisiana; USEPA

1. Ask some groups to share their hypotheses, data, what they think their data demonstrates about their hypotheses, and what we can learn from each individual experiment and the experiments as a whole.

MISCONCEPTION: Many students may feel that if their hypothesis is not "right" then their experiment is a failure. Emphasize that this is not true. Scientific understanding grows when we eliminate incorrect answers to scientific questions. The success or failure of a hypothesis and experiment is based on the accuracy of the process, not the result. Either way, we learn something.

---

2. Discuss results with students.

- Question: How did a change in the density of a substance affect the location of that substance in relation to other substances?
- *Answer: If the substance became more or less dense than the other substances around it, the substance would move.*

- Question: What would happen to the substance if it became less dense than the substances around it?
- *Answer: If a substance became less dense, it would rise.*

- Question: What would happen to the substance if it became denser than the substances around it?
- *Answer: If the density of a substance became greater, it would sink.*

- Question: What could you do to a substance to change its density?
- *Answer: A change in pressure or temperature can change the density of a substance.*

Explore – Part 2

(approximately 10 minutes)

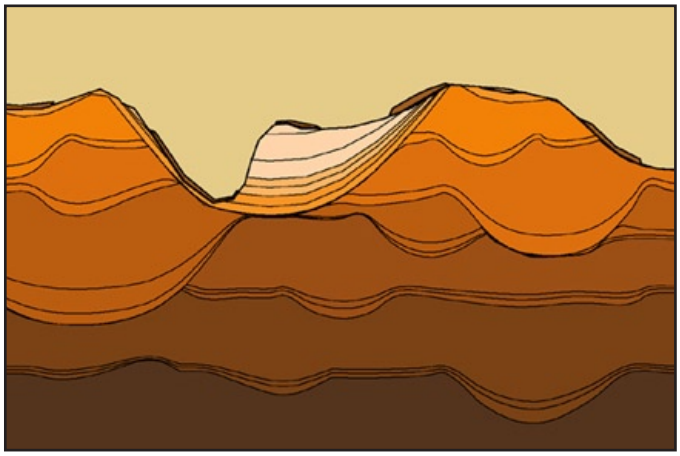


Illustration of possible upper martian crust derived from Mars Global Surveyor data; NASA

1. Lead students in the Convection Currents Demonstration.

- Say: In the previous activity, you learned that it was possible to change the density of a substance to cause movement. In this demonstration, you will use your knowledge to understand how the inside of the Earth moves.

Note to Teacher: This is written as a teacher demonstration, but students can complete this activity in small groups if enough resources are available.

- Conduct the Convection Currents Demonstration.
  1. Preheat a hot plate or other heat source to a medium-high setting.
  2. Use two beakers or glass containers that can be heated (made of material similar to Pyrex®). Fill both beakers $^3/_4$ of the way full with water.
  3. Sprinkle some glitter on top of the water in both beakers.
  4. Prior to the water being heated, have the students record their observations for both beakers in their Astro Journals.
  5. Place one of the beakers/containers on the hot plate or other heating source. Place the other beaker/container on the table next to the hot plate. This second beaker that is not heated will be the control for the experiment.
     - Question: Why is one beaker not being heated?
     - *Answer: One beaker is not being heated so that we can compare it to the effect of heat on the water and glitter on the other beaker.*

     - Say: The beaker that is not heated is called the "control."

  6. Have students observe the demonstration and record their observations in their Astro Journals.

  7. Have students respond to the questions in their Astro Journals.

Note to Teacher: Another great convection demonstration is the use of a lava lamp. Plug in the lava lamp prior to beginning your lesson. Have the students observe the lava lamp. Questions for discussion could include: What do you notice? What is happening to the "lava"? Why is this happening? Students should respond that the heat causes the "lava" to rise. When the "lava" rises, it cools and then sinks back down to the bottom to start the cycle again.

An alternative convection activity is to use soapy colored water. Fill each pie pan about one-half to three-quarters full of water, add 2 tablespoons soap, and stir gently until the soap is mixed throughout, without creating bubbles. Add a few drops of dye. Let the solution settle. Turn the hot plate on low until it is warm. Turn off the hot plate. Place one pan on the hot plate and leave the other off as a control. Convection cells may also be observed using a warm hand instead of a hot plate.

