Name: _____ Class Period: ____ Date: _____

Activity 1: The Goldilocks Principle

For this activity you will need to recall the story of "Goldilocks and the Three Bears". In the story, Goldilocks is faced with several choices during her time in the Bears' home.

A. Consider the information given in the table below and answer the following questions.

Bowl Name:	Papa Bear	Mama Bear	Baby Bear
Bowl Temp:	85° C	20° C	52° C
Bowl Diameter:	20 cm	13 cm	4 cm
Bowl Color:	Electric Blue	Red	Yellow

i. Whose bowl of porridge did Goldilocks choose?

ii. What characteristic about the porridge did Goldilocks use to decide which bowl was "just right"?

B. Consider the information given in the table below and answer the following questions.

Chair Name:	Papa Bear	Mama Bear	Baby Bear
Chair Temp:	22° C	22° C	22° C
Chair Height:	40 cm	33 cm	20 cm
Chair Material:	Metal	Wood	Plastic

i. Which chair did Goldilocks choose?

ii. What characteristic about the chairs did Goldilocks use to decide which one was "just right"?

C. Consider the information given in the table below and answer the following questions.

Bed Name:	Papa Bear	Mama Bear	Baby Bear
Bed Temp:	22° C	22° C	22° C
Bed Height:	15 cm	15 cm	15 cm
Bed Stiffness:	Hard	Soft	Medium

i. Which bed did Goldilocks choose?

ii. What characteristic about the beds did Goldilocks use to decide which one was "just right"?

D. If the diameter of Papa Bear's bowl had only been 10 cm, would your answers in question A change? If so, how? If not, why not?

E. If Mama Bear's chair was made out of plastic rather than wood, would your answers in question B change? If so, how? If not, why not?

F. If Papa Bear's bed was 12 cm tall, would your answers in question C change? If so, how? If not, why not?

G. If the height of Mama Bear's chair was 38 cm, would your answers in question B change? If so, how? If not, why not?

H. If Mama Bear had a medium stiffness mattress, would your answers in question C change? If so, how? If not, why not?

Name_____

STUDENT INSTRUCTION AND ANSWER SHEET

Activity 2: Why is There Abundant Life on Earth?

Examine the information provided in the table below and answer the following questions. (Note: 0.8 M_{Earth} means that the planet has a mass that is 80% the mass of Earth.)

Planet Name:	**Venus**	**Earth**	**Mars**
Planet Mass (M_{Earth}):	0.8 M_{Earth}	1 M_{Earth}	0.1 M_{Earth}
Planet Radius (R_{Earth}):	0.95 R_{Earth}	1 R_{Earth}	0.5 R_{Earth}
Distance from Sun (D_{Earth}):	0.7 D_{Earth}	1 D_{Earth}	1.5 D_{Earth}
Average Surface Temperature:	456 ^{o}C	10 ^{o}C	-95 ^{o}C
Atmosphere:	Thick	Medium	Thin

A. Which of the characteristics listed in the table above allow life to flourish on Earth but not Venus and Mars? Explain your reasoning.

B. Describe how the characteristics identified in question A would change if the following changes were made.

i. The Earth was moved closer to the Sun.

ii. The Earth was moved farther from the Sun.

iii. The Sun's temperature was much hotter and it was much larger.

iv. The Sun's temperature was much cooler and it was much smaller.

Name_____

STUDENT INSTRUCTION AND ANSWER SHEET

Activity 3: Defining the Habitable Zone

The planets in our Solar System orbit the Sun at very different distances. Scientists have developed a system for describing distances in our Solar System based on the average distance between Earth and the Sun. The Astronomical Unit (AU) is approximately 149,570,000 kilometers (the average Sun-Earth distance). The distances between objects in our Solar System are measured using the AU as the common unit of distance. The table below provides the planet's name and average orbital distance to the Sun.

