GreatHearts®

Earth Science 8

April 6-9

Time Allotment:30 minutes per day

Student Name: ________________________________

Teacher Name: ________________________________

GreatHearts®

Packet Overview

Date	Objective(s)	Page Number
Monday, April 6	1. Students will be able to define and differentiate constellations and asterisms, and describe the energy flow in a star.	2
Tuesday, April 7	1.Students will be able to describe and differentiate between neutron stars, black holes, supernova, and nova.	5
Wednesday, April 8	1. Students will be able to distinguish between star systems and star clusters, and between open star clusters and globular star clusters.	8
Thursday, April 9	1. Students will be able to explain the evidence that the universe is expanding using redshift.	11
Friday, April 10	Day off!	

Additional Notes: Students are to designate a specific location in their home for their workspace to learn about Earth and Space.

This could be a table or desk anywhere in the home that could be labeled their school zone. By doing so, the students will have a stable work environment that they will keep all of their learning materials organized, they can visit, and take a rest from.

Academic Honesty

I certify that I completed this assignment independently in accordance with the GHNO Academy Honor Code.

Student signature:

____

I certify that my student completed this assignment independently in accordance with the GHNO Academy Honor Code.

Parent signature:

____

Lesson 1: Monday, April 6

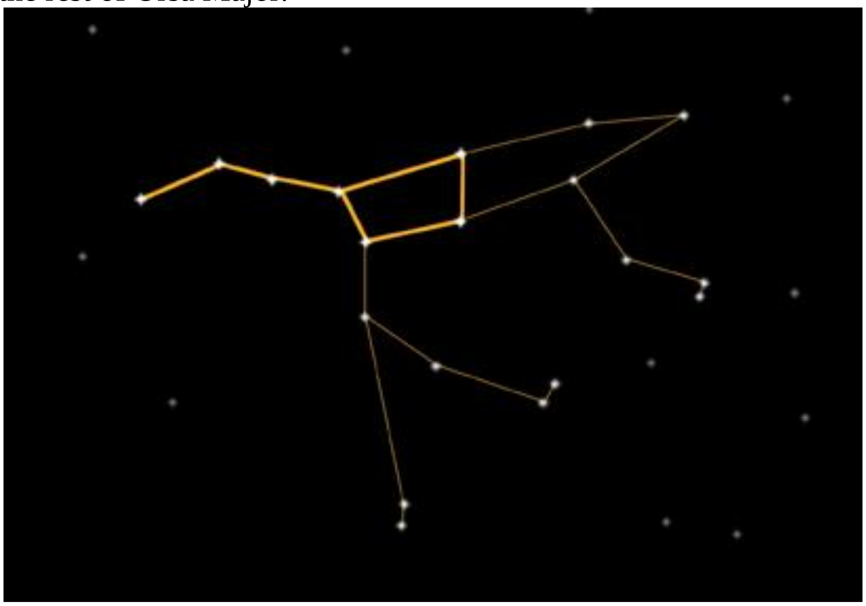
Read and annotate these pages carefully, and then answer the questions below.

Constellations:

When you look at the sky on a clear night, you can see dozens, perhaps even hundreds, of tiny points of light. Almost every one of these points of light is a star, a giant ball of glowing gas at a very, very high temperature. Some of these stars are smaller than our Sun, and some are larger. Except for our own Sun, all stars are so far away that they only look like single points, even when viewed through a telescope.