Explain – Part 2

(approximately 25 minutes)

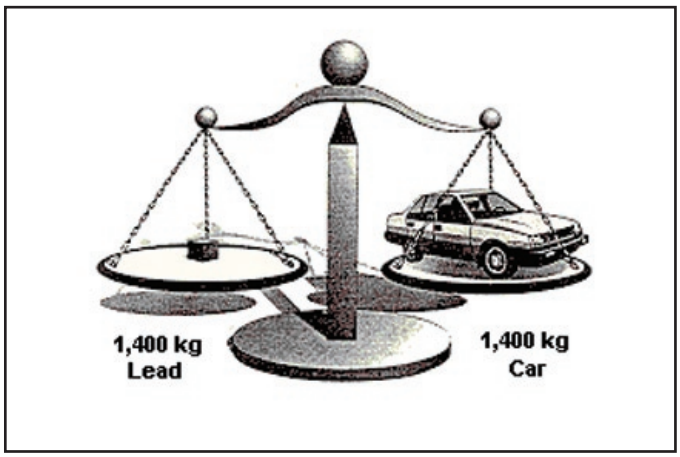


Illustration of density comparisons; USDOE

1. Discuss students' observations about the role of density in the Convection Currents Demonstration.

- Question: What do you think is causing the glitter to travel in circular paths?
- *Answer: (Accept all reasonable answers.)*

- Point to some of the glitter that is rising to the top of the beaker.

- Question: Why do you think this glitter is rising while the glitter over here is sinking? What could be the difference between the two sections of water containing glitter?
- *Answer: (Accept all reasonable answers.)*

- Question: What type of change in density causes substances to rise?
- *Answer: A decrease in density causes substances to rise.*

- Question: What factors can cause a decrease in density to occur? Why?
- *Answer: An increase in temperature or pressure can cause density to decrease. This occurs because the increase in temperature or pressure causes the molecules to spread further out. As a result, the molecules are not as tightly packed together so the substance is less dense.*

- Question: What is the one factor that we are changing in this activity that would affect density?
- *Answer: The change in temperature could affect density.*

- Question: Why is some of the glitter rising?
- *Answer: The sections of water with glitter that are rising have increased in temperature and become less dense. Because they are less dense, the molecules rise.*

- Question: Why then is some of the glitter sinking?
- *Answer: The sections of water with glitter sinking have decreased in temperature and become denser. Because it is denser, the molecules sink to the bottom.*

---

2. Introduce convection cells.

- Question: What is the main difference between the two sections of water—the one that is rising and the one that is sinking?
- *Answer: The main difference between the two sections is the temperature.*

- Question: So the water with the glitter that is sinking: is it cooler or warmer than the water with glitter that is rising?
- *Answer: The water with glitter that is sinking is cooler than the water with glitter that is rising.*

- Question: When the cooler water sinks to the bottom, where does it go next?
- *Answer: The water begins rising to the top forming a circle. (Hopefully students will see the circles of glitter in the water and understand that once the water sinks to the bottom it interacts with the heat source [hot plate] causing it to rise to the top, thus forming a circle.)*

- Say: This rising and sinking of water creates currents called convection cells.

- Question: If the water is moving to the top, what is causing it to rise?
- *Answer: An increase in temperature is causing it to rise.*

- Question: Where did this increase in temperature come from?
- *Answer: The hot plate provided this increase in temperature.*

- Say: So now we understand that when a substance cools, it becomes denser and sinks. We also understand that when the temperature of a substance is increased, it becomes less dense and rises.

- Question (point to the top part of the circle of the demonstration): How does the heated water that rises to the top then become the cooler water that sinks to the bottom of the beaker or glass container?
- *Answer: (Allow students to discuss their ideas.)*

3. Discuss the process of heat transfer.

- Question: What must happen to the heated water for it to sink?
- *Answer: The heated water must decrease in temperature.*

- Question: What causes the heated water to cool?
- *Answer: (Allow students to discuss their ideas.)*

MISCONCEPTION: Students do not always explain the process of heating and cooling in terms of heat transfer. Some students think that "cold" is being transferred from a colder to a warmer object, others that both "heat" and "cold" are transferred at the same time. Students often think that objects cool down or release heat spontaneously, without being in contact with a cooler object. The following will help to confront this misconception.

