UNIT 5

Galaxies and the Universe

5.1 Galaxies

5.2 - Expansion of the Universe

5.3 - Exoplanets, Space Travel, & Current Issues

A Grand Tour of the Universe Reading

Introduction:
Anyone who has ever gazed at the clear night sky from a dark location knows the special fascination of astronomy - the sense of awe and mystery that comes from considering our place in the vastness of the universe.

To the ancients, the planets and stars were simply mysterious lights scattered on the dome of the heavens. Our modern understanding adds the crucial dimension of depth to that simple picture. We now know that some celestial objects are relatively close, while others are unimaginably remote. The twinkling lights of the sky turn out to be other worlds and other suns. Spread among them are vast clouds of gas and dust - reservoirs of raw material to make new stars, new planets, and perhaps even new astronomers. And the countless numbers of stars are not randomly distributed in the universe - they cluster into vast islands that we call galaxies. The cosmos is much richer and more complex than the ancients ever dreamed.

Question: What is there beyond Earth?

Background: *(write a few things that you already know pertaining to about the question above)*

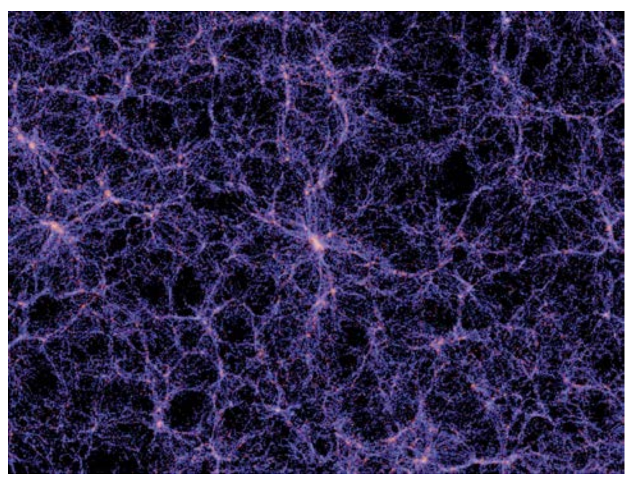
Vocabulary:
Galaxy
Local Group
Milky Way
Hubble Deep Field
The Big Bang

Materials:
This reading packet

Procedure:
Read through the following passage. **Underline statements** that you feel are important to the tone and message of the article.

Dividing up the Universe
Let us, in our mind's eye, take a short tour of the universe as astronomers understand it today, and get acquainted with the main types of objects in the universe.

For convenience, astronomers generally divide the universe into three realms:
1. Our Home: The Solar System
   (Our Street: The Local Group)
2. Our City: The Milky Way Galaxy
3. The Whole Shebang: The Universe.



Computer generated model of what the universe looks like

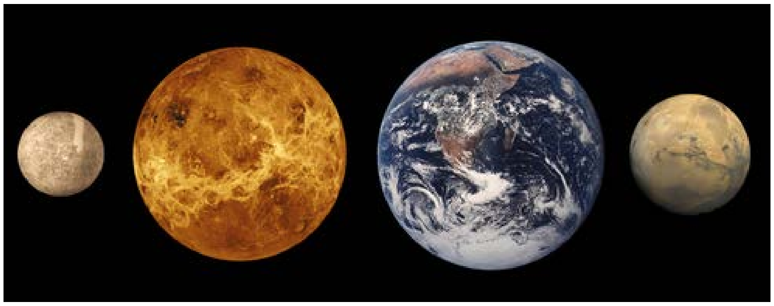
The Solar System

To begin at home, our Earth is a member of the family of planets and moons known as the solar system. Orbiting our star, the Sun, are eight major planets and their more than 160 known moons, each a unique world with its own special characteristics. In addition, we have smaller worlds, now called dwarf planets, such as Pluto, Ceres, and Eris, and more of these are being discovered all the time. Assorted cosmic debris – in the form of asteroids, and smaller chunks called meteoroids- also shares our system with us.

Let's examine a few of the neighbor planets that are especially noteworthy.

The Inner System

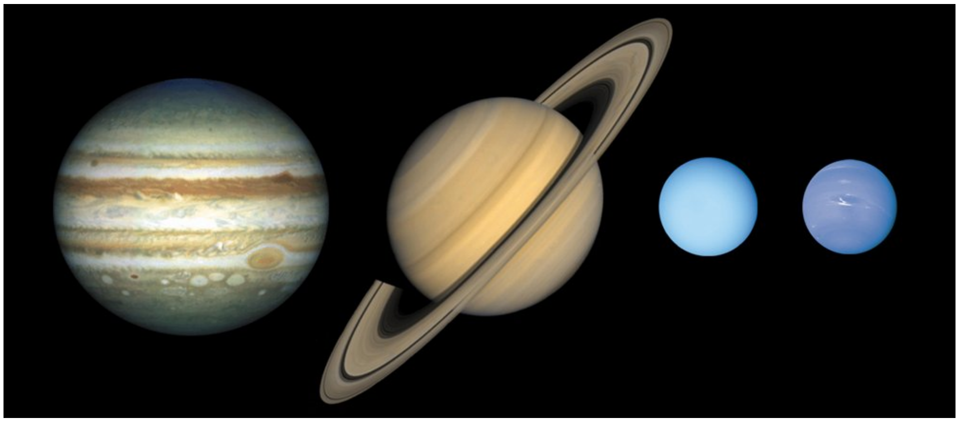
Sunward of us lies the glistening planet Venus, often seen as a brilliant morning or evening "star". Perpetually veiled by layers of clouds that include droplets of sulfuric acid, Earth's sister planet hoarded the Sun's heat under its vast cloud layers until surface temperatures stabilized at more than 900 degrees Fahrenheit –about the same temperature as the flames given off by burning gasoline! With an atmosphere made mainly of carbon dioxide, Venus is unlikely to be the site of new luxury hotels anytime in the near future. But it is a volcanically active, fascinating world that humanity is exploring by using radar beams to penetrate the clouds.



Our other planetary neighbor, the red planet Mars turns out to be a cold, "low-pressure" world, with air so thin that if you stepped out on its surface unprotected, your blood would literally boil. On a dry, dusty Martian plateau, there rises Mount Olympus, a volcano so enormous that its base would cover the entire state of Arizona. Nearby there begins the Mariner Valley, a "grand canyon" system so vast that on Earth it would stretch from Los Angeles to Washington, D.C. Between Venus and Mars is our own Earth, whose thick atmosphere contains oxygen and allows us to survive. Its surface is about two-thirds liquid water, another crucial ingredient to life as we know it. The Earth has one satellite, which we call the Luna (the Moon), and which orbits our planet in such a way that it always keeps one face toward us and one face away. Luna is the only other world on which human beings have actually landed, walked, and even driven a special moon-buggy.

The Outer System

Alien as our two neighbor planets sound, the more distant worlds are stranger still. From the perspective of these chilled outer planets, even the coldest and most inhospitable places on Earth begin to seem like great places to live. Take Jupiter, the largest of the planets, for example. It is so huge that more than 1,200 Earths would fit into its vast sphere. Yet if you tried to land on Jupiter, you couldn't - you would simply sink in and in and in. Like the other outer planets, Jupiter is composed mainly of gas and liquid, with a small solid core at its center. Yet this enormous planet spins on its axis in only 10 hours (more than twice as fast as our much smaller Earth), setting up vast circulation patterns and storms in its outer layers that can persist for centuries. Heat rising from within and the fast moving atmosphere produce huge weather patterns, each larger than an Earth continent, that are easily seen with our telescopes. One of these storms, which dredges up darker, redder material from the planet's interior, is called Jupiter's Great Red Spot – it is sometimes as large as three Earths laid side by side.



Surrounding Jupiter are more than 60 moons and a thin ring - a family so varied and complex, astronomers like to say that the giant planet is the center of a mini-solar system of its own. Four of Jupiter's moons are so large that if they orbited the Sun, we would respectfully call them planets and make students memorize their names. One of these satellites, lo, turns out to be the most volcanically active body in the solar system - our space probes have revealed that the moon is literally "churning itself inside out". And another large moon, Europa, has an icy covering that may be protecting a vast underground ocean, where heat from inside the moon could be keeping conditions warm.

Just a little smaller than Jupiter, but still much bigger than the Earth, Saturn is distinguished by a large and complex ring system. Saturn is not unique in having rings- we now know that Jupiter, Uranus, and Neptune have them as well - but its system of rings and ringlets is so huge that it would almost fill the space between our Earth and its Moon. These rings, by the way, are not solid, but consist of billions of icy pieces following a well-organized traffic pattern around Saturn's equator. Saturn's largest moon, Titan, has an atmosphere thicker than Earth's - something no other moon can boast of having. Under the frigid atmosphere, we have found eerie lakes of fuel oil and boulders made of water frozen harder than rock.