A. Convert the distances from km to AU for each of the planets in our Solar System.

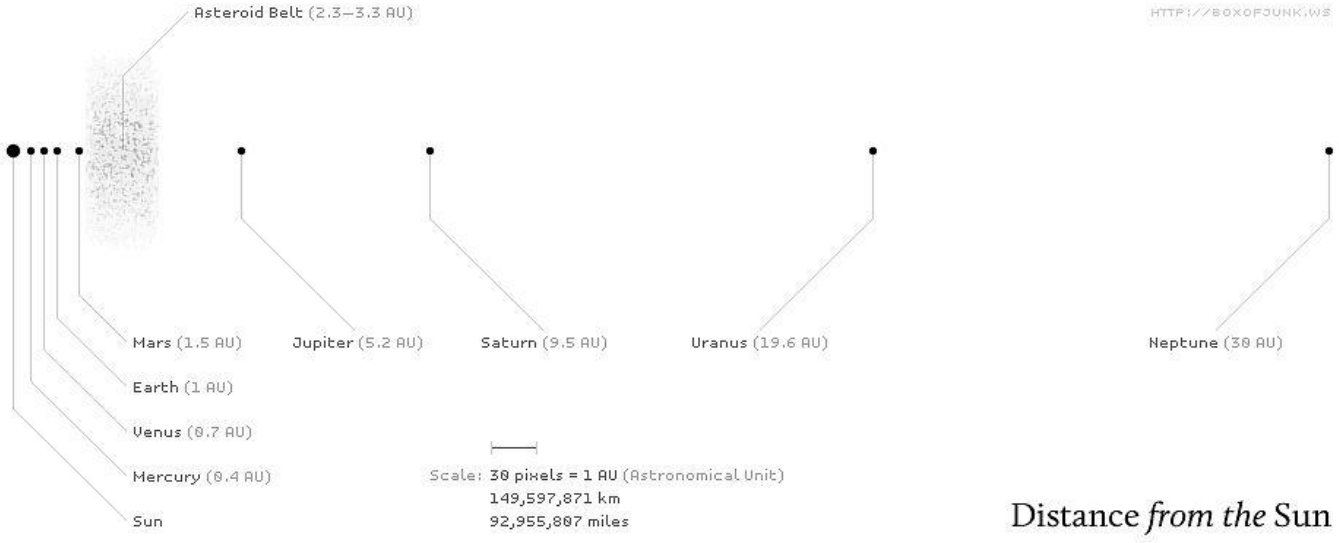
Planet Name	Distance to Sun in km	Distance to Sun in AU
Mercury	57,950,000 km	
Venus	108,110,000 km	
Earth	149,570,000 km	
Mars	227,840,000 km	
Jupiter	778,140,000 km	
Saturn	1,427,000,000 km	
Uranus	2,870,300,000 km	
Neptune	4,499,900,000 km	
Pluto	5,913,000,000 km	

B. Construct a scale model of our Solar System. Mark a large dot to represent the Sun at one end of your scale model. Then place dots at the correctly scaled distances away from the Sun to represent each of the nine planets. Your teacher will have further instructions on how to complete this activity.

The presence of liquid water at the surface of a planet appears to be one of the central characteristics that distinguishes whether or not a planet can harbor life. This requires that the planet be at a distance from the central star where the temperature is not too low to cause all water to freeze nor too high to cause all water to boil. The region around a star where the temperature is

"just right" is known as the *zone of habitability*. For a star like our Sun the zone of habitability has been identified as between .84 AU and 1.7 AU.

C. Mark the zone of habitability on your Solar System scale model.



D. Which of the planets in our Solar System may have the potential for liquid water on the surface? Explain how you can tell.

E. Is the Moon in the zone of habitability? Does the Moon have liquid water on the surface? Why, or why not?

F. Describe how the location of the zone of habitability would change if the central star's temperature was to increase.

Name_____

STUDENT INSTRUCTION AND ANSWER SHEET

Activity 4: The Sun is a Star?

A. Obtain a set of Star Cards from your teacher. Examine each star card and using the information provided, sort the stars by their distance from Earth, from largest to smallest.

B. Does the star's temperature appear to depend on the distance from the Earth?

C. Compare the color of the star to its temperature. Compare the spectral class of the star to its temperature. Do the color or spectral class of the star appear to be related to the star's temperature?

D. Sort your star cards by temperature, from coolest to hottest.

E. Consider the four characteristics (1) temperature, (2) color, (3) distance, and (4) class or spectral type. Which characteristics most strongly influence the size and location of the habitable zone? Explain your reasoning for each.

F. If we are looking for Earth-like life elsewhere in the universe, which of the stars described on the Star Cards would you explore first? What spectral classes did you choose? Explain the reasoning behind your choices.

Scientists believe that life as we know it is most likely to exist around stars most like our Sun, in the F, G and K classes. Size, temperature and light appear to be important factors in identifying these stars.

G. How would the zone of habitability be different around an "F" star, or a "K" star as compared to the Sun? Explain your reasoning.

Activity 5: Size and Mass Are Important!

Up to this point we have identified that the "just right" condition for life is the presence of liquid water on a planet's surface. This suggests we should first search for a planet that rests in orbit around a Sun-like star (classes F, G or K) within the star's zone of habitability. In addition to the distance from the star, the planet must also have a suitable atmosphere. This requires that the planet have a mass between 0.5 and 10 Earth masses, with a radius between 0.8 and 2.2 times that of Earth. Planets that are too small will not have enough gravity to hold an atmosphere, and larger planets will have an atmosphere too thick to support life as we know it. For example, photosynthesis cannot occur if the atmosphere is impenetrable, or a runaway greenhouse effect could occur such as on Venus today. A habitable planet would also need to have the right type of atmospheric chemistry. Nitro-gen, carbon dioxide and oxygen would likely need to be present in amounts similar to what is found on Earth.

Consider the information listed in the table below.