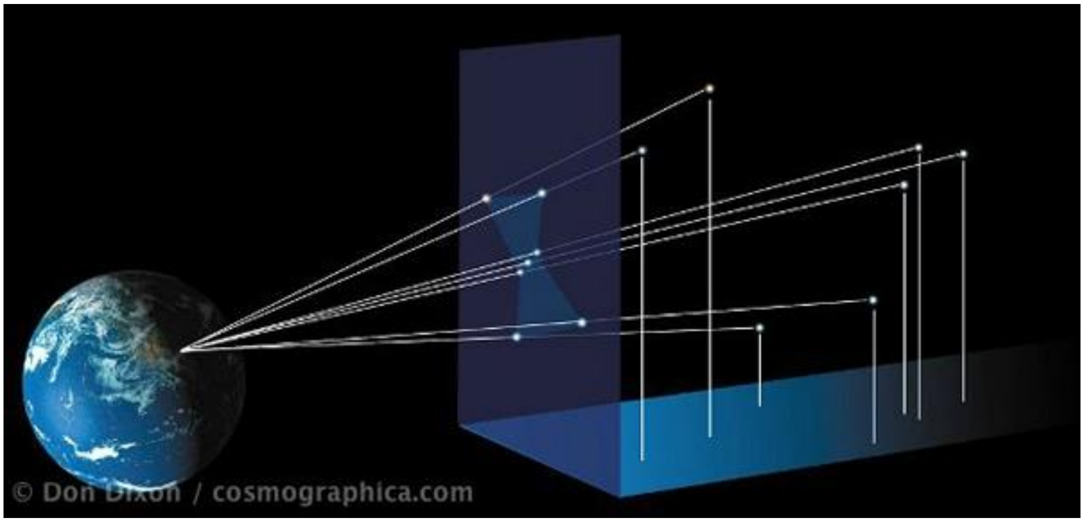
For centuries, people have seen the same stars you can see in the night sky. People of many different cultures have identified **constellations, which are apparent patterns of stars in the sky.** Below is the well-known constellation 'Orion.' The ancient Greeks thought this group of stars looked like a hunter from one of their myths, so they named it Orion after him. The line of three stars at the center of the picture is known as "Orion's Belt". Head outside on a clear spring night between approximately 8:00pm and 10:00pm and look high in the sky while facing south and Orion should be clear.

The patterns in constellations and in groups or clusters of stars, called asterisms, stay the same night after night. There are 88 **officially recognized** constellations. A well-known pattern that is **not officially recognized** by astronomers is called an **asterism.** The Big Dipper is actually NOT technically a constellation but rather is an asterism- it is part of the larger official constellation Ursa Major (The Great Bear). The Big Dipper is in bold lines below, the lighter lines draw out the rest of Ursa Major.



In a single night, the stars move across the sky, keeping the same patterns. This apparent nightly motion of the stars is actually due to the rotation of Earth on its axis. It isn't the stars that are moving; it is actually Earth spinning that makes the stars seem to move. The patterns shift slightly with the seasons, too, as Earth revolves around the Sun. As a result, you can see different constellations in the winter than in the summer. For example, Orion is a prominent constellation in the winter sky and spring sky, but not in the summer sky.

Although the stars in a constellation appear close together as we see them in our night sky, they are usually at very different distances from us, and therefore they are not at all close together out in space. For example, in the constellation Orion, the stars visible to the naked eye are at distances ranging from just 26 light-years (which is relatively close to Earth) to several thousand light-years away. So, while the stars in a given constellation appear to be 'flat' on the night sky, they are actually spread out through the three-dimensions of space. The image below shows the actual relative distances of the stars in Orion.



Stellar Energy:

Only a small portion of the light from the Sun reaches Earth; yet that light is enough to keep the entire planet warm and to provide energy for all the living things on Earth. The Sun is a fairly average star. The reason the Sun appears so much bigger and brighter than any of the other stars is that it is very close to us. Some other stars produce much more energy than the Sun. How do stars generate so much energy?

Stars are made mostly of **hydrogen and helium**. These are both very lightweight gases. However, there is so much hydrogen and helium in a star that the weight of these gases is enormous. In the center of a star, the pressure is great enough to heat the gases and cause **nuclear fusion reactions**. In a nuclear fusion reaction, **the nuclei, or centers of two atoms join together** and **create a new atom** from two original atoms. In the core of a star, the most common reaction turns two hydrogen atoms into a helium atom. Nuclear fusion reactions require a lot of energy to get started, but once they are started, they produce even more energy.

The **energy from nuclear reactions in the core pushes outward, balancing the inward pull of gravity on all the gas in the star**. This energy slowly moves outward through the layers of the star until it finally reaches the outer surface of the star. The outer layer of the star glows brightly, sending the energy out into space as electromagnetic radiation, including visible light, heat, ultraviolet light, and radio waves.

