Kepler
A Search For Terrestrial Planets

Habitable Planets

NASA Kepler Mission Education and Public Outreach.

Classroom Activity Trial Version: December 2004
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Grades 5-8

THE LAWRENCE HALL OF SCIENCE

Habitable Planets

This activity encourages a discussion about what makes a planet habitable. By the end of the activity, everyone should realize that for a planet to support life like we find on Earth, it must have:

(a) The right temperature range for there to be ***liquid water***, and
(b) The right size range to be able to have suitable ***atmosphere***.

In this activity, students match a series of questions with corresponding correct answers and keep track of planet characteristics in a simple table. They interpret the table to answer the basic question, "What makes a planet habitable?"

Materials

For the whole group/class:
1 Transparency (or Powerpoint slide) of "Match Game" (master on p. 5)

For each student or group of 2–5 students:
1 copy of the chart "What Makes a Planet Habitable?" (master on p. 6)

Preparation

Make a transparency or Powerpoint slides of "Match Game" (master on p. 5). For a powerpoint slide, make each set of match items (between the double lines) a separate slide. Make a copy of "What Makes a Planet Habitable?" (master on p. 6) for each student or group of 2–5 students.

Go

1. **Ask the class, "What does the word *habitable* mean?"** [Suitable for life. "Habitable" derives from the same root word as "habitat."] Explain that the class will play a match game—matching up questions with correct answers—to figure out what makes a planet habitable.

2. **Hand out a "What Makes a Planet Habitable?" chart** to each student or groups of 2–5 students. Explain that during the Match Game they can keep track of planet information on these charts by putting check marks in appropriate boxes.

3. **Show the first question:**
   "I. What is Essential for Life?"
   - Read each numbered match item out loud to the class and then ask the students to write "1", "2", and "3" on a sheet of scrap paper (can be the back of the "What Makes a Planet Habitable?" chart)
   - **Have the students match the items** and write "A," "B," or "C" next to the matching number on their paper. Poll the students on the correct order of the letters. The correct match is:
     1→B 2→C 3→A
   - **Emphasize** that air is one of ***the*** most important substances for life and that water is actually even more important. You can clarify these points by asking,
     "**Can you think of any life form on Earth that exists without water?**" and
     "Is there life on Earth that can exist without air?"
     [Allow time to discuss anaerobic bacteria if anyone brings that up. In some respects, air is not essential for life, since there are many anaerobic life forms. However, a planet without air will not have liquid water, since lack of atmosphere makes liquid water on planet surface evaporate quickly and escape the planet.]

4. **Show the next Match items**:
   "II. Planet Atmospheres."
   - Read each numbered item out loud to the class and then ask the students to write "4", "5", and "6" on the scrap paper and have them write "D," "E," or "F" by the matching number.
   - Poll the students on the correct order of the letters. The correct match is:
     4→F 5→E 6→D
   - Ask students to mark spaces relating to atmosphere in their charts of "What Makes a Planet Habitable?"—which planets have thick, thin, or no atmosphere. Ask these questions:

"Why do some planets have no atmosphere and others have very thick atmosphere?" [Some may suggest that planet size makes a difference.]

5. Show "III. Planet Sizes."

- Read each numbered item out loud to the class and then ask the students to write "7, "8," and "9" on the scrap paper. Have them to write "G," "H," or "I" next to the matching number on their scrap paper. Poll the students on the correct order of the letters. The correct match is:
  7→I 8→G 6→H
- Ask students to mark spaces relating to planet size in their charts of "What Makes a Planet Habitable?"—which planets have thick, thin, or no atmosphere.
- Ask, ***"Why do small planets have no atmosphere and large planets have very thick atmosphere?"*** [Gravity determines whether a planet can hold onto molecules of atmosphere. Smaller planets do not have enough gravity to hold onto the atmosphere.]
- Ask ***"Which planets are more likely to have life: ones with thick atmosphere, thin atmosphere, or no atmosphere?"*** [It's a little like the Goldilocks fable: too much atmosphere may not be as hospitable and no atmosphere is obciously a problem for life. But thin atmosphere may be "just right."

6. Show "IV. Temperature."

- Read each numbered item out loud to the class and then ask the students to write "10", "11", "12," "13," and "14" on the scrap paper. Have them to write "J," "K," "L," "M," or "N" next to the matching number. Poll the students on the correct order of the letters. The correct match is:
  10→L 11→N 12→J 13→M 14→K
- Ask students to mark spaces relating to planet size in their charts of "What Makes a Planet Habitable?"—which planets are hot, medium, or cold temperature.
- Ask, ***"Why is the temperature range for liquid water important in our discussion of what makes a planet habitable?"*** [All life needs liquid water, so the planet temperature must be within that range for liquid water to exist.]
- Ask, ***"What factors seem to affect the temperature of a planet?"*** [Distance from the Sun and, especially for the inner planets, presence or absence of atmosphere. If necessary, call students' attention to the last row of their "What Makes a Planet Habitable?" chart.]