Heat Transfer Kinesthetic Activity: Students need to understand the molecular basis of heat transfer. To help students with this, you could have them model the transfer of heat using themselves as models. Have a group of students represent water that has been heated. This group of students should move around very quickly. Have a second group of students who represent cooler water. This group of students should not move as quickly. During the modeling activity, the two sets of molecules should come in contact with each other. If a heated water molecule comes in contact with a cooler water molecule, the heated water molecule should transfer some of its movement to the cooler water molecule. This causes the cooler molecule to speed up its movement, and the warmer molecule to slow down a bit until both are moving at the same speed.

- Question: How do you think the movement of the molecules of the heated water compare with the movement of the molecules of the cooler water?
- *Answer: The heated water molecules are moving much faster than the cooler water molecules.*

- Question: Do you think the heated water molecules come in contact with the cooler water molecules?
- *Answer: Yes, the heated water molecules come in contact with the cooler water molecules.*

- Question: What do you think happens when the heated water molecules come in contact with the cooler water molecules?
- *Answer: (Accept all reasonable answers.)*

Note to Teacher: At this point, you could have your students complete the Heat Transfer Kinesthetic Activity described above.

- Say: The heated water molecules that are moving more quickly come in contact with the cooler water molecules that are not moving as quickly. When this contact occurs, the heated water molecules transfer heat to the cooler water molecules. The heated water molecules lose heat and slow down, and the cooler water molecules gain heat and speed up until both molecules are at the same temperature. This transfer of heat through a substance in motion (solid, liquid, or gas) is called convection.

Extend/Apply

(approximately 45 minutes)

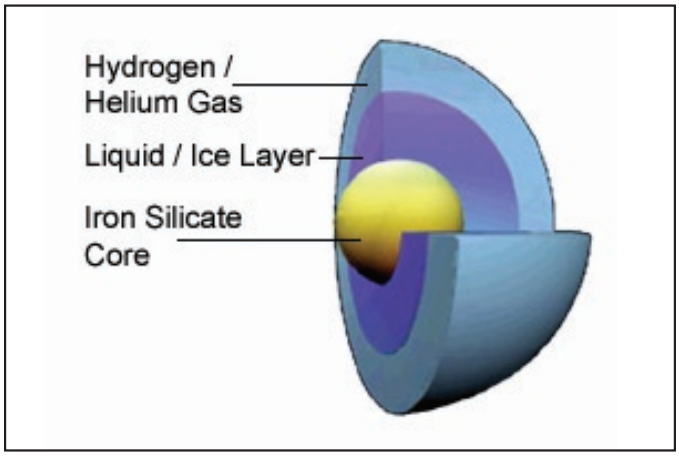


Illustration of Uranus using computerized 3D modeling

1. Discuss with students two ways to view the interior of the Earth.

- Question: How do you think your knowledge of convection and density can help you understand the interior of the Earth?
- *Answer: (Accept all reasonable answers.)*

- Question: Where do you think movement might occur in the Earth? Why?
- *Answer: (Accept all reasonable answers. Using their knowledge from the Geology Training module, student answers might include: a slow-moving lithosphere, a slow-moving viscous mantle, and a liquid, rotating outer core.)*

- Say: In the Geology Training module, you saw that there is movement in the lithosphere, the mantle, and the outer core.

- Say: There are two different ways that scientists can describe the layers of the Earth-based on composition or on movement.

Note to Teacher: There is an Earth Structure Transparency with two diagrams of the interior of the Earth at the end of this lesson that shows the lithosphere, asthenosphere, crust, mantle, and core and the convection of the mantle. It might be helpful to show the students this picture during the discussion below.

- Question: What are the main layers of the Earth?
- *Answer: The main layers of the Earth are the core, mantle, and crust.*

- Say: These layers are based on the composition of the layers. The rocky crust, the rock-metal mantle, and the metal core are how scientists describe what these layers are made of.

- Say: Scientists can also describe the interior of the Earth based on the movement of the layers.

