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Edible Earth and Space Science Activities

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Abstract. In this workshop we describe using Earth and Space Science demonstrations with edible ingredients to increase student interest. We show how to use chocolate, candy, cookies, popcorn, bagels, pastries, Pringles, marshmallows, whipped cream, and Starburst candy for activities such as: plate tectonics, the interior structure of the Earth and Mars, radioactivity/radioactive dating of rocks and stars, formation of the planets, lunar phases, convection, comets, black holes, curvature of space, dark energy, and the expansion of the Universe. In addition to creating an experience that will help students remember specific concepts, edible activities can be used as a formative assessment, providing students with the opportunity to create something that demonstrates their understanding of the model. The students often eat the demonstrations. These demonstrations are an effective teaching tool for all ages, and can be adapted for cultural, culinary, and ethnic differences among the students.

1. Introduction

Edible astronomy and Earth Science demonstrations increase student interest and knowledge of Earth/Space Science concepts. These have been successful with all age groups from elementary school through college students. Sometimes the students eat the results of the demonstrations. These demonstrations are an effective teaching tool and the students remember these demonstrations after they are presented. These demonstrations can be modified for cultural, culinary, and ethnic differences.

There are two categories of Edible Earth and Space Science demonstrations, ones that simulate phenomena or processes and ones that simulate a model illustrating structure, and morphology. Some examples may be mixed types. Edible Earth and Space Science demonstration examples and simulations:

- Differentiation (marshmallows, chocolate, nuts)
- Plate tectonics (crackers with peanut butter/jelly)
- Convection (hot chocolate, soup)
- Mud flows on Mars (melted chocolate poured on cake)
- Formation of the Galactic Disk (pizza)
- Formation of Spiral Arms (coffee with cream)

- Curvature of Space (Pringles)
- Expansion of Universe (chocolate-chip cookies)
- Radioactivity; radioactive dating (popcorn)
- Comets (Hostess snowballs, tartufo)
- Lunar phases (black and white cookies, Oreos)
- Solar radiation at the Earth's surface (solar heating of coffee/hot chocolate)
- Lunar crater formation (dropping candy into cocoa and flour)
- Light scattering, interstellar reddening (milk in water); why the sky is blue
- Star colors (cookies with different colored frosting)
- Black hole with jets (bagel or donut, ice cream cone)
- Colors of stars (gum drops)
- Star shaped cookies with colored frosting
- Chocolate chip constellations (Family Astro example)
- Pizza with pepperoni or mushroom spiral arms

For example to show differentiation during the formation of the Earth one can show how different densities interact. Melt chocolate, stir in nuts and marshmallows and when it cools and hardens—shows separation. Melt and re-freeze ice cream with fruit, nuts, chocolate (rocky road). Custards, flan, zabiaone, Crème brûlée (French), crema catalana (Spanish), burnt cream (English) berries and whipped cream can be used to show layered formation

In this workshop we will show in detail four examples of edible Earth and Space Science demonstrations: Starburst candy formation of the planets and popcorn radioactive dating by Donald Lubowich; Edible plate tectonics and Inside Mars—recipe for planet formation by Christine Shupla.

Figure 1. Starburst Candy formation of planets. *Left:* Starbust candies. *Right:* pressing the candy together, one can make square objects into "round planets."

2. Planetary formation (Lubowich)

Starburst candies are used to demonstrate how planets are formed. Rocky planets and dwarf planets in our solar system were formed by from gas, dust, and irregularly shaped objects called planetesimals in the early Solar System. The heat due to gravity from the collisions of planetesimals (and radioactivity in some planets) caused the hard rocks to "soften" and become round.

1. Unwrap a dozen "Starburst" candies of different colors and place them in your hand.

2. Put both hands together and roll them around with pressure. Soon the rectangular shaped candies will become a multicolored round candy ball like a round planet or dwarf planet.