The centerpiece of our planetary system is Sol (the Sun), a million-mile-wide, yellow dwarf star. Its gravity keeps the planets in orbit around it. Its vast outpouring of energy illuminates all the worlds around it and sustains the fragile life-forms on the watery planet we call Earth. To give you some sense of the scale of our solar system, consider the following analogy: If the Sun were reduced to the size of a basketball, the Earth would be an apple-seed some 115 feet from the ball. Jupiter would be a golf ball 450 feet away, and dwarf-planet Pluto would be a dust mote almost three-quarters of a mile from the center. And that is just our immediate neighborhood in the cosmos!

Light Years and the Stars

Beyond the solar system, there is a vast expanse of space, with an occasional grain of dust or elemental atom floating in the dark emptiness. The nearest other star system - known as Alpha Centauri and best seen from the Earth's southern latitudes - is so far away that the fastest spacecraft our species has built would take about 80,000 years to reach it. Even beams of light, which travel at a phenomenal 670 million miles an hour, take a little over four years to make the journey between these two systems.

Other stars are even farther than Alpha Centauri, separated from us by increasingly larger gulfs of space and time. Some of the brightest stars in the sky are hundreds of light years away. If we could visit them, many stars would look smaller and dimmer than the Sun while others would be much brighter and larger. The reason they all look like little points of light to us is that they are so enormously far away. We now know that many of these stars have planets orbiting around them, just like the Sun does.

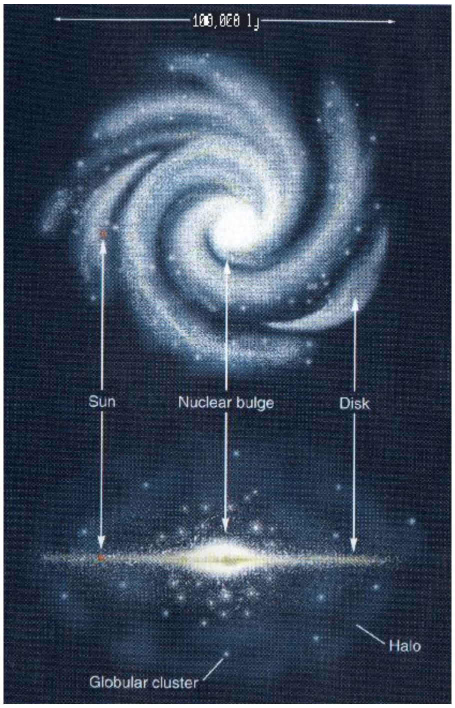
At the time we write this (spring 2012), about 800 of these exoplanets, as they are called, have been found around other stars - and dozens of stars show families of planets surrounding them. Most of these planets are too dim and too lost in the glare of their parent stars for us to be able to take a photo of them. We find planets either because their gravity tugs a tiny bit on their stars and makes the stars "wiggle" or because the planet gets in front of the star as it orbits and cuts down its light just a bit.

One of the most profound discoveries of modern astronomy is that stars do not last forever. Over the millions and billions of years, stars are born from the raw material of space, shine steadily for some 90% of their lives, swell up briefly, and eventually die when they run out of the central fuel that keeps them hot. Luckily new generations of stars keep forming all the time, maintaining a variety in our sky.

In The Milky Way Galaxy

All the stars visible with the naked eye and many others make up a huge spiral-shaped grouping called the Milky Way Galaxy. Being inside the dusty Milky Way Galaxy makes it hard for us to get a good picture of it - it's like trying to get a good photo of yourself from inside your stomach. Our best current estimate is that the Galaxy comprises some 200 billion to 400 billion stars and a vast amount of raw material (atoms, molecules and dust). Much of this raw material does not give off visible light (although we have observed it using other kinds of waves). Still, in a few places, the light of nearby stars energizes the gas and we get a shining nebula.

In the dark, moonless, night sky, it is possible to locate the Milky Way overhead in summer or winter. It appears as a light streak across the night sky. If possible, use binoculars or a telescope to see that it is really made of individual bright stars.



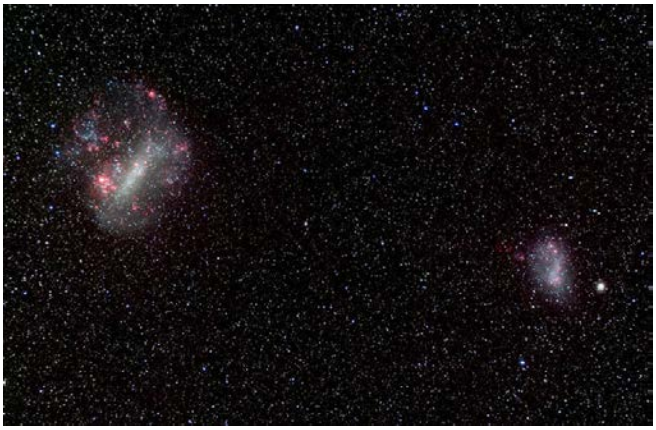
One of the most humbling discoveries of 20th century astronomy was the realization that the Sun resides in the "boondocks" of the Milky Way Galaxy, some 30,000 light years from its center. We don't even have a place on one of the main spiral arms of stars that define our galaxy's structure; instead, we are off on a small local "spur" of stars. All the stars in the Galaxy orbit around its center; our Sun takes about 225 million years to make one trip around the Milky Way.

The entire galactic spiral disk is at least 100,000 light years across and may be surrounded by a much larger "halo" of dark material whose nature astronomers do not yet understand. The shape of our Galaxy reminds us of a Frisbee with a golf ball in the middle - it's a flat disk with a bulge of stars at the center. Deep inside that bulge is a giant black hole - a place where gravity has become so strong that nothing, not even light, can escape. The black hole contains enough material to make 4 million Suns! It's a monster at the heart of the Milky Way, but luckily its strong gravity makes it so small, it's not a danger once you get away from its neighborhood.

Beyond the Milky Way

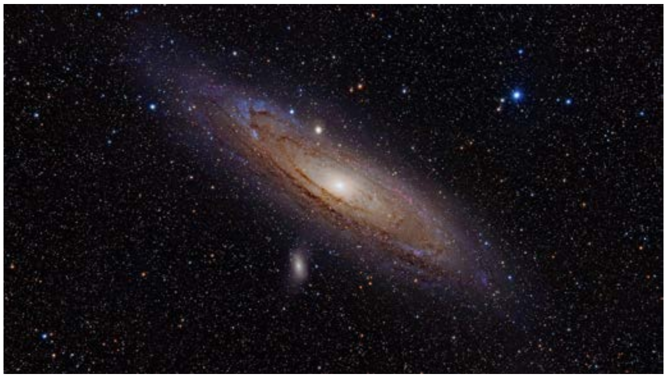
Beyond our own Galaxy lie even larger and emptier regions of what we call "intergalactic space:' These areas are so unpopulated that on average you might run across only a single atom in every cubic yard (or cubic meter) of space.

Accompanying our Milky Way are a number of small "satellite" galaxies, two of which are called the Magellanic Clouds (because they are only visible in the Southern Hemisphere and it was the crew of Magellan's voyages who brought news about them back to Europe). They are 150,000 to 200,000 light years away and give astronomers an excellent opportunity to study another system of stars that has evolved more or less separately from our own. They won't stay separate forever, though; astronomers now understand that the Milky Way has grown to its present size by “eating up” a good number of its smaller neighbor galaxies over the billions of years.



Magellanic Clouds

The nearest major galaxy, barely visible to the naked eye on dark nights in the constellation of Andromeda, is so well known among astronomy buffs it is often just called the Andromeda Galaxy. A beautiful spiral grouping just a little bigger than our own, this galactic neighbor is about 2 million light years away. Thus, the light we see from it tonight left this galaxy 2 million years ago, when the human species was just beginning to establish its foothold on our planet.



Our closest neighbor, The Andromeda Galaxy

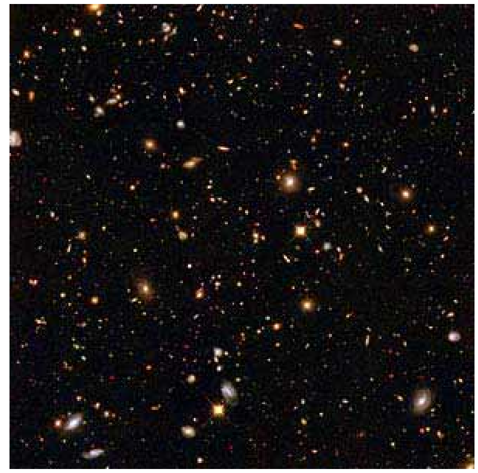
The Milky Way, the Magellanic Clouds, and the Andromeda Galaxy are all part of a small clustering of galaxies that we have named, with remarkable lack of descriptive imagination, the Local Group. Several dozen galaxies make up the Local Group and they move around a common center. Within such groups, galaxies are close enough to one another to collide or merge over long periods of time. There is even a possibility that the two larger galaxies in the Local Group, the Milky Way and Andromeda, may collide in the distant future, but this is not certain.

Galaxies Beyond the local Group

Beyond Andromeda, our telescopes have revealed billions of other galaxies - myriad islands of stars dotting the cosmic ocean. Some of these systems strongly resemble the ones in the Local Group, but others are strangely different. Many seem darker and "used up” with far fewer young stars than our Milky Way. Others seem to be the results of recent "mergers" - where the collision of two or more galaxies has produced a complex new system. Some are seen to be torn by violence - huge "engines" at their centers seem to be spewing out energetic "jets" of high -speed material that sometimes distort the shape of their galaxy.

