# Purpose

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| Because of changes in its core, over the next few billion years the Sun will continue getting larger and outputting more energy. (See graph to the right.) This will have many consequences for the Earth, including a significant rise in temperature and a complete evaporation of surface water by about 1 billion years from now. | 544px-Solar_evolution_%28English%29 |

Eventually, about 2.8 billion years from now, Earth will be completely, uninhabitable and so, if mankind is to survive, it will have to colonize other planets. In this activity, you will consider how the human race might evolve as it adapts to the changing conditions on Earth and on other planets.

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|  | How will living in a changing environment, or on another world, affect human evolution? |

# Initial Ideas

Before considering the future, let us consider how humans have evolved in the recent past. There is much debate about when Homo sapiens emerged as a distinct species but there is general agreement that it was no more than 200,000 years ago. Though it is tempting to think that human evolution stopped at this point, in fact, many advantageous adaptations have occurred since as a result of the different conditions human populations have encountered as they spread across most of the Earth.

On the next page are several changes that humans have undergone in the recent past. Participate in a discussion about some of these and make any notes you think necessary.

**Coloring**

The original Homo sapiens emerged in Africa with a strong preference for dark skin, dark hair, and dark eyes, caused by genes that promote high levels of pigment, such as melanin in the skin. However, now light skin, hair, and different colored eyes are extremely common.

***Lactase persistence***

Digestion of lactose is facilitated by the enzyme lactase. In most mammals, lactase activity is dramatically reduced after weaning, meaning lactose can no longer be digested. However, beginning about 10,000 years ago the number of adults who can still digest lactose began to increase significantly.

***High altitude breathing***

Compared to closely related Han Chinese (who live at sea level), indigenous Tibetans are genetically predisposed to produce more of the oxygen-transporting hemoglobin protein.

***Missing wisdom teeth***

Ancient humans ate tough, uncooked foods that wore away their teeth, so having a third molar was normal. Today, about 35% of the population do not even produce wisdom teeth.

***Shrinking brains***

For much of its history, the average brain size of Homo sapiens stayed about the same. However, over the past 20,000 years, the average size has decreased by about 10%.

# Collecting and Interpreting Evidence

You will need:

 Access to internet for possible research

## Exploration #1: Staying on Earth

Let us first assume that at least some humans remain on the Earth into the distant future. The following are several changes to the Earth that are expected over different time scales in the future. Discuss with your group and describe how humans might evolve in response to at least two of these. **Note**: You may have to consider possible mass migration in response to some of these.

***Global Warming***

In the very short-term, the most severe change to conditions on the Earth is likely to be due to global warming. In the most extreme (but feasible) scenario, this could result in a rise of over 8° F in the global average temperature over just a few hundred years.

***Next Ice Age***

About 50,000 years from now changes in the Earth's axial tilt and orbit will cause the Earth to enter another ice age. This could cause average temperatures to drop by as much as 18° F.

***Long-term increasing temperature***

A long-term increase in the luminosity (energy output) of the Sun will cause a gradual long-term increase in the average global temperature. In about a billion years from now, the average surface temperature will be about 116 ° F.

***Loss of plant life***

The long-term rises in temperature will speed up chemical processes, which in turn will decrease the level of carbon dioxide in the atmosphere. After about 1.2 billion years, the CO2 level will fall below that needed for photosynthesis and all plant life, as we know it, will die out.

## Exploration #2: Leaving Earth

Even if mankind were to evolve successfully to meet all the changes considered in Exploration #1, eventually the Earth will become uninhabitable. The temperature will continue to rise; 2.8 billion years from now, it will be 300 ° F. When the Sun transitions to a red giant in about 6 billion years, the Earth will be at 4,000 ° F with molten lava oceans and floating continents of metals.

Some people have suggested that to avoid this ultimate fate, mankind should already be planning to move outward in the solar system, and eventually to colonize planets around other stars.

In this exploration, you will consider just the first step, and hypothesize about what evolutionary changes might occur to Homo sapiens as they move into the outer solar system. In so doing, you will have to think about changes in conditions that you did not consider in Exploration #1, such as different strengths of gravity (discussed further below), differences in atmospheric pressure and composition, different lighting levels.

***Changes in the strength of gravity***

NASA has done a lot of research into what happens to astronauts who spend a lot of time in low/micro gravity. It seems there is significant bone loss, decreases in bone density, loss of muscle mass, drop in blood pressure and redistribution of bodily fluids.

The following are several places in the solar system that have been suggested for human colonization.

* ***Moon***
* ***Mars***
* ***Ceres (dwarf planet in Asteroid Belt)***
* ***Europa (moon of Jupiter)***
* ***Titan (moon of Saturn)***

Discuss with your group and describe how humans might evolve in response to settling at least two of these. Use the internet to research conditions on those you choose. Space to record your thinking is provided on the next page.