The center of the Earth is composed of iron and nickel compared to the surface which is sand and water. This second demonstration shows why the center of the Earth (and the other) planets is denser than the surface?

Early in the Solar System the planets were squishy and not very solid due to the heat of formation. The heavier denser elements sank to the center of the forming planets. The same effect occurred in the giant gas planets (Jupiter, Saturn, Uranus, or Neptune). Here is how to form a "rocky-road" Earth.

1. In a tall glass of chocolate milk drop M&Ms, nuts, or colored candy. They will sink to the bottom.

2. Drop mini-marshmallows into the milk. They will float to the top of the glass.

If you then freeze this mixture, you will get a "rocky-road" Earth which simulates the structure of the Earth. This process is called differentiation. As the planets cooled, the rocks became hard and the initial planetary structure was formed.

Figure 2. Lunar phases using a black and white cookie.

3. Edible Plate Tectonics (Shupla)

Students (grades 5 and up) use edible materials model a plate boundary, including the asthenosphere, the plate crusts, and the resulting features from the interaction, as an assessment of their understanding.[1]

3.1. Overview

The students will create an edible model of the lithosphere and asthenosphere, moving them and using a variety of materials to model different characteristics of interacting plate boundaries.

3.2. Objective

The students will:

- Determine which characteristics of plate boundaries to model.
- Discuss analogies for different types of volcanism.
- Create a model for a type of plate interaction.

3.3. Before you start

The students should be familiar with the concepts of the lithosphere and asthenosphere, and the different types of plate tectonics interaction (subduction, divergent, convergent, and transform fault boundaries).

3.4. Activity

Invite the students to describe different types of plate interaction. Share with the students that they are going to model these interactions with food. Hand out items as needed.

1. Each student should pick a particular type of plate boundary in advance to model.
2. Each student should take a paper plate and fill it with 2 centimeters of whipping cream.
3. Students will use vanilla wafers to model continental crust, and graham crackers to model oceanic crust.
4. Butterscotch chips will be used for volcanos in subduction zones.
5. Chocolate frosting will be used for volcanos at divergent boundaries and hot spots.
6. Students should position their materials to create their boundary, and then participate in a group or classroom discussion:

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[1] `www.lpi.usra.edu/education/workshops/plateTectonics/EdiblePlateTectonics.pdf`

- In what ways does the graham cracker model ocean crust? [thinner and denser]
- How does the vanilla wafer model continental crust? [thicker and less dense]
- What happens when two ocean plates collide? When they diverge?
- Which boundaries should have the volcanos? Where should they be?
- Which boundaries might have chocolate frosting?
- In what ways do these models succeed? In what ways do they fail?

Time to eat!

Figure 3. Black Hole Bagel. The bagel represents the accretion disk around a black hole. The radiation (Twizzlers candy) is emitted from jets perpendicular to the bagel accretion disk in a conical distribution. Adapted from Fermi satellite activity `http://fermi.sonoma.edu/teachers/tastyagnlitho06a.pdf`

4. Popcorn radioactive dating (Lubowich)

Use a small air popcorn popper. Have the students count 100 kernel groups (you can also use 200 kernels). Start the timing when first kernel pops. After a period of time, have students count the popped kernels. It is not always clear if a kernel has popped as there are intermediate cases. Plot the fraction (percent) popped and not popped, and estimate the popcorn "half-life." Have students test their prediction for time it will take for 50% of the popcorn to pop.

Explain radioactivity and the causes of different types of radiation. Discuss the random statistical nature of radioactivity—just as you don't know which kernel will pop, one cannot predict which atom will emit an alpha particle, beta particle, or gamma ray. Explain half-life and how to measure the age of rocks or stars. Discuss different examples of radioactive dating using uranium, argon, and carbon.