TERMS:

asterism
A group or cluster of stars that appear close together in the sky.

constellation
One of the 88 officially recognized patterns of stars that divide up the night sky.

nuclear fusion reaction
When nuclei of two atoms fuse together, giving off tremendous amounts of energy.

GreatHearts®

Review:

1. (Weather Permitting) Go outside and, using the instructions above find the constellation of Orion. Please show a parent or sibling and have them sign below confirming you have found the constellation:
   Family Signature:________________________

2. What kind of reactions provide a star with energy?

Lesson 2: Tuesday, April 7

Read and annotate these pages carefully, and then answer the questions below.

Stars come in many different colors. If you look at the stars in Orion as shown in yesterday's lesson you will notice that there is a bright, red star in the upper left and a bright, and a blue star in the lower right. The red star is named Betelgeuse and the blue star is named Rigel.

Color and Temperature

If you watch a piece of metal, such as a coil of an electric stove as it heats up, you can see how **color is related to temperature**. When you first turn on the heat, the coil looks black, but you can feel the heat with your hand held several inches from the coil. As the coil gets hotter, it starts to glow a dull red. As it gets hotter still, it becomes a brighter red, then orange. If it gets extremely hot, it might look yellow-white, or even blue-white. Like a coil on a stove, a star's color is determined by the temperature of the star's surface. Relatively cool stars are red, warmer stars are orange or yellow, and extremely hot stars are blue or blue-white.

The most common way of classifying stars is by color. The table below shows how this classification system works. The class of a star is given by a letter. Each letter corresponds to a color, and also to a range of temperatures. Note that these letters don't match the color names; they are left over from an older system that is no longer used.

Class	Color	Temperature Range	Sample Star
O	Blue	30,000 K or more	Zeta Ophiuchi
B	Blue-white	10,000-30,000 K	Rigel
A	White	7,500-10,000 K	Altair
F	Yellowish-white	6,000-7,500 K	Procyon A
G	Yellow	5,500-6,000 K	Sun
K	Orange	3,500-5,000 K	Epsilon Indi
M	Red	2,000-3,500 K	Betelgeuse, Proxima Centauri

Main Sequence:

As we learned last week, stars are born in clouds of gas and dust known as **nebula.** Once stars begin **nuclear fusion** they have entered the **Main Sequence**. For most of a star's life, the nuclear fusion in the core combines hydrogen atoms to form helium atoms. A star in this stage is said to be a **main sequence star**, or to be on the main sequence. This term comes from the **Hertzsprung-Russell diagram**, the plot of stars you made last week. For stars on the main sequence, the hotter they are, the brighter they are. The length of time a star is on the main sequence depends on how long a star is able to balance the inward force of gravity with the outward force provided by the nuclear fusion going on in its core. More massive stars have higher pressure in the core, so they have to burn more of their hydrogen "fuel" to prevent gravitational collapse. Because of this, **more massive stars have higher temperatures**, and also **run out of hydrogen sooner than smaller stars do.**

Our Sun, which is a medium-sized star, has been a main sequence star for about 5 billion years. It will continue to shine without changing for about 5 billion more years. Very large stars may be on the main sequence for "only" 10 million years or so. Very small stars may be main sequence stars for tens to hundreds of billions of years.

Red Giants and White Dwarfs

As a star begins to use up its hydrogen, it then begins to fuse helium atoms together into heavier atoms like carbon**. Eventually, stars contain fewer light elements to fuse**. In other words- they start to run out of **fuel.** The star can no longer hold up against gravity and it starts to collapse inward. Meanwhile, the outer layers spread out and cool. The star becomes larger, but cooler on the surface and red in color. Stars in this stage are called red giants. Again,

Eventually, a red giant burns up all of the helium in its core. **What happens next depends on how massive the star is**. A typical star like the Sun, stops fusion completely at this point**. Gravitational collapse shrinks the star's core to a white, glowing object about the size of Earth.** A star at this point is called a **white dwarf.** Eventually, a white dwarf cools down and its light fades out, and the star is no more.