- Question: What are the layers in the interior of the Earth that move?
- *Answer: The layers in the interior of the Earth that move are the lithosphere, asthenosphere, lower mantle, and outer core.*

- Say: Scientists can look specifically at these layers and study their movement. This is called the mechanical viewpoint of the interior of the Earth.

- Question: If you look at the interior of the Earth from a compositional viewpoint, what are the layers that make up the Earth?
- *Answer: The layers that make up the interior of the Earth based on composition are the crust, mantle, and core.*

- Say: If you look at the interior of the Earth from a mechanical viewpoint, what are the layers that make up the Earth?
- *Answer: The layers that make up the Earth based on mechanics are the brittle, rigid lithosphere, partially molten asthenosphere, the lower mantle, liquid outer core, and solid inner core.*

---

2. Discuss with students how the information they learned about convection and density relates to the Earth.

- Say: In this lesson, since we are looking at movement inside the Earth, we will focus on the lithosphere and the asthenosphere.

- Question: What is the lithosphere?
- *Answer: The lithosphere is formed by the crust and the uppermost part of the mantle.*

- Say: Scientists have evidence that the lithosphere is broken up into sections. These sections of the lithosphere are called plates.

- Question: What layer is under the lithosphere?
- *Answer: The asthenosphere is under the lithosphere.*

- Question: How would you describe the asthenosphere?
- *Answer: The asthenosphere is a part of the upper mantle below the lithosphere that is partially molten.*

- Say: Because the asthenosphere is partially molten, the plates move on top of the asthenosphere.

Note to Teacher: In the view of the Earth's mechanics, geologists generally refer to the section we are calling the "lower mantle" as "mesosphere." The mesosphere is the part of the Earth's mantle that is below the asthenosphere and above the outer core. Since this layer is not of major focus when describing plate tectonics, we decided not to introduce another new term here.

- Question: Which layer did the Geology Training module show convecting?
- *Answer: The Geology Training module showed the mantle convecting.*

Note to Teacher: There are two different theories about how Earth's mantle moves. One theory says that the upper mantle and lower mantle move together as a single convection system. Another theory states that the asthenosphere has its own convection system separate from the rest of the mantle. There is good evidence for both of the explanations. As with any scientific debate, more research and evidence must be presented before anyone can say for sure which theory is correct.

- Say: Material inside the mantle moves in convection cells. We are going to use our knowledge of convection cells from our demonstration to help us understand the convection cells in the mantle.

- Question: In the demonstration, what caused some of the molecules to start rising?
- *Answer: An increase in temperature caused some of the molecules to start rising.*

- Question: Where did this increase in temperature come from?
- *Answer: The increase in temperature came from the hot plate.*

- Question: What do you think might provide an increase in temperature inside the Earth?
- *Answer: The interior of the Earth is hot. This provides heat energy to the material within the interior of the Earth.*

Note to Teacher: Scientists do not agree on the cause of convection currents in the mantle. Some believe that the cause is the internal heat, while others believe that convection is generated by friction from plate movement.

---

3. Have students complete the Convection Cells Drawing in their Astro Journals.

---

4. Discuss with students how their knowledge of convection currents can be applied to real world situations.

- Question: Where do you think there is evidence of convection currents in your home?
- *Answer: (Allow students to share their ideas. Students may respond that steam rising in the shower is an example of convection currents.)*

- Question: In a two-story building, where do you think it is warmer? Why?
- *Answer: In a two-story building, it is warmer on the second floor than on the first floor due to heat rising.*

- Question: Where would you want to have heater vents in your home? Why?
- *Answer: Heater vents would be best located near the floor so that heat rises throughout the room. When it reached the ceiling, it would cool and sink causing convection cells that would transfer heat throughout the room.*

- Question: What would happen if the heater vents were located near the ceiling instead?
- *Answer: Unless there were a strong air flow in the room, the heat would tend to stay at the top of the room, since there would be nothing cooler to draw it down to the floor.*

Evaluate

(approximately 20 minutes)