For example, ^{235}U decays to ^{207}Pb with a half-life of ~700 Myr and ^{238}U decays to ^{206}Pb with a half-life of ~4.5 Gyr. The oldest Earth rocks are ~4.3 Gyr old, and the oldest Moon rocks are ~4.4 Gyr old. Uranium has been detected in two stars, and the ages determined from the U/Th ratios are 12.5 Gyr and 13.5 Gyr.

Table 1. Results of the popcorn radioactivity dating demonstration.

Time (s)	# kernels	% popped	% un-popped
0	100	0	100
10	100	35	65
20	100	85	15
30	100	95	5

5. Inside Mars—Recipe for a Planet (Shupla)

Students grades 3 and up build edible models of Earth and Mars to compare their sizes and illustrate their internal layers.[2] Related activities for comparing the interior structure or astronomical bodies include: Recipe for a Moon,[3] Jiggly Jupiter,[4] Candy Gas Giants,[5] and Edible Venus.[6]

5.1. Overview

"Recipe for a Planet" is a 45 minute activity in which children ages 8 to 13 build edible models of Earth and Mars to compare their sizes and illustrate their internal layers. An optional investigation, "Differentiation Demonstration," enhances this activity.

5.2. What's the Point?

- Mars is about half the size of Earth.
- Mars and Earth have internal layers, including cores, mantles, and crust.
- Earth has a solid inner core and molten outer core; Mars most likely has a molten core.

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[2] http://www.lpi.usra.edu/education/explore/mars/inside_mars/recipe_planet.shtml

[3] www.lpi.usra.edu/education/explore/marvelMoon/activities/makingMoon/recipe/

[4] www.lpi.usra.edu/education/explore/solar_system/activities/jigglyJupiter/

[5] http://www.lpi.usra.edu/education/space\days/activities/gasGiants/candyGas.pdf

[6] http://www.lpi.usra.edu/education/space_days/activities/venus/edibleNonedible.pdf

- Surface features on a planet provide clues to their internal processes.
- Volcanos on a planet's surface suggest that the interior of the planet is (or was recently) sufficiently hot to create magma, molten rock.
- Models—such as the children are using here—can be tools for understanding the natural world.
- Geologists use comparisons between features on Earth and other planets, like Mars, to help them identify differences in how the features may have formed or changed.

5.3. Materials

Each child should have one Geologic Science Investigator (GSI) Journal: "Mars Inside and Out" or one GSI Journal Part 2: "Inside Mars" (Lunar and Planetary Institute), and one pencil.
For each team of 3 to 4 children (or for each individual child if you prefer that they make their own planets):

- 10–12 mini chocolate chips and 3–4 regular size chocolate chips
- 2 teaspoons of green sprinkles or "jimmies"
- 4 teaspoons of blue sprinkles or "jimmies"
- 3 teaspoons of red sprinkles or "jimmies"
- 4 tablespoons of red icing
- 1 small paper cup
- 1 donut hole, preferably chocolate
- 6 pre-packaged Rice Krispies Treats
- 3 zip lock baggies
- 2 cardboard plates
- 1 ruler
- 1 pair of scissors
- 1 sturdy plastic knife
- Several wet wipes or damp paper towels
- Recipes for Earth and Mars
- Butcher paper, newspapers, or disposable table cloths for the activity area (optional)

Preparation notes:[7]

- You may need to modify this activity for children with dietary restrictions.
- Make copies of the global images of Earth and Mars.
- Place the different colors of sprinkles in separate baggies. Place both sizes of chocolate chips in a baggie. Place the red icing in the small paper cup.
- This is a fun, but messy activity! If possible, tell the children ahead of time to wear an old shirt or apron, or you may wish to provide trash bags for them to wear.