Supergiants and Supernovas

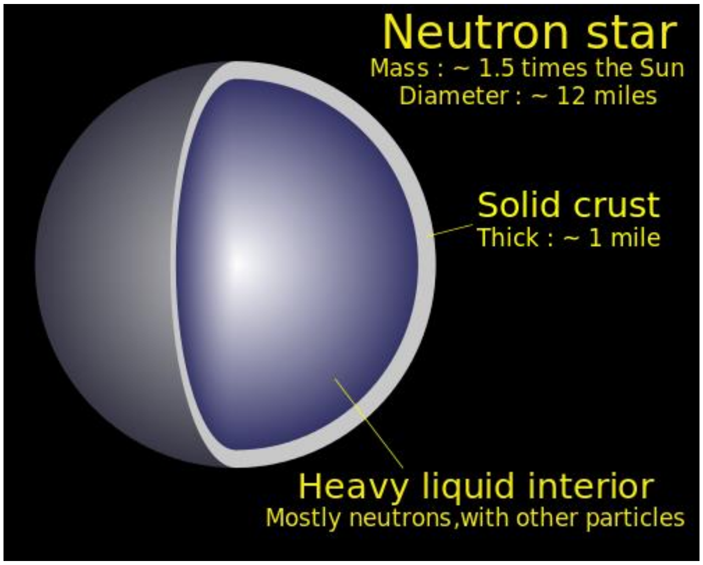
A star that has **much more mass than the Sun** will end its life in a **more dramatic way.** When very massive stars leave the main sequence, they become red **supergiants**. The red star **Betelgeuse in Orion** is a red supergiant.

Unlike red giants, **when all the helium in a red supergiant is gone, fusion does not stop.** The star continues fusing atoms into heavier atoms, until eventually its nuclear fusion reactions produce iron atoms. **Producing elements heavier than iron through fusion takes more energy than it produces**. Therefore, stars will ordinarily not form any elements heavier than iron. **When a star exhausts the elements that it is fusing together, the core succumbs to gravity and collapses violently, creating a violent explosion called a supernova**. A

supernova explosion contains so much energy that some of this energy can actually fuse heavy atoms together, producing heavier elements such as gold, silver, and uranium. A supernova can shine as brightly as an entire galaxy for a short time, as shown in the bottom left of the image below.

Neutron Stars and Black Holes

After a large star explodes in a supernova, the leftover material in the core is **extremely dense**. If the core is less than about four times the mass of the Sun, the star will be a neutron star, as shown below. A neutron star is made **almost entirely of neutrons**. **Even though it is more massive than the sun, it is only a few kilometers in diameter!**



If the core remaining after a supernova is **more than about 5 times the mass of the Sun**, the core will collapse so far that it becomes a **black hole**. Black holes are so dense that not even light can escape their gravity. For that reason, black holes cannot be observed directly. But we can identify a black hole by the effect that it has on objects around it, and by radiation that leaks out around its edges.

TERMS:

black hole
The super dense core left after a supergiant explodes as a supernova.
main sequence star
A star that is fusing hydrogen atoms to helium; a star in the main portion of its "life".
nebula
An interstellar cloud of gas and dust.
neutron star
The remnant of a massive star after it explodes as a supernova.
red giant
Stage in a star's development when the inner helium core contracts while the outer layers of hydrogen expand.
supernova
A tremendous explosion that occurs when the core of a star is mostly iron.

Review:

1. Suppose a large star explodes in a supernova, leaving a core that is 10 times the mass of the Sun. What would happen to the core of the star?

2. List the seven main classes of stars, from hottest to coolest.

3. What kind of star will the Sun be after it leaves the main sequence?

Lesson 3: Wednesday, April 8

Read and annotate these pages carefully, and then answer the questions below.