The most energetic of these "active" galaxies are called quasars by astronomers, a contraction from their original name "quasi-stellar objects” From far away, only the central pinpoint of violence can be clearly distinguished, and so the objects looked "quasi-stellar" (like a star) when first discovered. Most quasars are many billions of light years away and we thus see them as they were many billions of years ago. Astronomers now understand that the engine powering the small, active centers in these galaxies is a massive black hole – which is "eating" fresh material within easy reach.

Hubble Deep Field



Galaxies and quasars stretch away from us equally around the sky, with no preferred center or direction. In 1999, after receiving an upgraded camera, astronomers pointed the Hubble Space Telescope into a region of space in the constellation Ursa Major that was previously thought to be relatively absent of any stars or galaxies. The area was the equivalent in angular size to a tennis ball being held up at a distance of 100 meters. 342 exposures and 10 days later, the astronomers were astonished to see that there were more than 3000 galaxies in this small window of space (as shown to the right)!

The largest of Scales

Astronomers can measure that galaxy groups are moving away from each other in a grand pattern we call the expanding universe. According to our best understanding, the galaxies seem to move apart because space itself is expanding in all directions. The explosive beginning of that expansion- some 14 billion years ago is called the big bang. Understanding more about the big bang, the expansion of the universe, and its ultimate fate; tracing how the evolution of the universe made humanity possible; and exploring whether this vast cosmos might contain other examples of intelligent life - all these are the great questions astronomers will be trying to answer in the decades to come.

Analysis:

Answer the following questions on lined paper in complete sentences which restate the question in your answer.

1. What analogy is used to describe our solar system, galaxy and Universe?
2. List some of the things that can be found in our solar system.
3. Briefly describe conditions on Venus.
4. Briefly describe conditions on Mars.
5. Briefly describe conditions on Jupiter.
6. Why are Jupiter's moons Io and Europa thought by many astronomers as the next place to colonize after Mars?
7. The planets are incredibly far from one another and the Sun. Why do you think they are always drawn so close together on posters and diagrams?
8. What is found in space once you get away from the Sun and planets?
9. Why do really big stars look so small in the night sky?
10. How do we find exoplanets?
11. What keeps us from getting a good picture of the Milky Way Galaxy?
12. Where are we located within our galaxy?
13. What is found within the center of the galactic bulge?
14. How did the Milky Way Galaxy get to be its current size?
15. What is our Local Group? What can be found there?
16. Describe what occurs in a quasar.
17. What is the Hubble Deep Field?
18. What is happening to the size of the Universe?
19. What did you find most interesting from this reading?
20. What from this reading would you like to know more about?

The Universe – The Milky Way *(This video can also be watched on Netflix Streaming)*

Answer the following questions on a separate sheet of paper. You do not need to answer them in complete sentences. Questions are spaced out with enough time for you to answer each (1-3 minutes apart).

1. How is the Milky Way like a construction site?
2. When we look at the Milky Way, what is it that we are actually seeing?
3. How long does it take Sol to revolve around the center of the Milky Way?
4. How many galaxies are in our local group?
5. How do we know what the Milky Way is shaped like it is if we haven't been able to get out of our Galaxy?
6. How do elliptical galaxies get so large?
7. Why can't black holes be seen directly?
8. If our solar system were shrunken down to the size of a CD, how large would our Universe be?
9. What blocks most of the light from our galaxy? What enables us to "See" these parts of space?
10. Name three of the four wave types that help astronomers see distant galaxies.
11. How many main spiral arms does the Milky Way have? Where do we live?
12. How many open clusters are there in our galaxy?
13. Why does the sky appear blue?
14. Besides diffuse or emission nebulae, name the two other types of nebulae found in our galaxy.
15. How could the elements in your body have once been in a star?
16. What makes the star, Mira A, so spectacular?
17. How bright would it be if our Sun were located in the galactic bulge?
18. What type of waves allowed us to see the center of our galaxy?
19. What do astronomers think came first, the galaxy or the black hole?
20. Besides being sucked into the black hole, what else is happening at the edges of a black hole?
21. Once formed at the edge of a black hole, what is likely to happen to that star?
22. About how many times has our solar system been orbited around the Milky Way?
23. What galaxy is the Milky Way likely to merge with?
24. When will star formation stop?

All about Galaxies Reading

Introduction:
Galaxies are large systems of stars and interstellar matter, typically containing several million to some trillion stars that are all gravitationally bound together into some type of pattern. The mass of a galaxy is between several million and several trillion times that of our Sun. The distance across a galaxy can extend a few thousands to several 100,000s of light years. Typically, individual galaxies are separated by millions of light years distance. They come in a variety of shapes: spiral, lenticular, elliptical and irregular. Besides simple stars, they typically contain various types of star clusters and nebulae.

Question: What are the types of galaxies and what are their parts?

Background: *(write a few things that you already know pertaining to about the question above)*

Vocabulary:
Local Group
Spiral Galaxy
Barred Spiral Galaxy
Elliptical Galaxy
Irregular Galaxy
Lenticular Galaxy
Gravitational Lens
Active Galaxy
Galactic Cannibalism
Pulsating/Variable Star
Spiral Arm
Galactic Bulge
Galactic Disk
Globular Cluster
Galactic Halo

Materials:
This reading

Procedure:
Read through the following passage. **Underline statements** that you feel are important to the tone and message of the article.

Our own galaxy is a giant spiral galaxy, the Milky Way Galaxy, which is 100,000 light years in diameter and although it has an estimated 200-400 billion stars, it has a mass roughly a trillion times greater than our Sun.

The Milky Way galaxy is part of a cluster of more than 30 galaxies called the Local Group.
Our two closest neighbors arethe Andromeda and Triangulum galaxies, with the Andromeda Galaxy, also a spiral, being 2-3 million light years across.

The Milky Way as seen on a clear night

Types of Galaxies

Spiral

Spiral galaxies usually consist of two major components. The first is the nucleus, which is a flat, large disk which often contains a lot of interstellar matter (visible sometimes as reddish diffuse emission nebulae, or as dark dust clouds). The second is the spiral arms, which contain young (open) star clusters, (recognizable from the blueish light of their hottest, short-living, most massive stars). Our sun is one of several 100 billion stars in a spiral galaxy, the Milky Way. Other types of spiral galaxies include lenticular galaxies which are disk-shaped but have no recognizable arms, and barred-spiral which have a barred instead of circular center and two large arms that are opposite of each other.

Elliptical

Elliptical galaxies are actually of ellipsoidal shape, and it is now quite safe from observation that they are usually triaxial (sort of like *cosmic footballs*). They do not rotate as a whole (of course, the stars still orbit the centers of these galaxies, but the orbits are spinning in all different direction as they go around the center of these galaxies). Normally, elliptical galaxies contain very little or no interstellar matter. They appear like luminous bulges of spirals, without a disk component.

Irregular

Often due to distortion by the gravitation of their intergalactic neighbors, these galaxies do not fit well into the scheme of disks and ellipses, but have more of an odd shape to them. Galaxies of all types, though of a wide variety of shapes and appearances, have many basic common features. They are huge agglomerations of stars like our Sun, counting several millions to several trillions. Most of the stars are not lonely in space like our Sun, but occur in pairs (binaries) or multiple systems.

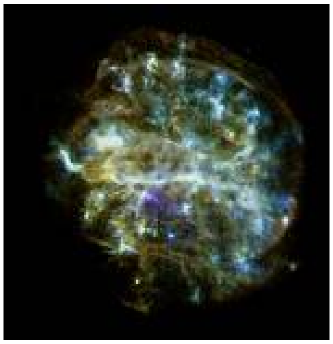
Lenticular

A lenticular galaxy is a type of galaxy which is intermediate between an elliptical galaxy and a spiral galaxy. Lenticular galaxies are disk galaxies (like spiral galaxies) which have used up or lost most of their interstellar matter and therefore have very little ongoing star formation. Therefore they consist mainly of aging stars (like elliptical galaxies). Because of their ill-defined spiral arms, if they are inclined face-on it is often difficult to distinguish between them and elliptical galaxies.

Behavior of Galaxies
Long ago, it was proven that that gravity has the ability to pull objects with mass toward a more massive object. In the 1920's, during a famous experiment that took place during a total solar eclipse, Albert Einstein proved that not only was gravity strong enough to pull matter towards a more massive object, it was strong enough to refract (bend) light that passes by a massive object. Because galaxies are super-massive, they can refract light that passes by it on its way through space. This bending of light as it passes by a galaxy is referred to as a gravitational lens and can distort or change the way that distant galaxies appear.

Just as a star is at some point in its life cycle, galaxies are also evolving because stars inside it are being born and dying out. Dying galaxies have few stars that are forming and most stars in the white dwarf, black dwarf, and neutron star phase. In contrast, active galaxies are alive and have young and forming stars as a part of it are called active galaxies. Active galaxies may be growing or decreasing in number of stars and may even contain pulsating or variable stars. Active galaxies, including the Milky Way, sometimes consume smaller galaxies to become larger in an act known as galactic cannibalism.