5.4. Activity

1. Introduce the activity by dividing the children into teams of 3 or 4 and explaining that each team will create edible models of Earth and Mars. Invite them to share what they know about Mars.
    - Are Earth and Mars the same size? Which is bigger?
    - What color is Mars from space? What about Earth?
    - Does Mars have several land masses—or continents—like Earth?
    - Does Mars have oceans like Earth?
    - Do Earth and Mars have volcanos? What differences in the volcanos can they recall from earlier activities?
    - Does Earth have layers inside? Can they name some of those layers?
    - What is the inside of Earth like? Children may say there is a molten layer under the surface; this is an important misconception that will be examined in the activity.
    - Does Mars have layers inside? What might they be like
    - Do you think Earth and Mars look similar on the inside?
2. Before you begin, explain to the children that this is a fun and tasty—but messy—activity! Have them wash their hands before they start and remind them to not lick their fingers while they are working on their models. For now, they will just make the model—they will be invited to eat it at the end of the activity!
3. Create a model of Earth! Provide the materials to the teams and invite them to create a model of Earth.
    - Earth's inner metallic core: a donut hole
    - Earth's molten outer core: red icing
    - Earth's mantle: 3 1/2 Rice Krispies Treats
    - Earth's oceanic crust: blue sprinkles or "jimmies"

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[7]Background information at `http://www.lpi.usra.edu/education/explore/mars/background/`

- Earth's continental crust: 1/2 of a Rice Krispies treat covered in green sprinkles or "jimmies"
- Have each team tear one of their Rice Krispies treats in half and set one half aside. Mash the other half together with 3 more Rice Krispies Treats so they make one "mega treat." Have them form the treat into a flat rectangle, about 4 inches by 6 inches. Starting in the center of the flattened "mega treat," smooth a thin sheet of the red icing to within one inch of each edge; they should use about half of the icing and save the rest for later. Place the donut hole in the middle. Gently wrap the Rice Krispies Treats around the donut hole—with the icing side against the donut hole—to form a ball. Roll it around and squeeze it to make it firm.
- Invite the children to add continental and oceanic crusts to their Earth. Have them place their Earth sphere in the baggie with the blue sprinkles. Roll it around until it is thoroughly covered in blue. Remove and set it aside.
- Ask the children what they think the blue represents. Many of the children may say "the ocean." Clarify that in this model we are using blue to represent the thin crust under the ocean (oceanic crust).
- Now invite them to make the continental crust—the land on Earth. Ask them to take the Rice Krispies Treat half they set aside earlier and flatten it into a thin layer. Have the children create four or five continent shapes, then gently press one side of each continent into the green sprinkles until covered. Have them gently press each continent onto the Earth sphere with the sprinkle side up. In reality, the thicker continental crust does not "sit" on top of the oceanic crust; both sit above the Earth's mantle.
- What do the green sprinkles represent? The crust, or land, that is above the ocean (the thicker continental crust).

4. Create a model of Mars. Provide the materials to the teams and invite them to create a model of Mars.

    - Mars' inner core: 2 tablespoons of red icing
    - Mars' mantle: 2 Rice Krispies Treats
    - Mars' crust: red sprinkles
    - Have the teams shape their Rice Krispies Treats into a rectangle about four inches by two inches. Place the red icing in the center and gently wrap the Rice Krispies Treat around it, shaping it into a ball.
    - What color is the surface of Mars from space? Mostly red.
    - Have the children place their Mars sphere in the baggie with the red sprinkles and roll it around until it is thoroughly covered in red. Remove and set aside.

5. Invite the children to examine and discuss their models.

    - Which is larger? Earth.
    - What features did they see on Earth and Mars in their earlier investigations? Channels, volcanos, and impact craters.

- How might they make their Earth and Mars more realistic? Their answers may include adding these features.

6. Revisit their crater ideas.

    - Which has more craters? Mars.
    - Which has bigger craters? Mars.
    - How might the children add craters to their Earth and Mars? They can use their fingers to make impressions in the surface to represent giant impact craters.

