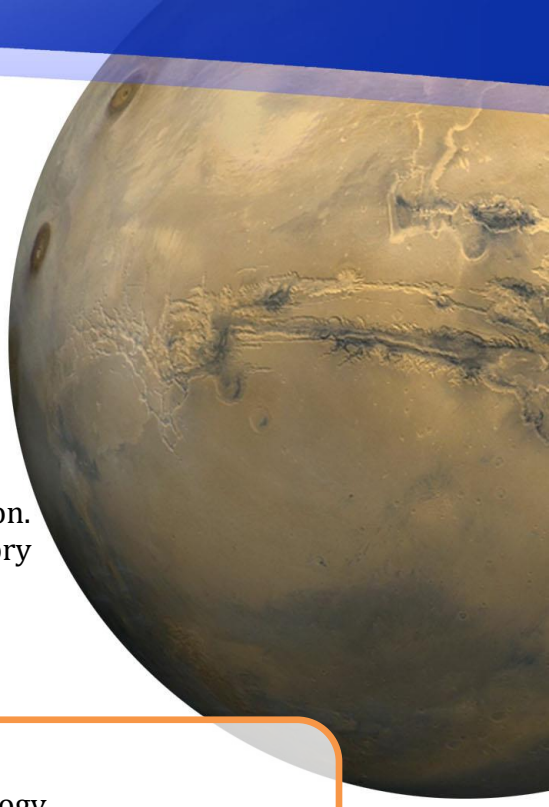
Lesson 2: Planetary Formation: Mars vs. Earth formation and the Case for Pluto



Summary
This learning module and related laboratory exercise exposes students to planetary body classification, and planet differentiation. Students will be able to compare and contrast the formation history of Mars and Earth as well as confidently assess the present classification of the planet Pluto.

Learning Goals

Students will be able to:

- Explain how planets form using JELL-O 1-2-3 as an analogy.
- Engage in a positive interactive debate regarding the classification of Pluto and in written format express their view competently using current scientific theory and resources.

Context for Use
This learning module is meant for adaptation in an introductory earth science course and/or planetary science course.

Description and Teaching Materials
In-Class Activity
In-Class Activity 1- Differentiation of Planets & Jell-O 1-2-3
Homework/Lab
Homework 1- Pluto Debate Write-up

Teaching Notes and Tips

1. JELLO 1-2-3 Analogy
    a. Small class size <20: have JELLO ingredients made up and ready for disbursement at end of class.
    b. Large class size >20: have both ingredients and one pre-made JELLO cup for students to analyze and develop an analogy for planet differentiation.
2. Pluto debate
    a. Prior to class assign students to either the Affirmative or Negative team so students have a chance to develop an argument. **OR**
    b. During class, allow students 10-15min to develop an argument

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References and Resources

1. Planetary Differentiation and Planet Comparison Overview: http://nineplanets.org/overview.html
2. Jello 1-2-3 recipe: http://gourmetish.blogspot.com/2006/10/jello-1-2-3.html
3. Mars vs. Earth size research: Brandon, Alan 2011. *Nature* 473, 460–461 (26 May 2011) doi:10.1038/473460a
4. Pluto and Planetary Body Classification : http://www.iau.org/public/pluto/
5. New Horizon Probe to Pluto NASA Video (see homepage for link) : http://www.nasa.gov/mission_pages/newhorizons/main/index.html
6. Kuiper Belt and the Oort Cloud information: http://www.nasa.gov/sites/default/files/files/Kuiper_Belt_Lithograph.pdf

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In-Class Activity 1
Planetary Formation MFE
Differentiation of Planets & Jell-O 1-2-3

Engage
To engage students, have a brief discussion on the interior of the Earth using the following explore activity as a preliminary analogy.

Explore
To explore the concept of differentiation, try an activity involving jello.
In Class activity 1 – Jello
Jello 1-2-3 recipe: http://gourmetish.blogspot.com/2006/10/jello-1-2-3.html

Differentiation is the concept of how different constituents of a planetary body separate out as a consequence of their physical or chemical behavior. The planetary body develops into compositionally distinct layers. Can students come up with any other examples of differentiation (e.g., salad dressing oil and water)?

