THE GEOLOGICAL SOCIETY OF AMERICA

TITLE: **A Discussion of Space Distances**

TOPIC: A model for understanding the distances between stars

GRADE LEVEL: 6-12

CONTENT STANDARD: Earth and Space Science

CONTENT OBJECTIVE: To help students comprehend the vast distances between stars, and that the light we see is not recent starlight, but may be millions of years old. The teacher will help students understand how astronomers find out about origins of the universe.

TIME REQUIRED: 10 minutes, but a warning, it may springboard into a much longer discussion!

MATERIALS NEEDED: None, but color photos of planets, suns and galaxies is nice.

DIRECTIONS FOR INSTRUCTION/ACTIVITY:
This is instruction for a discussion on the distance between the Earth and stars.

Background:

- During a discussion of planets, stars, the galaxy, and the universe, point out that over half of the stars we see in the sky are not stars at all, but are galaxies, consisting each of hundreds of millions of stars. The number of stars is therefore incomprehensible. We cannot see **planets**, they don't give off enough light, so if we assume the Earth is typical of suns this size with 9 planets, imagine the number of planets there may be in the universe!!
- **Stars** are suns, but there are many different types. Most of them burn hydrogen in a fusion reaction for the majority of their lives. The temperatures of stars range from 80,000 degrees centigrade to –3,000 degrees. In a smaller star like the Sun, when the hydrogen is used up, the core will shrink and heat up once more as different nuclear reactions begin; the star will become a red giant. Our sun will do this in five to seven hundred million years from now. When those reactions use up all fuel, the Sun will collapse into a white dwarf, small and super-dense. Larger star don't last as long, and die with a spectacular explosion called a supernova, leaving dense star material to blow away. The largest of stars collapse so rapidly and violently that not even light can escape it. These are what we call black holes, and they are difficult to comprehend and to study.
- **Galaxies** are systems of stars. Our Milky Way Galaxy contains about 100,000 million stars. The overall diameter may be as large as 100,000 light-years, with the majority of stars located within 20,000 light-years from the center. Our Sun is about 32,000 light-years from the center of the system, so we are more on the outer edge than most stars. Some galaxies are so far away from Earth that, even though they are composed of millions of stars that are each light-years apart, they still look like one bright light in our

sky. The Universe is composed mostly of empty space, but is so vast that looking out at it from Earth, it seems quite crowded.

- How far away are these stars and galaxies? They are tens or hundreds or thousands or millions of light-years away. A **light-year** is how far visible light will travel in a vacuum in a year. Light travels at 300,000 km per second. To find the distance for a year, multiply by 60 seconds, 60 minutes, 24 hours, and 365.25 days = 9,467,280,000,000 km or 9.467 million million kilometers/year. This is about 5,878,000,000,000 miles in a year!

Now for the fun stuff:
Have your students imagine the following scenario. They **write three letters** tomorrow morning, all with the same content, telling a friend about how they are and everything that has happened to them up until that moment. They then send the letters, one to a friend across town, one to a friend across the country, and one to a friend in Australia. When the first friend across town gets the letter the next day, how old is the news? It is one day old, of course. Anything could have happened to the writer between now and then. Maybe the student won an award, aced a big test, or got hurt during a game and broke their leg! The friend is reading news that is one day old. When does the friend across country get the news? Maybe they'll get it in 3 or 4 days (if they're lucky). The news is now 3 or 4 days old, think of the things that may have happened to the writer between now and then!! The friend in Australia gets the letter over a week later. The letter is pretty old news by now.

Now apply this logic to the light of the stars. The nearest star to us (besides our own star, the Sun) is Alpha Centauri and it is 4.3 light-years away, so that light is a little more than four years old by the time it reaches Earth. Many different things could have happened to that star by the time we see it (although unlikely). Some stars are one hundred million light-years away. What we see is what the star looked like over 100 million years ago. Astronomers look for stars or galaxies that are more than 10 billion light-years away to give us clues to how the universe formed, because the light we see from those sources is from a time close to the Big Bang. The shapes of galaxies that far away (which is the light given off when the galaxies were very young) are also different from older galaxies that are closer to us (and have been around a long time). Even the Sun's light takes time to reach the Earth's surface, eight minutes, to be exact!

I have never failed to have students in every class who have a great interest in such lofty topics. Be prepared for many questions about all aspects of astronomy, and to encourage your students to do further research. This is often a good lead in to a project about space science. How do scientists know how far away the planet is and therefore how old the light is? Great research topic!!

EVALUATION: None, just the comprehension and amazement of your students.

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