7. Revisit their volcano ideas and their findings from earlier activities.

    - Which has more volcanos? Earth.
    - Which has bigger volcanos? Mars.
    - Is there a pattern to where the volcanos on Earth are? They are mostly in a line or chain. Sometimes they are in chains along continents or in the middle of oceans.
    - Invite the teams to add chocolate chip volcanos to their Earth and Mars models, based on their observations and what they learned in other activities. They may want to use the left-over red icing to help the chocolate chips stick.
    - Where should small chocolate chip volcanos go? Earth. Facilitator Note: at the model Earth scale, these chocolate chips are really much too large!
    - Where should the large chocolate chips go? Mars.
    - Which will have more chocolate chip volcanos? Earth.
    - Which planet has volcanos in chains? Earth.

8. Ask the children what volcanos tell us about a planet.

    - What makes volcanos? Molten rock or magma coming from inside the planet.
    - If the rock is melted, what does this mean about the temperature of the planet? It is hot enough to melt the rock!
    - Earth has lots of active volcanos—like Hawaii, Mount St. Helens, Mount Erebus in Antarctica, and Mount Etna in Italy. What does that mean about its inside? Earth is very hot.
    - On Mars, we have the volcanos, but there are fewer than on Earth—and we have never observed one erupting. What might this tell us about Mars? Mars has been hot enough to make volcanos, perhaps not very long ago, but it is not as hot as Earth.
    - Planetary scientists hypothesize that some of Mars' volcanos were active not very long ago, between 10 million years ago and a hundred million years ago. They suggest this because the volcanic rock around many of the volcanos is not heavily cratered; the surface appears fresh.

- What does the red icing represent? Melted or molten rock, or magma under the volcano. Is there a layer of melted rock under the Earth's crust in their model? No, just little pockets. This is an important point to make, as children often think there is a melted layer under Earth's crust that feeds magma to volcanos. If there were a molten layer everywhere, we might expect to see volcanos everywhere!
- Is there a melted layer anywhere in Earth—did they use the red icing for any layer? Yes, the red icing was used for the outer core. Earth's outer core is molten.

9. Have the children spend a few minutes talking in their groups about what the inside of their Earth and Mars model planets will look like if they cut them open. Invite them to draw their predictions if they wish.

10. Return to their models and have the teams carefully cut both Earth and Mars in half. Small children may need help cutting, and they may need to reshape the planets after cutting.

11. Invite the teams to examine the cross sections of their planets.

    - Were their predictions correct about the interiors of Earth and Mars? Do the insides of the planets look like the children thought they would?
    - What do the different layers represent? Refer to steps 3 and 4.
    - In what ways are the interiors of Mars and Earth similar? They both have layers, with a central core, a middle mantle, and an outer crust. They both have magma chambers under the volcanos.
    - In what ways are they different?
    - Earth has a layer of icing that represents the liquid molten outer core. Earth has a solid inner core.
    - Share with older children that Earth's molten layer of material—iron and nickel—is very important. Convection (flow) of material in Earth's outer core creates Earth's magnetic field. This magnetic field protects us from dangerous particles from the Sun called solar wind. Without a magnetic field, these particles would wear away our atmosphere and dangerous radiation from the Sun would reach Earth's surface.
    - Mars also has a molten core—but no solid inner core.
    - Share with older children that because there is not convection within the liquid core, Mars does not have a magnetic field like Earth's. Without this protective magnetic field, solar wind has worn away the atmosphere of Mars, and dangerous radiation reaches its surface.
    - In general, Earth has two different types of crust—thick crust where there is land (continental crust) and thin crust under the oceans (oceanic crust). On Mars, the crust is relatively thick everywhere.

5.5. Conclusion

Ask the children if they think the differences in the interiors of Mars and Earth are somehow related to the differences in their surface features. Give them a few minutes to discuss the possible relationship. You may wish to have them share some of their ideas and record them in their GSI Journals.