Galactic cannibalism

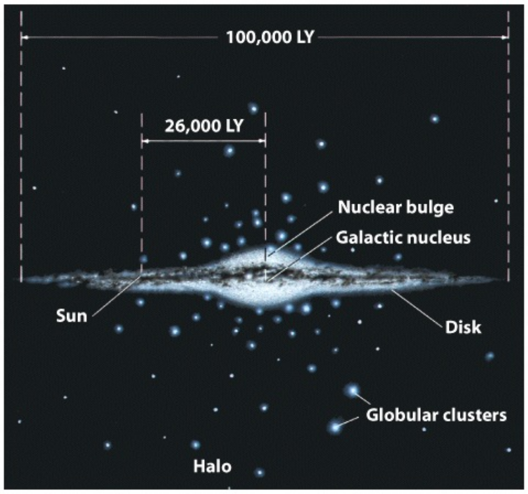


A pulsar

Some galaxies contain a special type of star, a pulsating, or variable, star. As its name implies, a pulsating or variable star varies in luminosity. It does this because it is a rotating neutron star with beams of radiation coming out of its poles. It is important to remember that, just like stars, galaxies normally emit light of every wavelength, from the long radio and microwave end over the IR, visual and UV light to the short, high-energy X- and gamma rays

Characteristics of the Milky Way (Spiral Galaxies)
We know by watching the way that stars move in our own night sky that the Milky Way is a spiral galaxy. We know by looking at other spiral galaxies that they contain a few important features including a galactic bulge, galacitc halo, galactic disk, globular clusters, and spiral arms.

The galactic bulge is the group of stars surrounding the immediate center of a spiral galaxy, the galactic disk is the portion of a spiral galaxy that contains most of the interstellar matter, the nucleus and the spiral arms are a part of it. The spiral arm is the winding offshoot from the center of a spiral galaxy.



The globular cluster is the group of thousands of stars tightly packed together lying outside the galactic disk, but within the galactic halo. The galactic halo is the imaginary sphere surrounding a spiral galaxy that contains ALL of the interstellar matter of that galaxy.

Analysis:

Answer the following questions on lined paper in complete sentences which restate the question in your answer.

1. How many stars are estimated to be in the Milky Way Galaxy?
2. Galaxies are made up of stars and interstellar matter. What do you think “interstellar matter” is?
3. What is the local group?
4. What are the four main types of galaxies?
5. What type of galaxy is the Milky Way?
6. Our neighboring galaxy, the Andromeda Galaxy, is 2-3 million light years across. How does that compare to our Milky Way galaxy?
7. What are the two major parts of a spiral galaxy? What does each part contain?
8. What makes lenticular galaxies unique from spiral galaxies?
9. Do all stars in an elliptical galaxy rotate in the same direction? Explain your answer.
10. Why are irregular galaxies given their name?
11. Our sun is very unique in that it doesn’t exist as a part of a binary system. What does it mean to be a star in a binary system?
12. What type of radiation do galaxies emit?
13. What’s at the nucleus of a spiral galaxy?
14. Where is our solar system located in the Milky Way?
15. Briefly describe each:
    a. Galactic cannibalism
    b. Pulsating/Variable Star
    c. Spiral Arm
    d. Galactic Bulge
    e. Galactic Disk
    f. Globular Cluster
    g. Galactic Halo
16. Sketch a diagram of the Face-on-View of the Milky Way galaxy.
    Label the:
    a. Spiral Arm
    b. Galactic Bulge
    c. Galactic Disk
    d. Globular Cluster
    e. Galactic Halo

Variable Stars and the Julian Day Calendar System

Stars appear to shine with a constant light; however, thousands of stars vary in brightness. The brightness that a star appears to have (apparent magnitude) from our perspective here on Earth depends upon its distance from Earth and its actual intrinsic brightness (absolute magnitude.)

The behavior of stars that vary in magnitude - known as variable stars - can be studied by measuring their changes in brightness over time and plotting the changes on a graph called a light curve. Amateur astronomers around the world observe variable stars using as little as their unaided eye or binoculars and assist professional astronomers by sending their data to variable star organizations, such as the American Association of Variable Star Observers (AAVSO) in Cambridge, Massachusetts.

Measuring and recording the changes in apparent magnitude and drawing the resulting light curves will allow you to begin to unravel the stories of the often turbulent and always exciting lives of variable stars. The collection and study of variable star data requires the ability to estimate the apparent magnitudes of stars.

Question: How do study variable stars?

Background: *(write a few things that you already know pertaining to about the question above)*

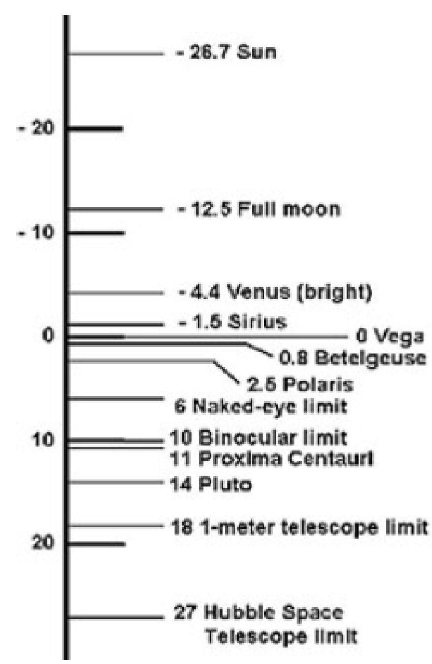
Vocabulary:
Variable Stars
Julian Date
Magnitude

Materials:
This assignment

Procedure:
Read through the following passage. **Underline statements** that you feel are important to the tone and message of the article.

Magnitudes

The method we use today to compare the apparent brightness (magnitude) of stars began with Hipparchus, a Greek astronomer who lived in the second century BC. Hipparchus called the brightest star in each constellation "first magnitude." Ptolemy, in 140 A.D., refined Hipparchus' system and used a 1 to 6 scale to compare star brightness, with 1 being the brightest and 6 the faintest. This is similar to the system used in ranking tennis players, etc. First rank is better than second, etc. Unfortunately, Ptolemy did not use the brightest star, Sirius, to set the scale, so it has a negative magnitude. (Imagine being ranked -1.5 in the tennis rankings!)



Astronomers in the mid-1800's quantified these numbers and modified the old Greek system. Measurements demonstrated that 1st magnitude stars were 100 times brighter than 6th magnitude stars. It has also been calculated that the human eye perceives a one-magnitude change as being 2 and ½ times brighter, so a change in 5 magnitudes would seem to be 2.5 to the fifth power (or approximately 100) times brighter. Therefore a difference of 5 magnitudes has been defined as being equal to a factor of exactly 100 in apparent brightness.

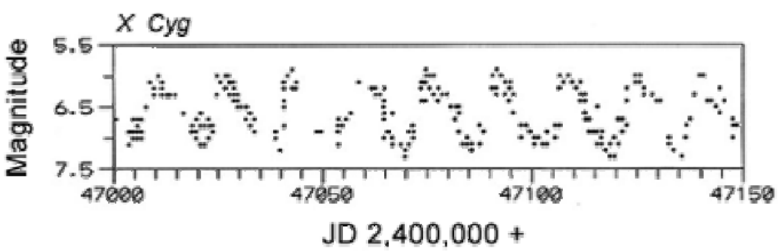
Astronomers simplify their timekeeping by merely counting the days, and not months and years. Each date has a Julian Day number (JD), beginning at noon, which is the number of elapsed days since January 1st, 4713 B.C. For instance, January 1st, 1993, was JD 2448989; January 2nd, 1993, was JD 2448990; and January 1st, 2000, was JD 2451545. Why the year 4713 B.C.? The Julian Day system of numbering the days is a continuous count of days elapsed since the beginning of the Julian Period. This period was devised by Joseph Justus Scaliger, a French classical scholar in the 16th century. Scaliger calculated the Julian Period by multiplying three important chronological cycles: the 28-year solar cycle, the 19-year lunar cycle, and the 15-year cycle of tax assessment called the Roman Indiction. To establish a beginning point for his Julian Day system, Scaliger calculated the closest date before 1 B.C. which marked the first day for the beginning of all three cycles. This day is January 1, 4713 B.C., which is Julian Day number 1.

Stellar Heartbeats

Variable stars are stars that vary in brightness, or magnitude. There are many different types of variable stars. One group of variable stars is the pulsating variables. These stars expand and contract in a repeating cycle of size changes. The change in size can be observed as a change in apparent brightness (apparent magnitude.) Cepheid variables are one type of pulsating variable stars. Cepheids have a repeating cycle of change that is periodic - as regular as the beating of a heart. Observations of the changes in apparent magnitude of variable stars - including Cepheids - are plotted as the apparent magnitude versus time, usually in Julian Date (JD). The resulting graph is called a light curve.

The light curve for the Cepheid variable star X Cyg (located in the constellation Cygnus) is shown below. Each data point represents one observation. Once many observations have been plotted, important information can be obtained from the resulting pattern of changing magnitudes.