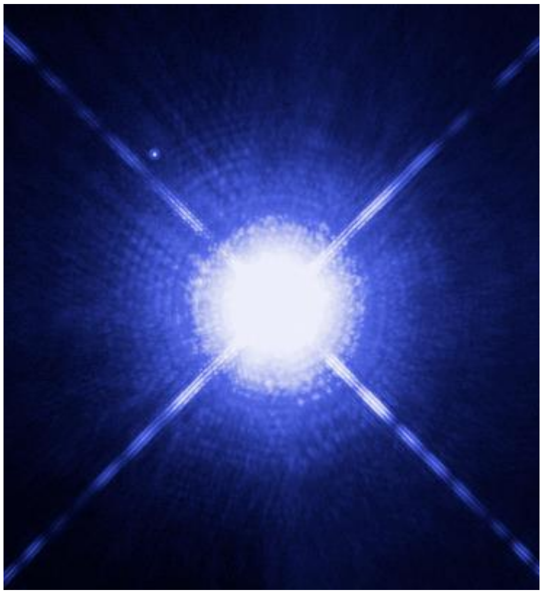
Compared to your neighborhood, your country, or even planet Earth, the solar system is an extremely big place. But there are even bigger systems in the universe; groups of two, two hundred, or two billion stars! Small groups of stars are called **star systems**, and somewhat larger groups are called **star clusters**. There are even larger groups of stars, called **galaxies**. Our solar system is in the Milky Way Galaxy, which is just one galaxy in the universe. There are several different types of galaxies and there are possibly billions of galaxies in the universe.

As we discussed earlier this week, just because stars appear close together in the sky (in constellations or asterisms), doesn't mean that they are actually close together out in space. However, **some stars are actually grouped closely together in space**. These small groups of stars are called **star systems** and larger groups of hundreds or thousands of stars are **called star clusters.**

Star Systems

Our solar system has only one star, the Sun. But many stars—in fact, more than half of the bright stars in our galaxy—**are in systems of two or more stars**. A system of two stars orbiting each other is called **a binary star system**. A system with more than two stars is called a multiple star system. In a multiple star system, each of the stars orbits around the others.

Often, the stars in a multiple star system are so close together that you can only tell there are multiple stars using binoculars or a telescope. The image below shows Sirius A, the brightest star in the sky. Sirius A is a very large star. If you look to the upper left of Sirius A in the figure, you can see a much smaller star. This is Sirius B, a white dwarf companion to Sirius A.



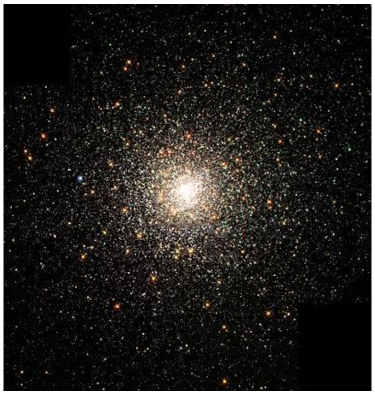
Incidentally, now that you know how to find Orion, it's easy to find Sirius- it's the very bright blueish-white star below and to the left of Orion (see the image from Monday's lesson).

Star Clusters

Star clusters are divided into two main types: **open clusters** and **globular clusters**. Open clusters are groups of up to a few thousand stars that are **loosely held together by gravity**. The Pleiades, shown below, is a well-known open cluster. The Pleiades are also called the Seven Sisters, because you can see seven stars in the cluster without a telescope, but with good vision. Using a telescope reveals that the Pleiades has close to a thousand stars.

The stars in an open cluster are young stars that formed from the same nebula. Eventually, the stars may be pulled apart by gravitational attraction to other objects. In the image above you can even see faint wisps of leftover gas from the nebula in which the Pleiades cluster was born.

The image below shows an example of a globular cluster. **Globular clusters are groups of tens to hundreds of thousands of stars held tightly together by gravity**. Unlike open clusters, globular clusters have **a definite, spherical shape**. Globular clusters contain mostly old, reddish stars. As you get closer to the center of a globular cluster, the stars are closer together. Globular clusters don't have much dust in them—the dust has already formed into stars. Globular clusters are particularly impressive when viewed through a telescope.



TERMS:

binary star system
Two stars that orbit each other.
globular cluster
Groups of tens to hundreds of thousands of stars held together by gravity.
open cluster
Groups of up to a few thousand stars loosely held together by gravity.
Small groups of stars.
star cluster
Larger groups of hundreds of thousands of stars.