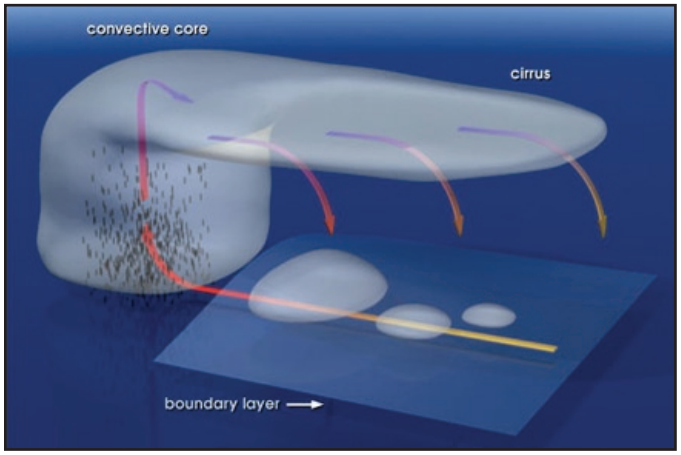


Illustration of convection principle showing hot, humid air rising, then cooling, resulting in heavy precipitation; NASA

1. Have students share their Convection Cells Drawings.

---

2. Discuss students' responses in their Astro Journals to ensure they have mastered the major concepts.

- Question: What are convection cells and how are they helpful?
- *Answer: Convection cells are circular currents formed when heated material rises and cooler material sinks. They transfer heat.*

- Question: Why does the material rise or sink?
- *Answer: The loss or gain of heat energy results in a change in density that causes the material to rise or sink.*

- Question: How does the inside of the Earth move?
- *Answer: Heat from deep inside the Earth heats up the lower mantle. This increase in heat results in a decrease in density. This decrease in density causes the lower mantle material to rise. Mantle material near the crust comes in contact with cooler material. During this contact, heat energy is transferred from the warmer material to the cooler material. Once cooled, the material is denser, causing it to sink and come into contact with the heat from the interior of the Earth where it heats up, becomes less dense, and rises once again.*

---

3. Collect students' Astro Journals and evaluate them to ensure they have each mastered the major concepts.

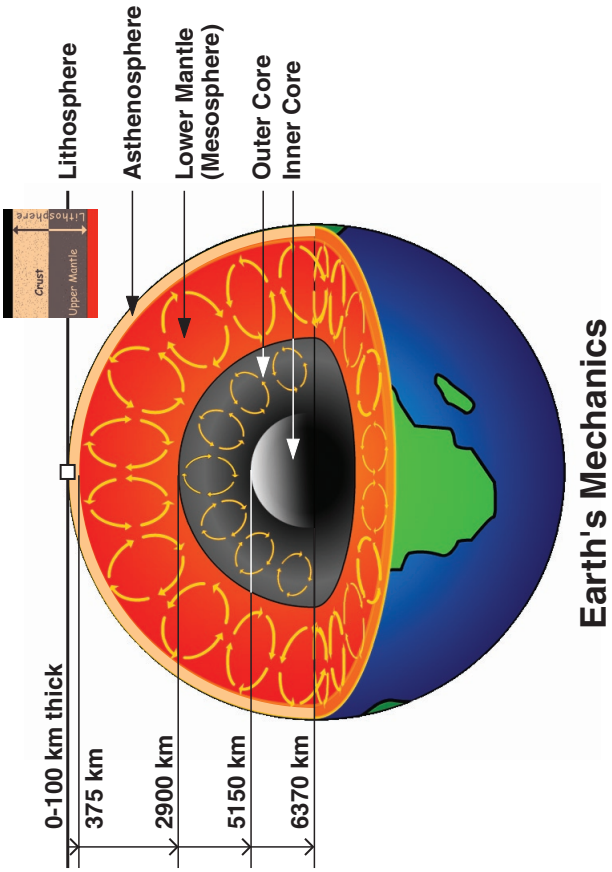
- The interior of the Earth is hot. This heats up the lower mantle, which becomes less dense and rises to the upper mantle where it comes in contact with cooler material. The warmer material loses heat and the cooler material gains heat until both are the same temperature. As the resulting material cools, it becomes denser and sinks back to the lower mantle. The temperature of the material is then increased by the heat inside the Earth, decreasing density and rising again. This results in convection cells that transfer heat and create movement inside the Earth.