A very interesting additional activity or demonstration that would be great to do with regard to temperature is to measure temperature of ice and of boiling water. The actual temperature of an ice water mixture depends on how much impurity (such as salt) is in the water. The actual temperature of boiling water depends on the atmospheric (barometric) pressure of the air in contact with the water.

7. Ask, *"What are the most important things that make a planet habitable?"* [First, make sure the students recall what *habitable* means. The most important factor is presence of liquid water. This, in turn, is determined by temperature and presence of some, but not too much atmosphere. Atmosphere, is in turn, affected by the size, and hence gravity, of the planet.]

8. Have the students work in discussion groups to further analyze the comparative characteristics of planets in their charts of "What Makes a Planet Habitable?" In particular, they could discuss questions such as

- Why do some planets have a wide temperature range and others have narrow temperature range?
- Are there other factors, not on the chart, that could affect a planet's temperature or what kind of atmposphere it might have?
- Could there be a moon of a planet that is suitable for life? If not, explain why not and if so, how might those conditions occur?

9. **Ask, "What does it mean to say that finding a habitable planet is sort of like the story of Goldilocks?"** [SIZE and TEMPERATURE of the planet are keys to their habitability. If a planet is too cold it can't support life. If it's too hot, it can't support life. If it has *just the right temperatur*e (as Goldilocks would say) to have liquid water, then there can be life. Likewise, if a planet is to small, it doesn't have enough gravity to hold an atmosphere. If it's too large, it holds too much atmosphere. If it's *just the right size* (as Goldilocks would say), it can have the perfect atmosphere for life.]

10. **NASA missions.** Conclude by explaining that a series of NASA missions are planned to search for planets around other stars (extrasolar planets). In particular, the first one is the NASA *Kepler* mission that will be able to detect planets down to Earth size or smaller. *Kepler* will be able to determine the size of a planet as well as it's distance from its star, and hence give us an idea of possible planet temperature.

Students can visit to the Kepler website to find more about the *Kepler* mission, e.g.

How does Kepler find planets?
How small a planet can Kepler detect?
When will the Kepler spacecraft be launched?

Kepler website: http://kepler.nasa.gov

For a follow-up activity on how *Kepler* works, see the *Detecting Planet Transits* on the *Kepler* website.

The *Kepler* spacecraft.

Apollo photograph of Earth as seen from the Moon. View of a planet that is not only habitable, but a pretty nice place to live, too.

I. What's essential for life?

Match Game

1. Deprived of this, you would die within a few minutes.	A. Food.
2. Deprived of this, you would die within a few days.	B. Air.
3. Deprived of this, you would die within a few weeks.	C. Water.

II. Planet Atmospheres

4. Planets that have thick layer of atmosphere.	D. Earth, Venus, and Mars
5. Planets that have no atmosphere.	E. Mercury, Pluto, and the Moon
6. Planets that have a thin layer of atmosphere.	F. Jupiter, Saturn, and Neptune

III. Planet Sizes

7. Medium-size planets *(1/2 to twice the diameter of Earth)*	G. Jupiter, Saturn, and Neptune
8. Giant planets *(over 3 times the diameter of Earth)*	H. Mercury, Pluto, and the Moon
9. Small bodies *(less than 1/3 the size of Earth)*	I. Earth, Venus, and Mars

IV. Temperature

10. Percent of our bodies that is water.	J. 464 to 470
11. Temperature range of liquid water *(in degrees Celsius at sea level on Earth)*	K. -133 to 27
12. Temperature range of the Venus *(in degrees Celsius)*	L. 50 to 70
13. Temperature range of Mercury *(in degrees Celsius)*	M. -163 to 427
14. Temperature range of Mars *(in degrees Celsius)*	N. 0 to 100

What Makes a Planet Habitable?

	Mercury	*Venus*	*Earth*	*Moon*	*Mars*	*Jupiter*	*Saturn*	*Neptune*	*Pluto*
Size									
Big									
Medium									
Small									
Atmosphere									
Thick									
Thin									
None									
Temperature									
Hot									
Medium									
Cold									
Distance from Sun	0.39 AU	0.72 AU	1.0 AU	1.0 AU	1.5 AU	5.2 AU	9.5 AU	30 AU	39 AU

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Size									
Big									
Medium									
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