Star (Temp/Class)	Planet Name	Distance (AU)	Mass	Size
Altair (7,900/A)	Brady	0.05	72.4 M_E	10.7 R_E
Regulus (11,500/B)	Schembechler	0.75	1.5 M_E	1.1 R_E
Procyon (6,600/F)	Desmond	0.55	7.7 M_E	3.5 R_E
Beta Cassiopeia (8,000/F)	Braylon	1.25	8 M_E	2.1 M_E
Alpha-Centauri (5,750/G)	Harbaugh	0.46	250 M_E	175 R_E
Epsilon Indus (4,400/K)	Denard	1.6	0.3 M_E	0.42 R_E
Epsilon Eridanus (4,600/K)	Manningham	1.5	0.9 M_E	1.75 R_E
Barnard's Star(2,700/M)	Woodson	2.2	195 M_E	182 R_E

A. On which of these hypothetical planets would you search for Earth-like life? Explain your reasoning for each planet.

Activity 6: Recently Discovered Planets

In this activity we will investigate real data corresponding to new planets that have been discovered outside our Solar System. Refer to the data found (half way down the page) in the table #1 titled "Confirmed Planets" at: http://www.obspm.fr/encycl/catalog.html .

The (primary) star is classified by its spectral type. The planet mass is provided in multiples of the mass of Jupiter which is 317 times more massive than Earth. The distance from the star to the planet is shown in AU.

For example the table shows that the star named HD 16141 is a G-type star. The orbiting planet has a mass of 0.215 times the mass of Jupiter or about 68.2 times the mass of Earth. We also find that the planet is located 0.35 AU from the star.

A. Examine the first 6 planets in the table. In the space below, state whether or not the companion planet can support Earth-like life. To assist you in making this determination use the Planet Classification Flowchart. For planets that fail the test, state the major factors that keep them from being candidates for Earth-like life.

Star	Spectral Class	Distance (AU)	Mass	Support Earth-like life?
GI 785	K-0	0.038	111 M_E	
Wolf1061	M-3	.036	4M_E	
Kepler 408	G-5	0.35	.68 M_E	
HD20782	F-8	0.98	1.08 M_E	
Wasp109	K-2	3.3	27.3 M_E	
Gliese	M-4	0.13	41 M_E	

B. Could any of the planets you have listed have an orbiting Earth-like moon that could support life? List any possible candidates and explain your reasoning for each.

Activity 7: Crash Landing!

A meteoroid has hit your spaceship! Luckily, you are passing through the Nonog System, which consists of a sun-like star surrounded by seven planets, some of which have moons. Your ship has barely enough fuel and guidance ability to allow you to select a nearby place to crash-land. Below are profiles of each of the planets and moons in the Nonog system. The information is sketchy, but it's all your sensors had time to collect before going off-line due to the damage caused by the meteoroid. Good luck.

Planet 1 (closest the star) Mass: 1.5 (Earth = 1) Tectonics: Active volcanoes and seismic activity detected. Atmosphere: CO_2, N, and H_20 Average Temperature: 651 degrees C Description: Thick clouds surround the planet. No surface is visible through the clouds.	**Planet 4** Mass: 1.5 Tectonics: Active volcanoes and seismic activity detected. Atmosphere: N, O_2, and ozone layer Average Temperature: 2 degrees C Description: Cold oceans, covered with ice along much of the globe. Some open water around equator.
Planet 2 Mass: 0.5 Tectonics: No activity detected. Atmosphere: Thin CO_2 atmosphere detected. Average Temperature: 10 degrees C Description: Polar ice caps, dry riverbeds, and many craters can be seen from orbit.	**Planet 5** Gas Giant with one large moon. **Moon**: Sulfur dioxide (SO_2) atmosphere. Many volcanoes and hot springs on surface. Temperatures in hot spots can be up to 600 degrees C. Other spots away from volcanic heat can get as low in temperature as 145 degrees C.
Planet 3 Mass: 1 Tectonics: Active volcanoes and seismic activity detected. Atmosphere: CO_2, H_20 Temperature: 30 degrees C Description: Liquid water oceans cover much of the surface. Volcanic island chains make up most of the dry land.	**Planet 6** Gas giant with four large, rocky satellites (moons). Moons have no appreciable atmosphere. Ice detectable on one.
	Planet 7 (furthest from star) Gas giant with two large moons. **Moon 1:** Thick methane atmosphere with high enough pressure to keep a potential methane ocean liquid underneath. Temperature: -200 degrees C **Moon 2:** Covered in water ice. Ice appears cracked and re-frozen in parts, indicating a potential liquid ocean underneath. Surface temperature -100 degrees C.

1. Which Planet Will You Choose and Why?

2. What Makes this planet a better choice than the others? Be specific!

3. Imagine you were a microbe or some form of life not human, would that change the planet that you choose? Why? What planet(s) would you pick then?