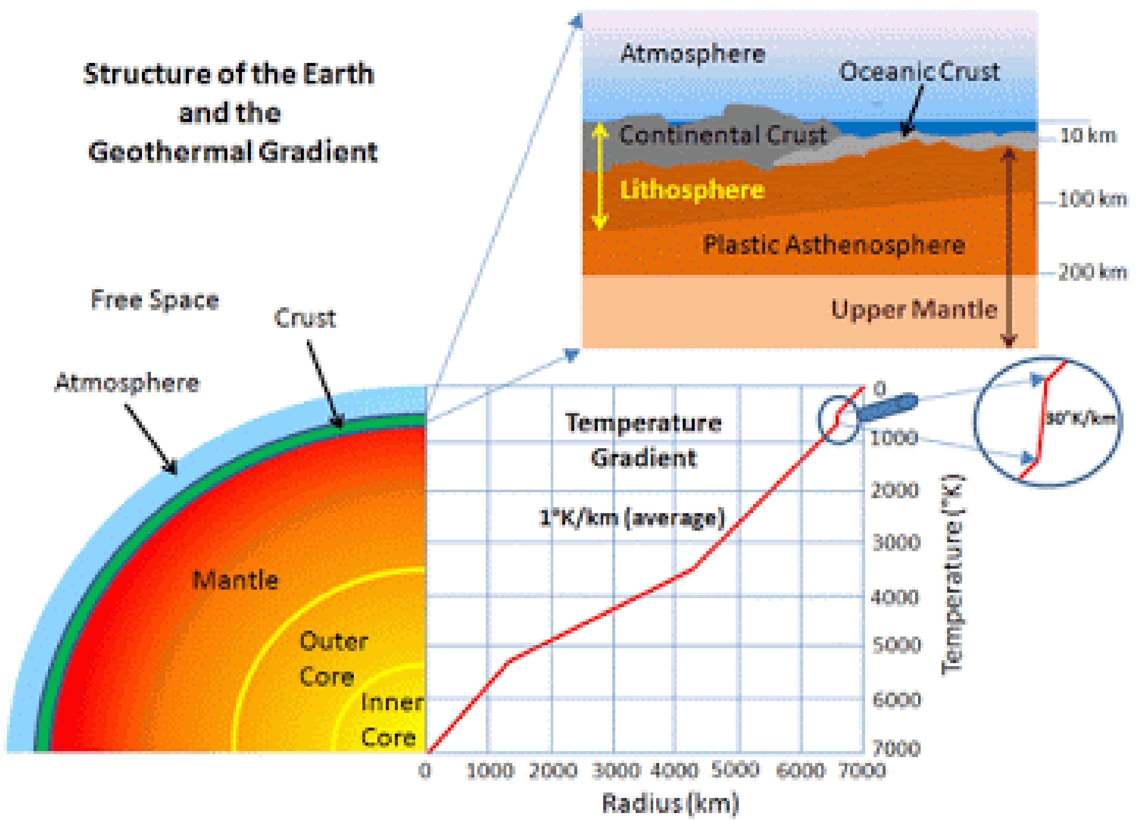
URBAN HEAT ISLAND MODULE

LESSON 4:

CONDUCTION



Source: Geothermal Gradient. *Geology In.* (http://www.geologyin.com/2014/12/geothermal-gradient.html) 12/8/2014

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The following lesson and associated materials are part of the Integrating Chemistry and Earth science (ICE) Urban Heat Island Module. The Module brings together important concepts from Earth science and chemistry to help students build an understanding of why urban areas have higher temperatures both during the day and at night, than their rural counterparts.

ICE Partners

Cary Institute of Ecosystem Studies · Baltimore City Public Schools · The George Washington University, Washington, DC

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Lesson 4: Conduction

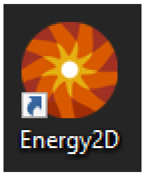
Driving Question: *What happens when two objects, at different temperatures, touch?*

Summary: Students will utilize a computer simulation to study the process of conduction and compare the conductivity of different materials.