Review: Answer in complete sentences

1. What is a binary star system?

2. Compare globular clusters with open clusters.

3. (Weather Permitting) Go outside and, using the instructions above find the star Sirius. Please show a parent or sibling and have them sign below confirming you have found the star:

   Family Signature:__________________________

Lesson 4: Thursday, April 9

Read and annotate these pages carefully, and then answer the questions below.

So far we have talked about bigger and bigger systems, from stars to star systems to star clusters and galaxies. The **universe** contains all these systems, including all the matter and energy that exists now, that existed in the past, and that will exist in the future. The universe also includes all of space and time.

Our understanding of the universe has changed a lot over time. The ancient Greeks thought the universe contained only Earth at the center, the Sun, the Moon, five planets, and a sphere to which all the stars were attached. Most people had this basic idea of the universe for centuries, until Galileo first used a telescope to look at the stars. Then people realized that Earth is not the center of the universe, and there are many more stars than thought before. Even as recently as the early 1900s, some scientists still thought the universe was no larger than the Milky Way Galaxy.

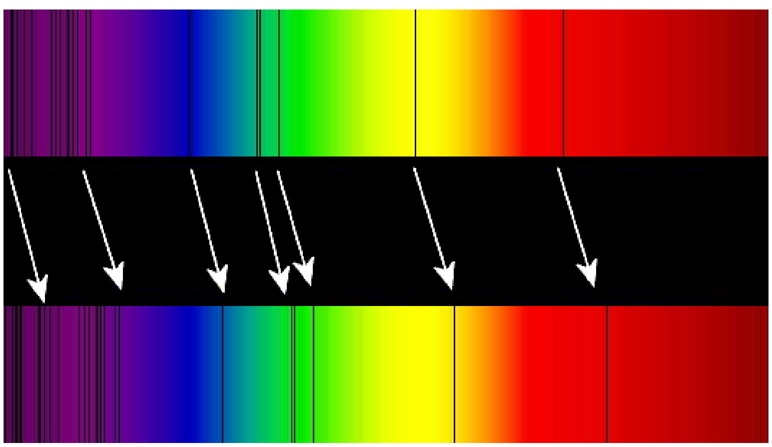
In the early 20th century, an astronomer named Edwin Hubble discovered that the Andromeda Nebula is actually over 2 million light years away—many times farther than the farthest distances we had measured before. **He realized that many of the objects astronomers called nebulas were not clouds of gas, but collections of millions or billions of stars**—what we now call **galaxies**. Our view of the universe changed again—we now knew that the universe was much larger than our own galaxy. Today, we know that the universe contains about a **hundred billion galaxies**—about the same number of galaxies as there are stars in the Milky Way Galaxy.

After discovering that there are galaxies outside our own, Edwin Hubble went on to measure the distance to hundreds of other galaxies. His data would eventually show us how the universe is changing, and even give us clues as to how the universe formed.

Redshift

If you look at a star through a prism, you will see a **spectrum, or a range of colors through the rainbow**. We saw these same phenomena when we looked at the different colored lightbulbs through the special spectrum glasses not long before spring break. Interestingly, when observing stars the spectrum will have specific dark bands where elements in the star absorbed light of certain energies. By examining the arrangement of these dark absorption lines, astronomer can **actually determine which elements are in a distant star**. In fact, the element helium was first discovered in our Sun—not on Earth—by analyzing the absorption lines in the spectrum of the Sun.

When astronomers started to study the spectrum of light from distant galaxies, they noticed something strange. The dark lines in the spectrum were in the patterns they expected, **but they were shifted toward the red end of the spectrum**, as shown below. This shift of absorption bands toward the red end of the spectrum is known as **redshift**.



Redshift is the shift of absorption lines- lines which tell you what elements are in a star- in a uniform way towards the red side of the spectrum.