The period for X Cyg is the amount of time it takes for the star to go through one complete cycle from maximum magnitude (brightness), through minimum magnitude (dimmest), and back to maximum magnitude (brightness.)



Light curve for the Cepheid variable star X Cyg.

Analysis of the light curve for X Cyg shows that the magnitude ranges from an average maximum magnitude of 6.0 to an average minimum magnitude of 7.0 with a period of approximately 16 days. X Cyg exhibits periodic behavior - it is a Cepheid variable star with a predictable cycle of changing magnitudes, a stellar heart that beats once every 16 days.

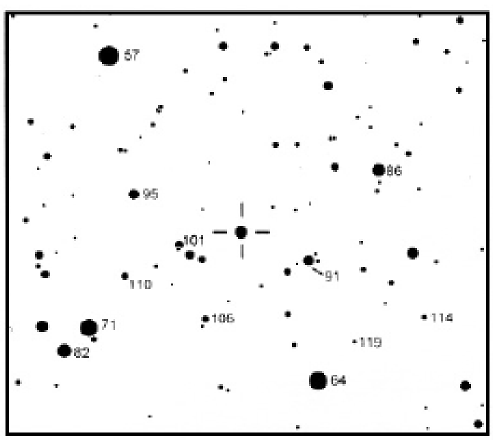
Observing Stellar Heartbeats

Look at the simulated reproduction of a star field on the following pages. It contains a variable star that is located in the middle of a set of crosshairs, and surrounding the variable star are several comparison stars of known magnitudes.

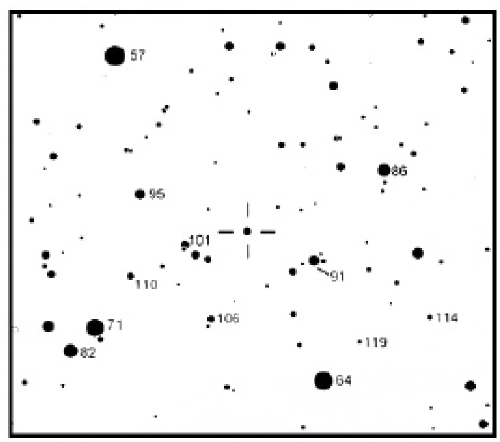
These stars, which do not vary in brightness, are used to compare the changing brightness, or magnitude, of the variable star. Knowing the values of the magnitudes of the comparison stars, you can estimate the magnitude of the variable star as it changes over time. On a star chart, different magnitudes are portrayed as different sizes - the brighter the magnitude the larger the size of the star, and the dimmer the magnitude the smaller the size of the star. **Magnitudes have one decimal, such as 6.3 - however in star fields, the decimals are not indicated. A magnitude of 6.3 is written as 63 so that the fields are not as cluttered and the decimal points are not mistaken for stars.** When you record your magnitude estimation you need to include the decimal.

Create a table like the one below on your assignment sheet. In the table, estimate the magnitude of the variable star on the first picture of the star field using the magnitudes of the stars around it. You will have to estimate this number based on the brightness of known stars around it. (Remember: lower magnitude numbers indicate brighter stars). Proceed through each of the pictures and place your estimated magnitudes and the corresponding Julian Day (JD) numbers in the table.

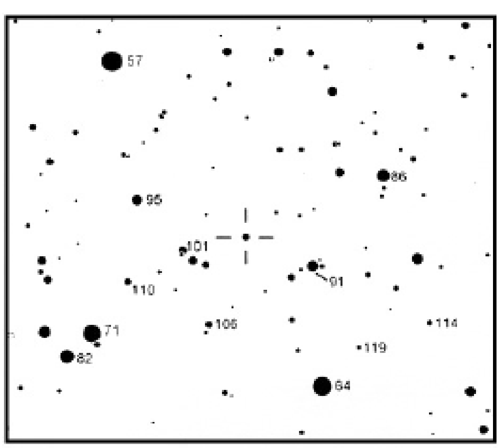
Julian Day	Magnitude	Julian Day	Magnitude	Julian Day	Magnitude



