**Why is there abundant life on Earth and not Venus or Mars:**

Uses several audience members to model the habitable zone around Sun-like stars and how an atmosphere influences the habitability of a planet.

*Recommended audience:* 3rd grade and above.

*Duration:* 5 – 15 minutes.

<table>
<thead>
<tr>
<th>Leader’s Role</th>
<th>Participants’ Role (Anticipated)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Materials:</strong></td>
<td></td>
</tr>
<tr>
<td>Sheet of yellow cellophane</td>
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</tbody>
</table>

*NOTE:* This activity was developed from an idea in NASA’s “Astro-Venture” guide: http://astroventure.arc.nasa.gov/

**To Say:**

- Look up – what do you mostly see in the sky at night?
- Can we see any stars in the daytime?
- Does our star have planets orbiting it?
- Do you suppose some of the stars we see at night also have planets orbiting them?
- Yes. Scientists have already found many that do, but only planets that are very large, close to the size of Jupiter and bigger.
- Do you suppose some of those planets might be able to support life?
- NASA’s *Kepler Mission*, within about five to eight years, will determine if small Earth-size planets exist around other Sun-like stars. It is looking for planets in the habitable zone of stars.
- But what is a “habitable zone”? Why do you suppose there is so much life on Earth and no apparent life on Venus or Mars?
- Earth is in the “habitable zone” of our star, the Sun. Let’s see what it means.
**Leader’s Role**

**PART I: Habitable Zone of a Sun-Like Star**
This section addresses the topic of “habitable zone” and how atmosphere affects the habitability of a planet.

**To Do:**

Grab the sheet of yellow cellophane in the center and flare it into a bouquet shape.

**To Say:**

Pretend we are outside on a cold night and all we have is this campfire.

**To do:**

Give the campfire prop (one sheet of yellow cellophane) to one person.

**To say:**

Imagine this fire is as big as [his/her] upper body.

*(Point to someone in the crowd)* Where would you have to stand to be comfortable?

The campfire represents the Sun and you represent the position of Earth.

Does Earth have liquid water?

What about the people in the back – would you be comfortable? Would you be too warm?

**Participants’ Role (Anticipated)**

<table>
<thead>
<tr>
<th>Person adjusts their position.</th>
<th>Yes. Lots.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>No! Too cold.</td>
</tr>
<tr>
<td>Leader’s Role</td>
<td>Participants’ Role (Anticipated)</td>
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<tr>
<td><strong>To do:</strong></td>
<td>Move one person very close to the fire.</td>
</tr>
<tr>
<td></td>
<td>I need you to take off your jacket.</td>
</tr>
<tr>
<td></td>
<td>Would you be comfortable here?</td>
</tr>
<tr>
<td><strong>To say:</strong></td>
<td>(Indicating person next to fire) This person is like Mercury – too close to the Sun. Mercury has a daytime high temperature of 800° F (430° C). Can liquid water exist on its surface?</td>
</tr>
<tr>
<td></td>
<td>I’m going to ask you to take off your jacket too. This person is like Mars – too far from the Sun and too cold. The temperature at the planet's surface varies widely during the course of a Martian day, from about -125° F (-87° C) just before dawn and warms up to about -4° F (-20° C) in the afternoon. Can it have liquid water?</td>
</tr>
<tr>
<td></td>
<td>(Indicating the person in the middle) This person is like Earth – just right. Earth is in the habitable zone around our star, the Sun.</td>
</tr>
</tbody>
</table>
**Leader’s Role**

*To say:*
The “habitable zone” around a star is where liquid water could exist on the planet’s surface year-round. What’s the most common substance in most living things?

Yes, Water! And not just any water, but liquid water. Most living things we know of require liquid water to live.

So one thing that determines habitability is a planet being at the right distance from its star so the planet might have liquid water.

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<td>Water?</td>
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### More info about Mercury:
Virtually no atmosphere and very close to the Sun. Like being in the desert in a swimsuit. Daytime high temperature on Mercury is 800° F (430° C) and nighttime is about –300° F (–180° C).

Mercury’s “day”, from one sunrise to the next, is 176 Earth days long and its “year” is about 88 Earth days – its day is longer than its year!