Explain
To further explain how differentiation occurs in planets, have students examine other references, such as:

Planetary Differentiation and Planet Comparison Overview
Mars vs. Earth size research: Brandon, Alan 2011. *Nature* **473**, 460–461 (26 May 2011) doi:10.1038/473460a

Elaborate
To distinguish planetary classifications, provide the following reading for further information on Pluto.
Pluto and Planetary Body Classification
http://www.iau.org/public/pluto/

Evaluate
The Pluto debate demonstrates the evolution of science as new information becomes available. This is a fundamental component of the Nature of Science. Have a class debate about whether or not Pluto is a planet.

New Horizon Probe to Pluto NASA Video (see homepage for link) :
http://www.nasa.gov/mission_pages/newhorizons/main/index.html

Kuiper Belt and the Oort Cloud information:
http://www.nasa.gov/sites/default/files/files/Kuiper_Belt_Lithograph.pdf

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After the in-class debate, students will write up a short 1 page cited discussion paper on their opinion regarding the classification of Pluto (see link for paper guidelines). Make sure students include and discuss the current planetary classification scheme.

Students will develop an analogy, as a class, between JELL-O 1-2-3 and planetary differentiation.

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Homework 1
Birth of Planets_MFE
The Pluto Debate

Directions:
1. Ask the students to argue in the affirmative or negative for the retention of Pluto's classification as a planet. Utilize facts of Pluto and the IAU Planet Classification system (http://www.iau.org/public/pluto/).
2. Have them write a 1 page, 12pt font, double-spaced summary of their position regarding Pluto's classification as a planet.

Pluto Facts:
1. Pluto is the smallest planet in the Solar System, smaller than Earth's Moon, and half the width of Jupiter's moon, Ganymede.
2. Pluto's journey around the Sun takes 248 Earth years. This means that, since its discovery in 1930, it still has 177 years to go until it has made a complete orbit around the Sun.
3. Pluto's atmosphere is composed of a thin layer of gas containing carbon monoxide, methane, and nitrogen. Its atmospheric pressure has been estimated to be 1/700,000 compared with that of earth.
4. Pluto orbits the Sun on a different plane than the other 8 planets.
5. Pluto has three identified moons. Charon, the largest, is not much bigger than Pluto itself (Pluto is 2,280 kilometers wide, Charon is 1,212 kilometers wide).
6. A day on Pluto is equivalent to Earth's 6 days and 9 hours, meaning that it has the second slowest rotation in the Solar System (after Venus, which takes 243 days to turn on its axis).
7. Pluto's orbit is the more eccentric (more elliptical) than any planets' orbit. It can come closer to the Sun than Neptune, but then go almost two billion kilometers further away from Neptune's orbit.
8. Pluto maximum distance from the Sun – 7.38 billion km (4.6 billion miles).
9. Pluto's minimum distance from Earth – 4.28 billion km (2.7 billion miles).

Kuiper Belt and the Oort Cloud:
1. Have the students familiarize themselves with the Kuiper Belt and the Oort Cloud: http://www.nasa.gov/sites/default/files/files/Kuiper_Belt_Lithograph.pdf

IAU Classification System:
1. A planet is a celestial body that
    a. is in orbit around the Sun,
    b. has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, and
    c. has cleared the neighborhood around its orbit.
2. A "dwarf planet" is a celestial body that
    a. is in orbit around the Sun,

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b. has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape,
c. has not cleared the neighborhood around its orbit, and
d. is not a satellite.

The New Horizons Probe:

1. Ask the students to explore the mission page for the New Horizons Probe. (http://www.nasa.gov/mission_pages/newhorizons/main/)

2. What new information did they learn about Pluto from this mission? Does this information change their opinion about Pluto's classification? Why or why not?

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