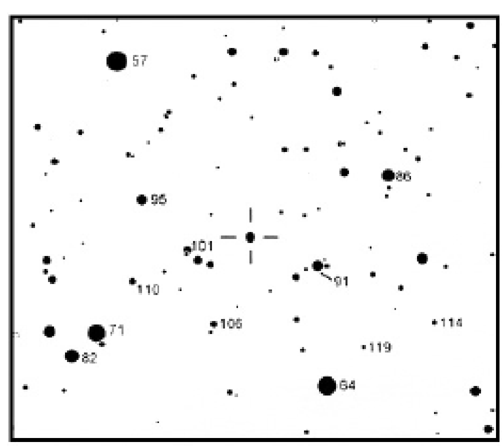
JD 2449050



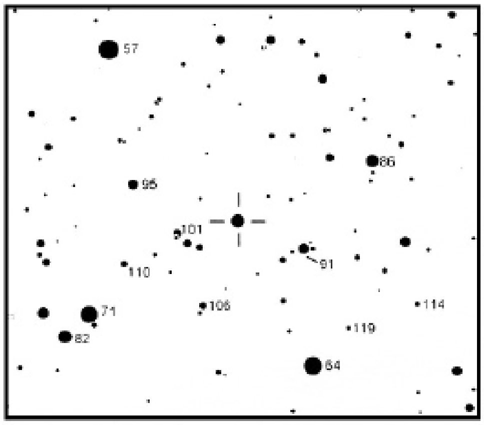
JD 2449110



JD 2449150

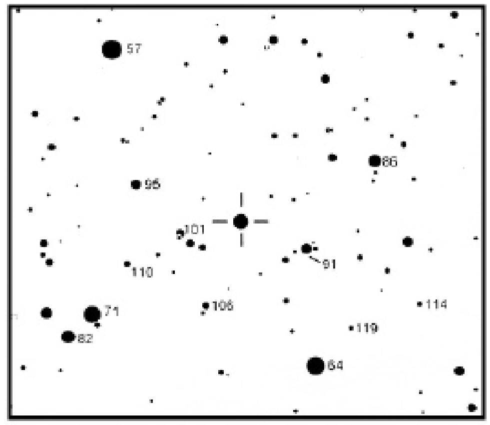


JD 2449180

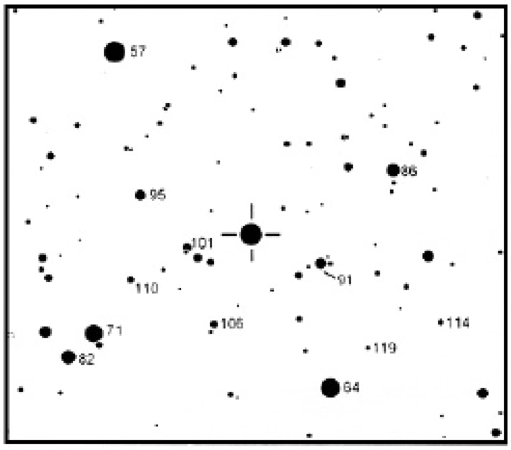


JD 2449240

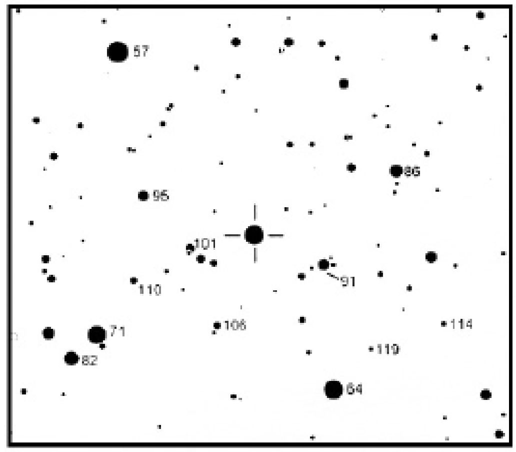
4



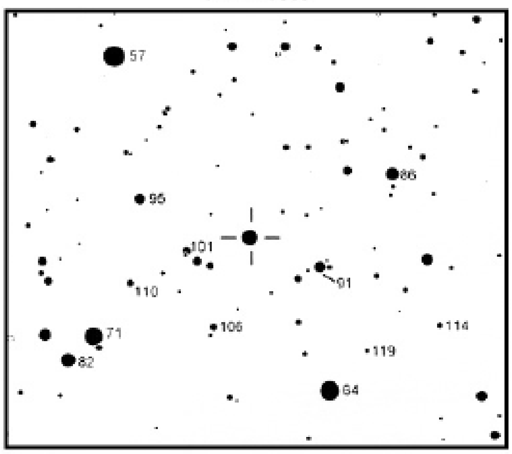
JD 2449300



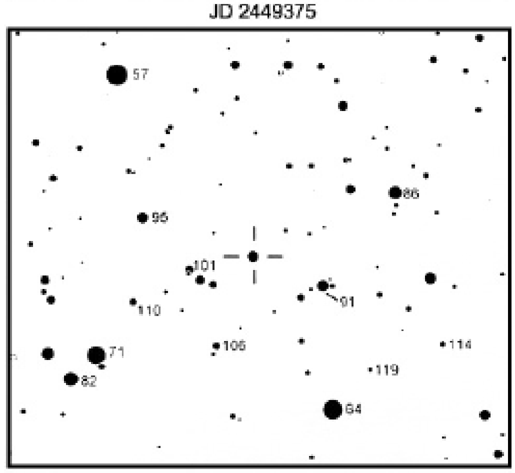
JD 2449350



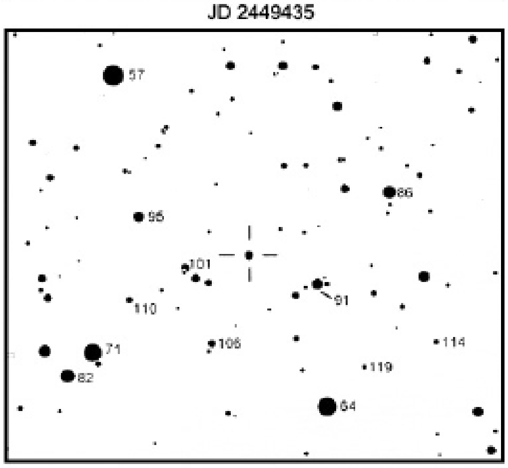
JD 2449375



JD 2449435

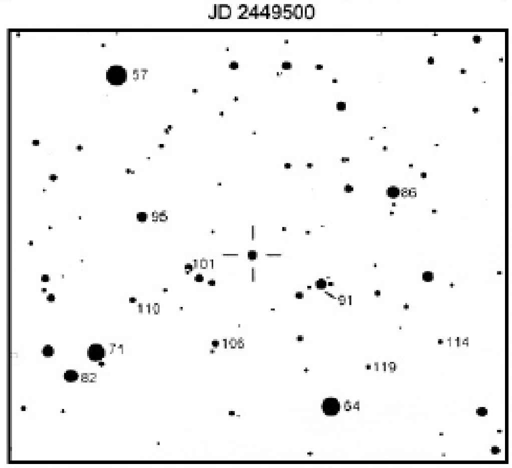


JD 2449500

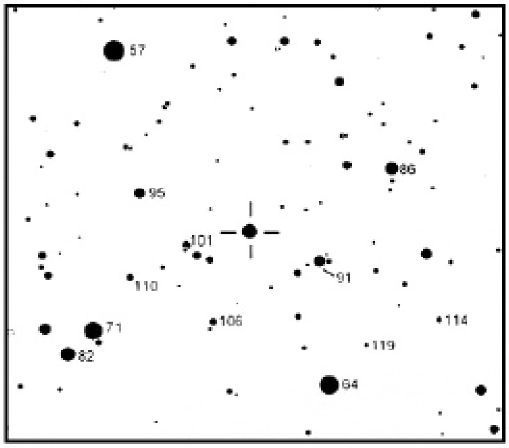


JD 2449540

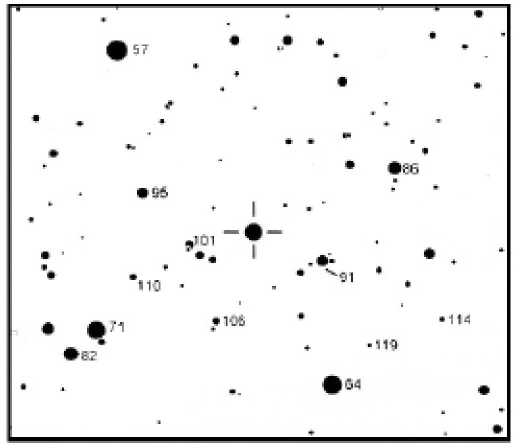
5



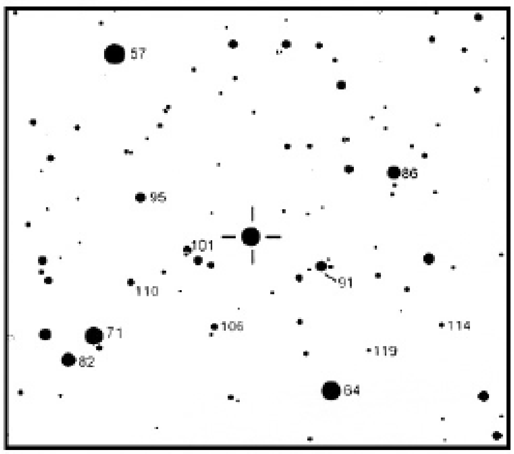
JD 2449635



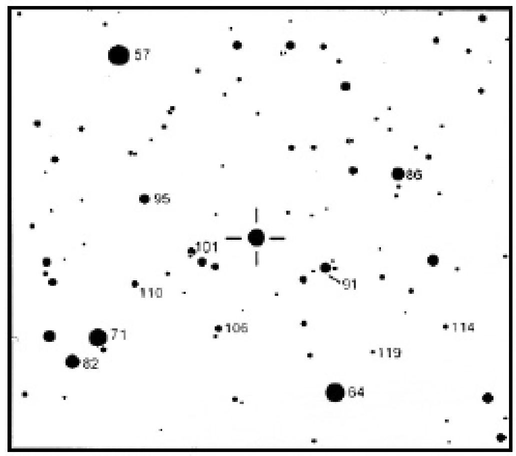
JD 2449700



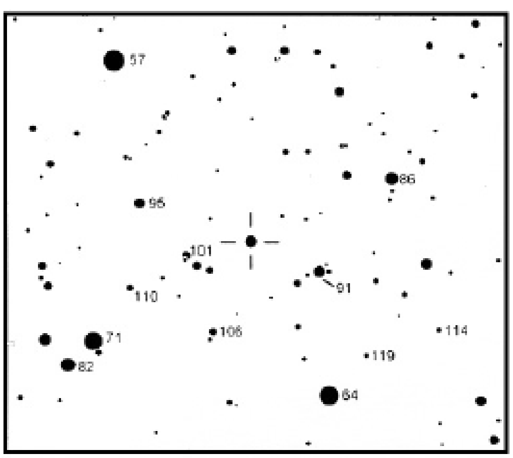
JD 2449740



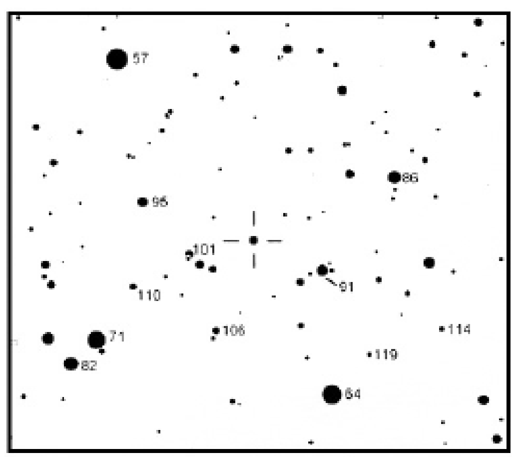
JD 2449760



JD 2449800



JD 2449870

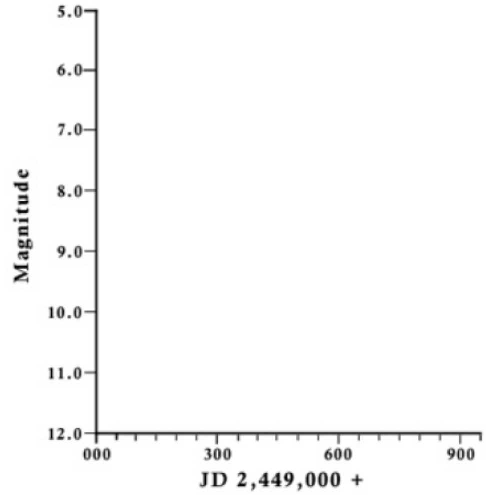


JD 2449950

Recording Stellar Heartbeats

To determine if the variable star that you have "observed" has a regular cycle, you will need to plot your observations on the magnitude versus Julian Day (JD). Draw a graph similar to the one to the right on your assignment sheet and plot the points from earlier in the assignment on your graph.

Please take note that the JD 2,449,000+ means that you will need to subtract 2,449,000 before plotting your JD. This is done to save you having to write such large numbers on your x axis.



Analysis:
Answer the following questions on lined paper in complete sentences which restate the question in your answer.

1. Why is it important to study variable stars?
2. How did the Julian Date calendar come about?
3. What is the Julian Date?
4. Why do you think astronomers use the JD Calendar instead of our normal (Gregorian Calendar) date?
5. Draw a Venn Diagram comparing and contrasting the Julian Date calendar and the Gregorian Calendar.
6. How do you determine a period for a variable star?
7. Why do we not include decimals for magnitude on a star map?
8. What trend did you see in your magnitudes vs. JD chart?
9. Backyard astronomers keep an eye out for variables stars. What galaxy are these stars in?
10. What else in your life would you consider a variable (astronomically, not algebraically)?