Redshift occurs when the source of light is moving away from the observer. So when astronomers see redshift in the light from a galaxy, **they know that the galaxy is moving away**

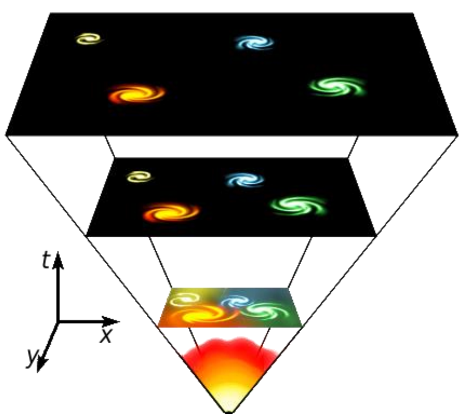
from Earth. The strange part is that **almost every galaxy in the universe has a redshift**, which means that **almost every galaxy is moving away from us.**

This is the same principle as our old friend the **Doppler Effect**. As you recall the Doppler Effect is the apparent change in pitch of a sound as its source moves towards or away from you. As a train blasting its horn moves towards you, the sound waves are compressed thus shortening their wavelength and increasing their frequency. As we know increasing the frequency of a sound wave gives it a higher pitch. As soon as the train passes the sound waves are spread out, rather than compressed, and so the pitch drops. The same thing is happening with light waves- as the objects of the universe move away from us, the light waves are spread out, just like when the train is moving away from you. The frequency of the waves is reduced, and the wavelength is increased. But instead of this change in frequency effecting *sound* the change effects *color*. The spectrum of visible light, you'll recall, goes from longest to shortest frequency: Red Orange Yellow Green Blue Indigo Violet. Thus objects moving away from us at very high speeds will appear more RED than they would if they were stationary.

The Expanding Universe

Edwin Hubble combined his measurements of the distances to galaxies with other astronomers' measurements of redshift. He noticed a relationship, which is now called **Hubble's Law: The farther away a galaxy is, the faster it is moving away from us**. In other words, **the universe is expanding!**

The image below shows a simplified diagram of the expansion of the universe. Another way to picture this is to imagine a balloon covered with tiny dots. Each dot represents a galaxy. When you inflate the balloon, the dots slowly move away from each other because the rubber stretches in the space between them. If it were a giant balloon and you were standing on one of the dots, you would see the other dots moving away from you. Not only that, but dots farther away from you on the balloon would move away faster than dots nearby.



TERMS:

redshift

Shift of wavelengths of light towards the red end of the spectrum; happens as a light source moves away from us.

universe

Everything that exists; all matter and energy; also includes all of space and time.

Edwin Hubble

The scientist who discovered redshift and determined that the universe was expanding

Hubble's Law

The farther away a galaxy is, the faster it is moving away from us.

Graphing Redshift:

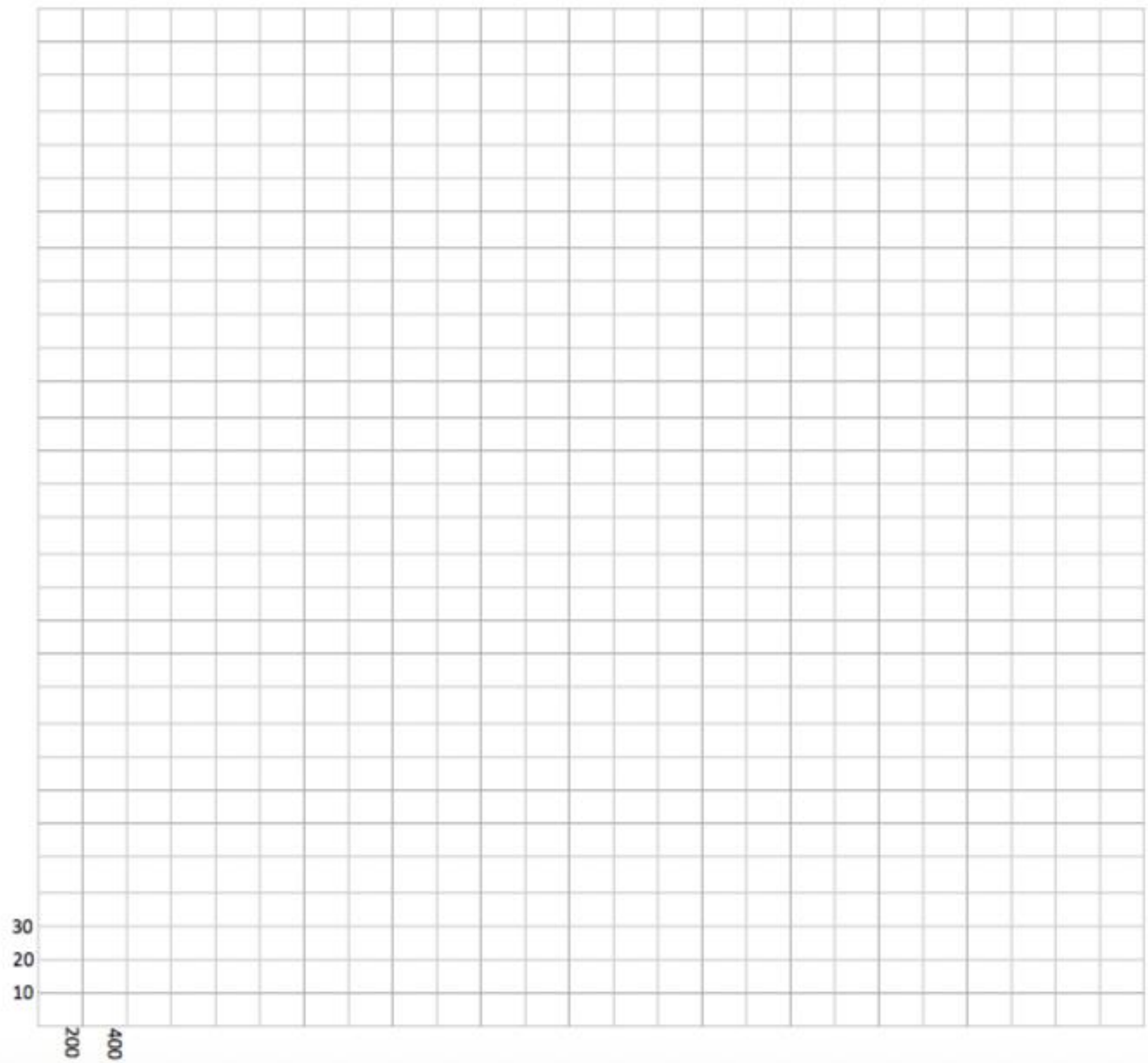
For the last century, Astronomers have gathered information about bright objects in our sky. Below you will find information about 16 celestial objects. The objects are labeled as "M" objects (M stands for Messier, an Astronomer from the 18th century), or "NGC" objects (NGC stands for New General Catalog, which is a world-wide complied list of objects in our night sky).

Object **M60**, which is 55 million light-years away (Mly), is traveling at 1,117 km/s.
Object **M82** is 11.5 Mly away, traveling 203 km/s.
NGC 5490 is a whopping 218 Mly from Earth, and it is traveling 4,928 km/s.
NGC 5091 is 150 Mly away from Earth, traveling at 3,420 km/s.
An object called **M105** is 32 Mly away, traveling at 911 km/s, and just a little farther is object **M95**, 33 Mly away, and it is moving at 778 km/s.
M74 is closer than those last two, at just 30 Mly away. Its speed is 657 km/s.
M84 is twice as far, 60 Mly away! Its speed is 1,060 km/s! Object
M49 is 56 Mly away, traveling at 997 km/s.
M66 is 36 Mly away, traveling at 727 km/s.

Object	Speed (km/s)	Distance (Mly)
M60	*1,117*	*55*
M82	*203*	*11.5*

Now make a scatter plot graph with each celestial object below. Don't forget to label the objects on the graph as well as the x and y axis.

(HINTS: speed will be on the x-axis and distance will be on the y-axis; label the x-axis in increments of 200—up to 5000, and the y-axis in increments of 10—up to 250)



Analysis Questions:

1. Which object is farthest from Earth?

2. Which object is closest to Earth?

3. Which object has the fastest speed?

4. Which object as the slowest speed?

5. Complete this sentence: “The farther away an object is from Earth, the…”