Activity Description:

- **Opening Activity:** Engage students' prior knowledge by asking student what happens if you put your tongue on a cold pole?
    - Ask, "What happens when two substances at different temperatures touch?"
    - Show A Christmas Story – Tongue Stuck to Pole (YouTube-2:14) from 1:10-2:14 to illustrate how heat flows from warmer substances to cooler substances.
- **Simulation:** Students will investigate the conductive properties of materials using a computer simulation.
    - Use the Energy2D simulation from the Concord Consortium.
        - The simulation is free.
        - It can be downloaded and installed on school computers without requiring an administrator password.
    - Students will design an experiment to rank which of four materials (copper, glass, rubber, oak wood) is the best heat conductor and make a claim, provide evidence from the simulation, and explain their reasoning for their conclusion.
    - *Energy 2D Student Sheet*
    - Discussion Prompt: What is happening to energy in this system?
- **Conduction through Earth's Crust:** Students connect the information from the simulation to the Earth's structure and behavior.
    - Students read about *Geothermal Gradients* and use the UHI Modeling Template to update their global heat models to show conduction through Earth's crust.
        - See the Modeling Template – Teacher Instructions for additional information.
        - Earth Heat Flow Map – for teacher information.
- **Global Heat Model:** Students will make a final version of their global heat models by editing their current version and completing the explanation portion of the model sheet.
    - UHI Modeling Template
- **Homework:** Complete model if extra time is needed.

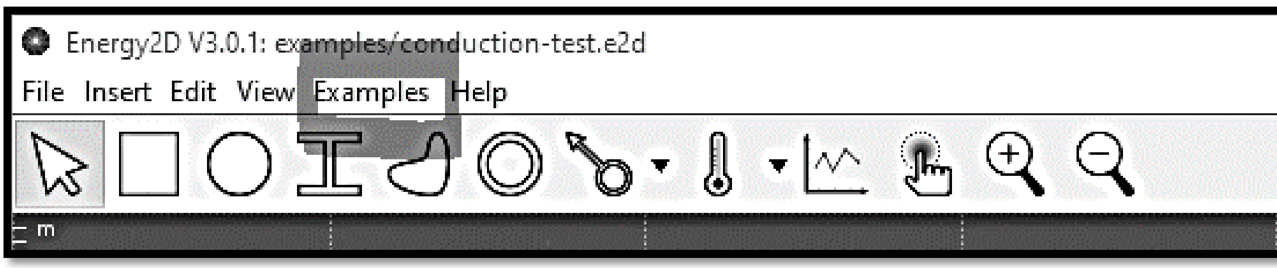
Energy 2D Conduction Computer Lab



For this investigation you will be using the Energy 2D Simulation found on your computer.

Look for the Energy 2D icon.

- To begin this investigation look at the top of the screen and find and click on examples "Examples"
- Click on Conduction "Which Material is the Best Conductor"



- Each "Substance bar" can be dragged down between the energy boxes. By connecting the boxes and clicking "Run" at the bottom of the screen you can observe the conductivity properties of each.
    - Please note that there is a timer in the upper right hand corner of the screen.
- Your job is to design and run an experiment to rank which of the four materials [copper, rubber, glass, oak wood] is the best conductor of heat.
- Hypothesis:

- Procedures:
    - Write out the procedures you will follow to test your hypothesis:

- Data Collection:
  - What data will you collect it and how will you record the data?

- Conclusion (CER format) Which substance is the best conductor of heat?
  - Outline:
    - Claim:
    - Evidence:
    - Reasoning:
  - Final conclusion must be in paragraph form:

Geothermal Gradients: Conduction through the Earth.

From: Geothermal Gradient. *Geology In.* (http://www.geologyin.com/2014/12/geothermal-gradient.html) 12/8/2014

Read the article below, annotate, and answer the questions.

Geothermal gradient is the rate of increasing temperature with respect to increasing depth in the Earth's interior. Away from tectonic plate boundaries, it is about 25 °C per km of depth (1 °F per 70 feet of depth) in most of the world. Strictly speaking, geo-thermal necessarily refers to the Earth but the concept may be applied to other planets.	1. Define, in your own words, Geothermal Gradient.
The Earth's internal heat comes from a combination of residual heat from planetary accretion; heat produced through radioactive decay, and possibly heat from other sources. The major heat-producing isotopes in the Earth are potassium-40, uranium-238, uranium-235, and thorium-232. At the center of the planet, the temperature may be up to 7,000 K and the pressure could reach 360 GPa (3.6 million atm). Because much of the heat is provided by radioactive decay, scientists believe that early in Earth's history, before isotopes with short half-lives had been depleted, Earth's heat production would have been much higher. Heat production was twice that of present-day at approximately 3 billion years ago, resulting in larger temperature gradients within the Earth, larger rates of mantle convection and plate tectonics, allowing the production of igneous rocks such as komatiites that are not formed anymore today.	2. What is the source(s) of the Earth's internal heat? 3. What was the effect of higher heat production earlier in the earth's life?