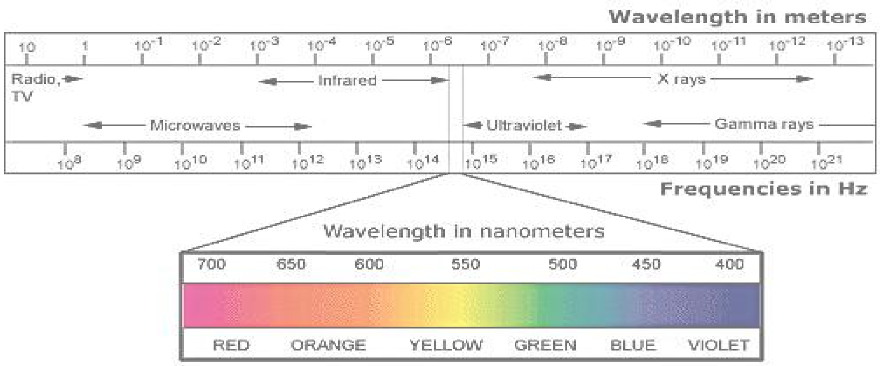
The Expanding Universe Lab

Introduction:
Doppler Effect and Light Waves is similar to Doppler Effect with sound waves.

If you are standing in one spot and a fire truck is coming closer and closer to you, what is happening to the pitch of the sound?
→ It gets higher pitched, which means its frequency increases!

As the fire truck gets further and further from you, what is happening to the pitch of the sound?
→ It gets lower pitched, which means its frequency decreases!

Light waves behave in a similar manner. Look at the visible light section of the electromagnetic spectrum. If radiation is moving closer to us, we would expect the frequency to increase. If radiation is moving away from us, we would expect frequency decrease.



Question: What evidence do we have that the universe is expanding?

Background: *(write a few things that you already know pertaining to about the question above)*

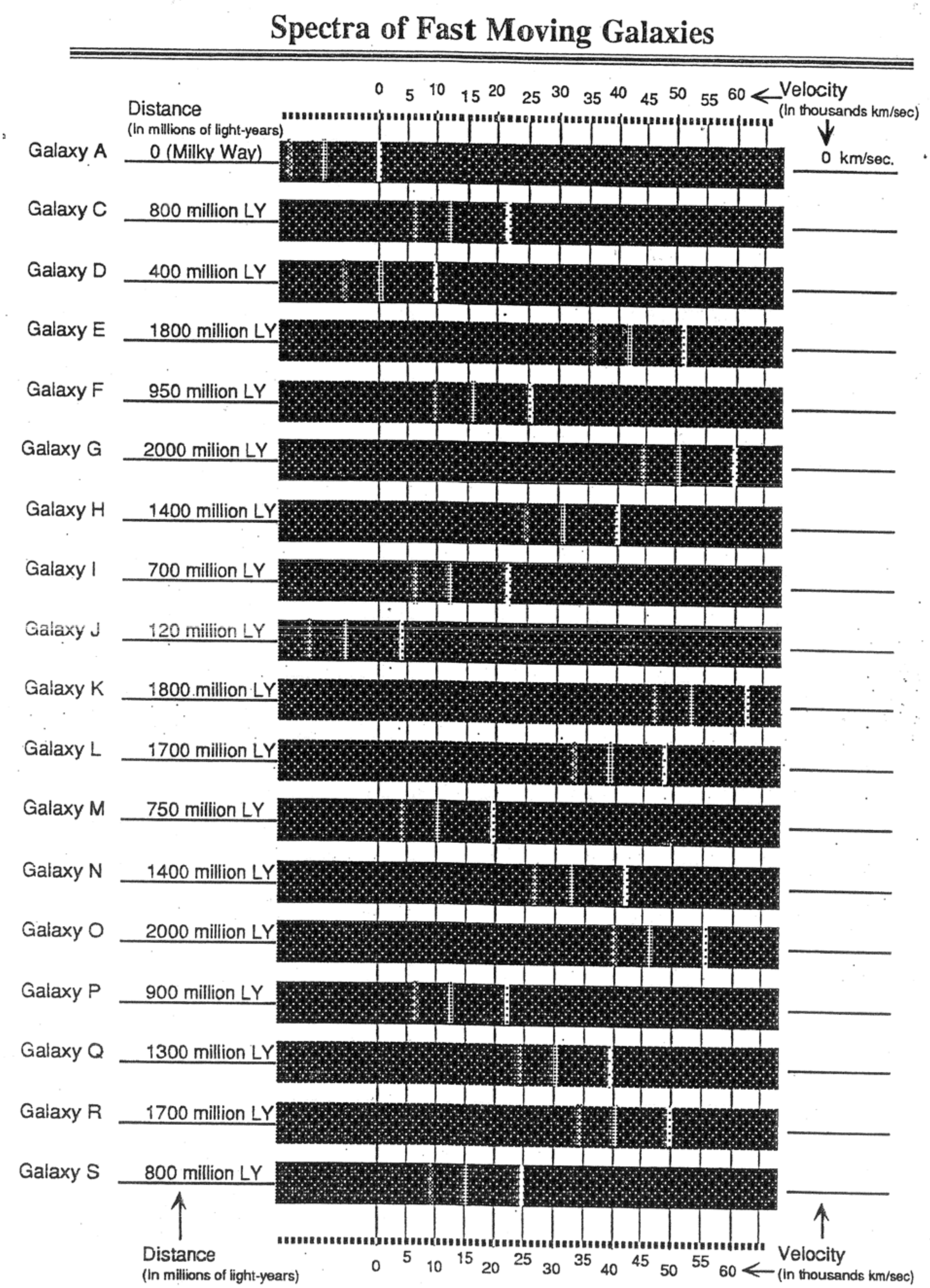
Vocabulary:
Doppler effect
Redshift
Hubble's Law
Megaparsec (Mpc)

Materials:
The Universe 1 billion years ago Picture
The Universe today Transparency
A ruler

Procedure:
Part I - Finding the velocity of galaxies using redshift
Answer the following questions on lined paper before beginning the activity.

1. Which color and wavelengths of our visible light section have the highest frequency?
2. Which color and wavelengths of our visible light section have the lowest frequency?
3. If an object is moving away from you what color would you expect the object to shift to (think about the frequency of radiation that is moving away from you)?
4. If an object is moving toward you what color would you expect the object to shift to (think about the frequency of radiation that is moving toward you)?

Step 1: List the velocity of each of the galaxies by looking at the given spectra. The velocity can be found at the brightest line in the spectra of that galaxy.



Step 2: Graph the distance of each galaxy vs. its velocity on the graph titled "Hubble's Law."

Next to each point you plot, write the letter of the galaxy represented by that dot.

Analysis:
Answer the following questions on lined paper in complete sentences which restate the question in your answer.

5. Using the graph, if a galaxy is about 200 million light years away, how fast is it moving?
6. Using the graph, if a galaxy is about 1600 million light years away, how fast is it moving?
7. Using the graph, if a galaxy is traveling at 20,000 km/sec, how far away is that galaxy?
8. Using the graph, if a galaxy is traveling at 50,000 km/sec, how far away is that galaxy?
9. Using this information and the graph itself, what does this graph tell you about the relationship between the distance of galaxies and the speed they are traveling?

Use the following information to answer the questions: Hubble's Law implies that the further a galaxy is away from us, the faster it is moving away from us.

The equation for Hubble's Law is:
$V = H_o D$, where
V = Recessional Velocity (km/sec),
H_0 = Hubble's Constant
D = distance (Mpc).
*1 Mpc ≈ 3.26 million LY

Points are not going to fall directly on this line, however this is the best fit line (and equation) for this situation. Hubble's constant varies because it is not a perfectly straight line, but today we will use it as ***60 km/sec/Mpc.***

10. Using the equation, how fast is a galaxy that is 0.5 Mpc away moving?
11. Using the equation, how far away is a galaxy that is found to be receding from us at 120,000 km/sec?
12. Using the equation, if a galaxy is 490.5 Mpc away how fast it is moving?
13. Knowing that 490.5 Mpc ≈ 1600 million light years, compare your answer in #7 (using the equation) to the answer you got in #2 (using the graph).
14. Using the equation, how far away is a galaxy that is moving at 50,000 km/sec.
15. Compare the answer you got in #10 (using the equation) to the answer you got in #4 (using the graph).
    HINT: 833.3 Mpc ≈ 2700 million LY

Procedure:
Part II - Visualizing the Expanding Universe
Answer the following questions on lined paper as you complete the activity.

The picture represents the universe 1 billion years ago. The transparency represents the universe today.
Each dot is a galaxy cluster. Evidence of studying the motion of galaxies in the universe indicates that universe is expanding at a rate indicated by the dot patterns.

16. On each individual sheet, do you notice any "center" to the pattern of dots?

Place the transparency over the picture, being careful not to rotate them relative to each other (line up the outer boxes). Once you see this, you will see a "center". Measure the location of this center:

17. Distance (in cm) from the left edge of the paper:
    Distance (in cm) from the top edge of the paper:

18. Shift the transparency without rotating it. What happens to the center point?
19. Pick a dot. Can you discover how to move the transparency so that any point you choose will become the center? If you can shift it, describe your method of shifting in words.