4. Bridge to next lesson.

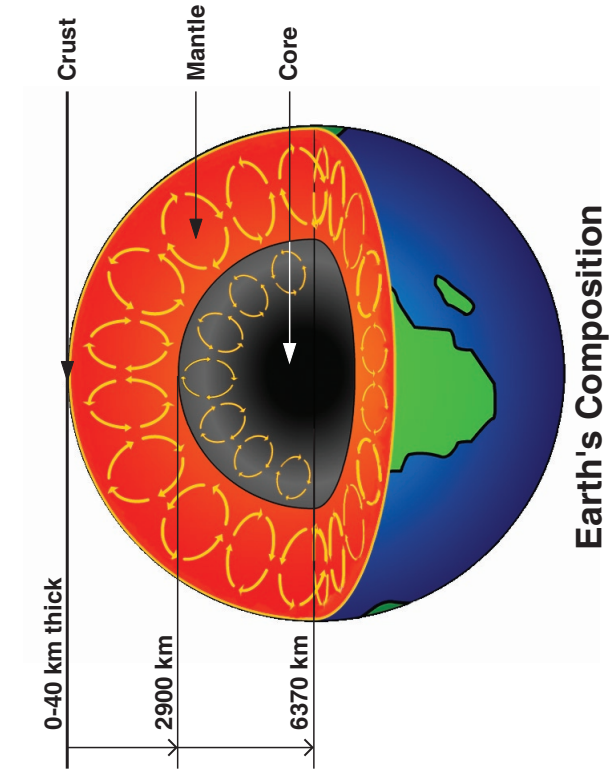
- Say: Today we learned that temperature and pressure affect density and how this causes movement inside the Earth. In the next two lessons we will see how this movement is important for human survival on Earth.

Note to Teacher: After each lesson, consider posting the main concept of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Earth Structure Transparency



Earth's Mechanics



Earth's Composition

Astro Journal Geology Lesson 4: Convection in the Earth

Name _____ Date _____ Class/Period _____

Scientific Question:
How does the inside of the Earth move?

1. Hypothesis/Prediction: Is it possible to change the density of a substance in order to cause movement? Explain your answer.

2. Refined Hypothesis/Prediction:

3. Materials: What materials will you use to test your hypothesis/prediction?

4. Procedures:

Astro Journal Geology Lesson 4: Convection in the Earth

Name _____ Date _____ Class/Period _____

5. Data: Record and display your data in a chart, table, or graph.

Charts/Graphs:

Astro Journal Geology Lesson 4: Convection in the Earth

Name _____ Date _____ Class/Period _____

6. Results: Is it possible to change the density of a substance in order to cause movement? Use data from your experiment to support your answer.

7. Conclusions: Compare and contrast your hypothesis and results. How did testing your hypothesis/prediction and drawing relationships change your original ideas?

Astro Journal Geology Lesson 4: Convection in the Earth

Name _____ Date _____ Class/Period _____

Convection Currents Demonstration
1. What observations did you make during the Convection Currents Demonstration?
2. What do you think is causing the glitter to travel in circular paths?
3. Why do you think this glitter is rising while the glitter in another area is sinking? What could be the difference between the two sections of water containing glitter?

Convection Cell Drawing Activity

Draw and describe how convection cells in the mantle work. Be sure to include:

1. Labels of the parts of the Earth involved.
2. Labels and description of how heat is transferred at each step.
3. Description of what causes the movement of the materials at each step.
4. Explanation of how convection cells are important.

Your drawing and description will be evaluated using the following rubric:

4 Expectations Exceeded	• Drawing clearly and accurately explains how convection cells in the mantle work. • Drawing has all required parts and uses excellent reasoning to create exceptionally powerful and detailed descriptions.
3 Expectations Met	• Drawing clearly and accurately explains how convection cells in the mantle work. • Drawing has all required parts and uses good reasoning in descriptions.
2 Expectations Not Quite Met	• Drawing is not completely clear or accurate in explaining how convection cells in the mantle work. • Drawing has most required parts and uses some good reasoning in descriptions.
1 Expectations Not Met	• Drawing is not clear or accurate in explaining how convection cells in the mantle work, is missing several parts, and uses little or no good reasoning.