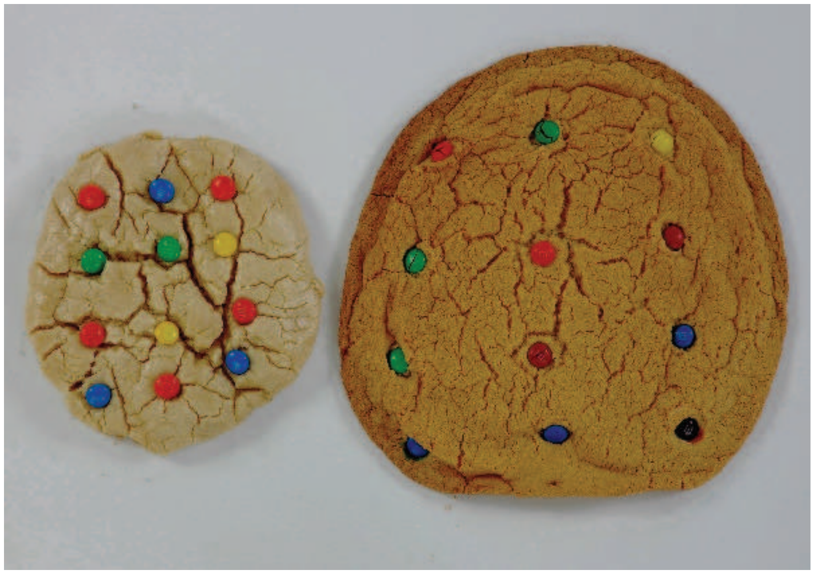

Figure 4. Big Bang Chocolate-chip cookie. *Left:* pre-baked cookie with the M&Ms 3 cm apart. *Right:* baked cookie. M&Ms are 7 cm apart.

6. Chocolate-chip Big Bang cookies

The Universe began with an explosion 14 billion years ago called the Big Bang. All of the matter and energy in the Universe was created and expanded everywhere at once. There is no center of the expansion and no center of the Universe. Here is how to use chocolate chip cookies to show the Big Bang and the expansion of the Universe, first discovered by Edwin Hubble.

1. Purchase two one-pound pieces of chocolate-chip cookie dough (e.g., Nestle).

2. Shape each one into a round disk about six inches in diameter and 1 to 1.5 inches thick.

3. Use M&Ms, to make the letter "H" on each piece of cookie dough. The H is for Hubble, hydrogen, or heat. Use blue M&Ms for the H on one piece of cookie dough red M&Ms for the second piece of cookie dough.

4. Place the chocolate-chip cookie dough piece with the red M&M on a large round pan or large cookie sheet and bake for about 30 minutes at 350 degrees F (or as instructed on the cookie dough package).

5. The M&Ms represent galaxies in the Universe. The unbaked chocolate-chip cookie dough represents the early Universe (500 million years to one billion years after the Big Bang). The larger baked chocolate-chip cookie represents the current Universe.

6. The larger baked chocolate-chip cookie shows the expansion of the Universe. All of the galaxies (red M&Ms) in the current Universe are father away and receding

from each other as compared to the galaxies (blue M&Ms) in the Early Universe that were initially closer together.

7. Additionally, the galaxies in the current Universe appear redder (called the red shift) due to the expansion of the Universe.

For the older students, explain the physical reasons for the expansion of the Universe and that the space between galaxies is expanding as the result of Einstein's General Theory of gravity. Eat the baked chocolate-chip Big Bang Universe and serve with milk!

7. Feedback and Discussion of Impact On Student Engagement

The workshop participants liked the demonstrations and left less hungry. The participants said that they would use the plate tectonics, Big Bang cookie, popcorn radioactivity, and Inside Mars—Mars/Earth structure comparisons with their students. One wanted to use the messy plate tectonic activity with younger students. Participants asked for worksheets and more printed materials. They thought that their students would enjoy these different and tasty learning experiences.

References

Lubowich, D. A. 2006, Innovation in Methods of Teaching and Learning Astronomy (SpS2), J. M. Pasachoff & R. M. Ros, eds., (Cambridge University Press)