(NOTE: You may have seen Mercury’s day quoted at 58 Earth days. 58 days is its sidereal day, not its solar day.)

### More info about Venus:
A very dense atmosphere. Like wearing a parka in the desert. The temperature of Venus is always about 880° F (470° C).

Venus’s “day”, from one sunrise to the next, is about 117 Earth days long (it rotates very slowly) and its “year” is about 225 Earth days.

(NOTE: You may have seen Venus’s day quoted at 243 Earth days. Once again, 243 days is its sidereal day, not its solar day.)

Venus has a pressure at the surface about 90 times that of Earth - a pressure equivalent to a depth of 1 kilometer under the ocean – lie down and imagine the weight of one dictionary sitting on your chest. Now imagine 90 dictionaries. That represents the pressure difference between Earth’s atmosphere and the atmosphere of Venus. What do you think would happen to you if you were on the surface of Venus? (I’d be crushed!)

### More info about Mars:
Very little atmosphere – like wearing a t-shirt in the Arctic. The temperature at the surface of Mars varies widely during the course of a Martian day, from about -125° F (-87° C) just before dawn and warms up to about -4° F (-20° C) in the afternoon. A day on Mars is about 24 hours 40 minutes – just a bit longer than an Earth day.

Atmospheric pressure at the surface of Mars is like Earth at 20 miles up – 0.7% of the surface pressure on Earth.
Now let’s look at something else that determines habitability: an atmosphere! Let’s use a jacket to represent a planet’s atmosphere.

Why do you suppose I had Mars and Mercury take their jackets off? Mars and Mercury have little or no atmosphere. Wearing a jacket is like a planet having an atmosphere. Earth has just the right amount of atmosphere to insulate it and maintain a comfortable temperature.

The Moon is essentially the same distance from the Sun as Earth – but has no life and no liquid water – what’s different? Right – no atmosphere – daytime temp on Moon: 273° F (134° C) Nighttime temp on Moon: -274° F (-170° C)

But we have a planet missing. Which planet is between Mercury and the Earth? (Select another person from the audience) Would you stand here and be Venus? Venus has a very dense atmosphere. I’m going to have you keep your jacket on and imagine that I’m putting another other big down jacket on you too. Imagine I’m also wrapping a blanket around you. Would you be comfortable here?

Right – Venus has too dense an atmosphere too close to the Sun. The temperature of Venus is always about 880° F (470° C). Can it have liquid water?

So an atmosphere can make a big difference too in whether a planet might be habitable.

Would it be easy for us to live on any of these planets, other than Earth? No!
Notes for activity leaders:

Here is how we have classified the stars to take a more simplified approach to main sequence stars of various spectral types:

“Cool, red stars”: Main Sequence stars of spectral type K, M, and cooler (lowest mass)
“Yellow/white stars”: Main Sequence stars of spectral type G and F (mid-mass)
“Hot, bluish stars”: Main Sequence stars of spectral type O, B, and A (higher mass)

All main sequence stars are classified as “dwarf” stars.

“White dwarf” is the hot dense core of a star that has lost its outer layers – a star that has “died”.
“Red dwarf” is a cool, red main sequence star.

Giant stars (of various sizes) are stars that are “in retirement”, no longer fusing primarily hydrogen at their cores. These are stars no longer on the main sequence. They still are given one of the above spectral types, but they are in a different “luminosity class”. Main sequence stars have a luminosity class of “V”. Here are the others:

Ia Most luminous supergiants
Ib Less luminous supergiants
II Luminous giants
III Normal giants
IV Subgiants
V Main sequence stars (dwarfs)

For more information on spectral types of stars:
http://antwrp.gsfc.nasa.gov/apod/ap040418.html (basic discussion - follow the links)

If you are working with a middle school or high school teacher, here is a downloadable exercise to address different types of stars and discuss habitability:
http://astrobio.terc.edu/samples/chpt2_act3.html

“Habitable Zone”
For a discussion of why scientists are looking for planets that could have LIQUID water on their surface: http://www.pbs.org/wgbh/nova/mars/essential.html (NOTE: The explanation of why the sky is blue is generally attributed to Lord Rayleigh who described “Rayleigh scattering”, rather than to Einstein as the above referenced article may imply.)