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Heat sources

- Much of the heat is created by decay of naturally radioactive elements. An estimated 45 to 90 percent of the heat escaping from the Earth originates from radioactive decay of elements mainly located in the mantle.
- Heat of impact and compression released during the original formation of the Earth by accretion of in-falling meteorites.
- Heat released as abundant heavy metals (iron, nickel, copper) descended to the Earth's core.
- Latent heat released as the liquid outer core crystallizes at the inner core boundary.
- Heat may be generated by tidal force on the Earth as it rotates; since rock cannot flow as readily as water it compresses and distorts, generating heat.
- There is no reputable science to suggest that any significant heat may be created by electromagnetic effects of the magnetic fields involved in Earth's magnetic field, as suggested by some contemporary folk theories.

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<td>4. As the article says, much of the internal heat comes from the decay of radioactive elements. Examine the other presented sources and list the 3 that you believe are the next most important in the heat generation process, and why you chose them.</td>
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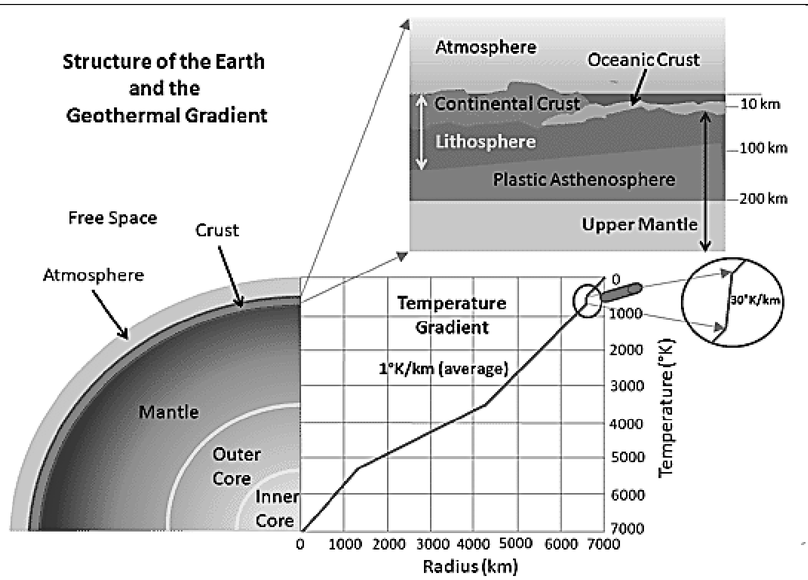

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<td>5. Examine the diagram. Based on the slope of the graph, which layer decreases in temperature fastest, per km?</td>
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Application Heat from Earth's interior can be used as an energy source, known as geothermal energy. The geothermal gradient has been used for heating spaces and bathing since ancient Roman times, and more recently for generating electricity. As the human population continues to grow, so does energy use and the correlating environmental impacts that are consistent with global primary sources of energy. This has caused a growing interest in finding sources of energy that are renewable and have reduced greenhouse gas emissions. In areas of high geothermal energy density, current technology allows for the generation of electrical power because of the corresponding high temperatures.	6. How can we use the heat within the earth?
Generating electrical power from geothermal resources requires no fuel while providing true baseload energy at a reliability rate that constantly exceeds 90%. In order to extract geothermal energy, it is necessary to efficiently transfer heat from a geothermal reservoir to a power plant, where electrical energy is converted from heat. On a worldwide scale, the heat stored in Earth's interior provides an energy that is still seen as an exotic source. About 10 GW of geothermal electric capacity is installed around the world as of 2007, generating 0.3% of global electricity demand. An additional 28 GW of direct geothermal heating capacity is installed for district heating, space heating, spas, industrial processes, desalination and agricultural applications.	7. What is required for efficient geothermal electricity generation to occur?