Each dot represents a galaxy. The picture represents the universe 1 billion years ago and the transparency represents the universe today. Select a dot to be your home galaxy. Line up the transparency exactly so there is no rotation (line up the outer boxes). The separation between a dot on the picture and the corresponding dot on the transparency represents the speed of the galaxy.

20. How far the galaxy has moved in 1 billion years.
    a) What direction are the galaxies moving?
    b) Are the galaxies moving at the same speed?
    c) What patterns do you see in the speed and direction of motion of the galaxies?

If you know the distance a galaxy has traveled in 1 billion years and the total distance a galaxy has traveled from the center, you can figure out how many billions of years have elapsed using proportions. This is the same as dividing the total distance by the 1 billion year distance.

Draw a table similar to the one below.

Pick 5 different galaxies (dots) at different distances from the center. For each galaxy:

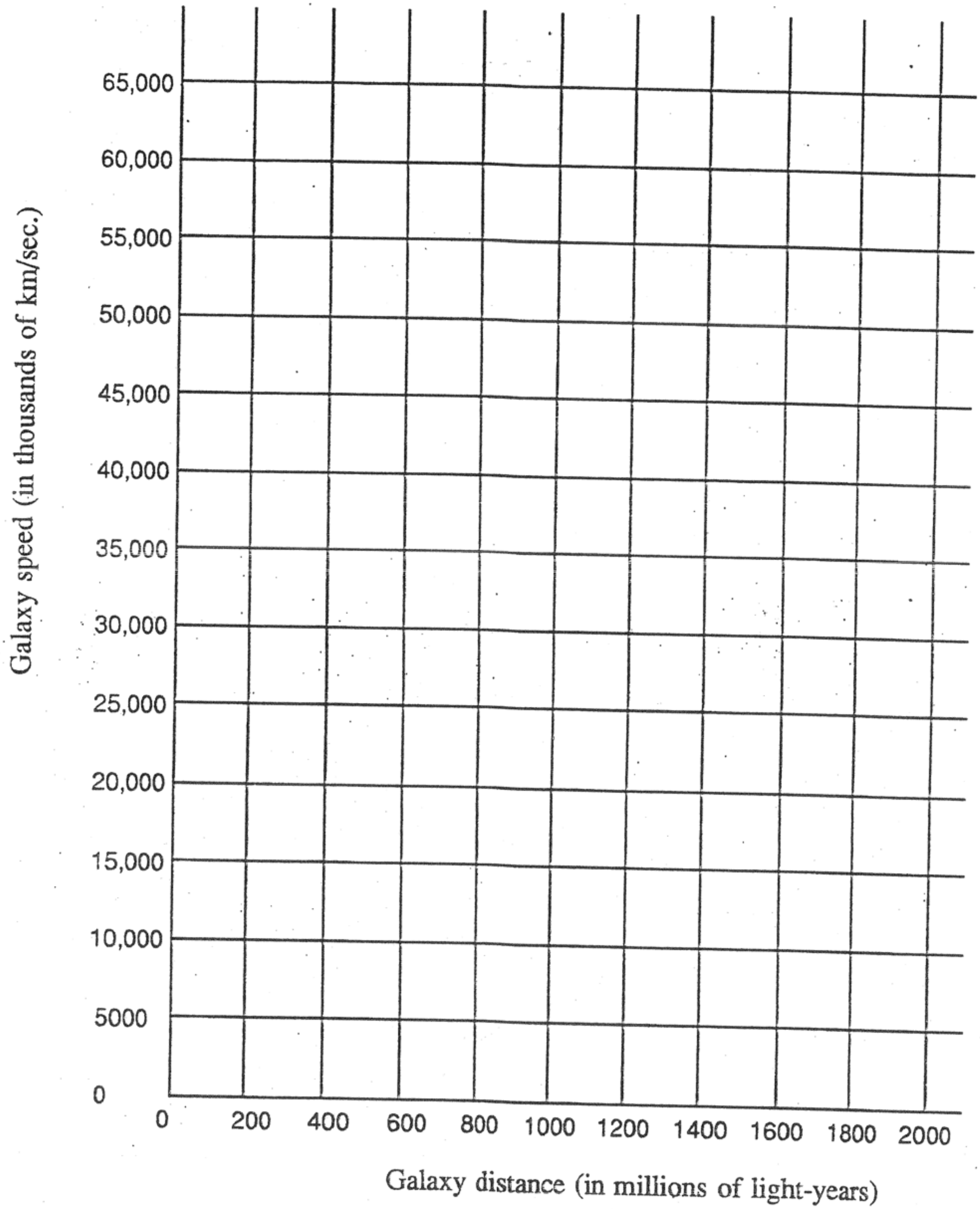
1. Measure the total distance it has moved from the center of your expansion.
2. Measure the distance it has moved in the 1 billion year time period (the distance between the 2 dots representing that galaxy) in millimeters.
3. Divide

	TOTAL DISTANCE		1 BILLION YEAR DISTNCE	=	AGE OF UNIVERSE
21.	________________	/	___________________________	=	______________
22.	________________	/	___________________________	=	______________
23.	________________	/	___________________________	=	______________
24.	________________	/	___________________________	=	______________
25.	________________	/	___________________________	=	______________

Your Average Age of the Universe = ___________

26. How does your computed age for the universe compare with your classmates, who used different galaxies to compute their average ages? Why might there be differences in your answers? Do you think astronomers in distant galaxies would agree with astronomers on earth about the age of the universe?

Hubble's Law



Galaxy speed (in thousands of km/sec.)
65,000
60,000
55,000
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5000
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Galaxy distance (in millions of light-years)

Milky Way Math Assignment

Every 250 million years, our sun revolves once about the center of the Milky Way Galaxy. Find how many revolutions or parts of a revolution have occurred since the following events in Earth's history.

Show your work for each event.

1. Earth formed 4600 million years ago.

2. Oceans of water began forming 3800 million years ago.

3. Animals with shells and skeletons first appeared 570 million years ago.

4. The Appalachian Mountains began forming 500 million years ago.

5. The first mammals appeared 225 million years ago.

6. The Atlantic Ocean basin began forming as Africa, Eurasia, and the Americas began separating 190 million years ago.

7. The last dinosaurs died 65 million years ago .

8. The Himalaya Mountains began forming 53 million years ago.

9. The light we now see from the Andromeda Galaxy began traveling through space 2.4 million years ago.

10. The last ice age ended 10 000 years ago.

11. The Apollo astronauts first landed on the moon in 1969.

12. The year you were born.

The Theory of Universal Expansion Lab

Introduction:
In the 1920s, Edwin Hubble found that the Universe is expanding. On a very large scale, objects such as superclusters, clusters and galaxies appear to be moving at great speeds away from all other objects.

Recently, astronomers have discovered evidence to suggest that the farther away an object is from the observer, the faster it moves. This information is used to support the idea that the universe as a whole is growing in size and is speeding up as it does so. This can be seen in the way that clusters of galaxies recede faster the farther away they are from the observer, the faster it moves. It can also be seen in how all objects (superclusters, clusters, some galaxies) move away from all other objects regardless of their position in space.

The Hubble Velocity Distance Law of Recession is the evidence for this expansion--it describes the rate at which large objects like clusters and superclusters are moving relative to other large objects.

Question: What evidence do we have that the Universe is expanding?

Background: *(write a few things that you already know pertaining to about the question above)*

Vocabulary:
Galaxies
Clusters
Superclusters
Parsecs

Materials:
Balloon, round shaped
Metric ruler or meter stick
Marker
Pre-expansion Grid

Activity 1
Procedure:
1. Blow a balloon up to the size of a grapefruit. Hold it tight so no air escapes. **Do not tie a knot in it**.
2. Use a marker to make 10-12 uniformly spaced dots all over the surface of the balloon. (Make each dot is 0.5cm (5 mm) in diameter.)
3. Continue to blow up the balloon and watch how the positions of all circles change.

Analysis:
Answer the following questions on lined paper in complete sentences which restate the question in your answer.
1. What did you observe as you inflated your balloon?
2. Were the dots moving across the balloon or with the balloon?
3. What does the balloon represent?
4. What do the dots represent?
5. From what area was the balloon expanding most?
6. Where were the fastest moving dots located relative to this location?
7. Not all models are perfect. In what way(s) does this model not represent the Hubble Velocity Distance Law of Recession?

Activity 2
Procedure:
Performed Inside
1. Find letter F on the Pre-Expansion Grid on the Universal Expansion Diagram.
2. Draw a line from the Pre-Expansion Grid F to the Post Expansion Grid F (the matching grid location on the grid.
3. Do this for each of the lettered points on your sheet.
4. Assuming that it took the same amount of time for each of the points to travel to their new locations, answer the analysis questions.

Analysis:
Answer the following questions on lined paper in complete sentences which restate the question in your answer.
1. What does the grid represent?
2. What does each letter in the group represent?
3. How does the rate at which the stars move compare with distances to they travel?
4. Is there a "center" that does not move in Universe?
5. Is the Universe enlarging?
6. How can we tell that the Universe is getting larger?
7. Did any of the clusters move closer to one another?
8. Imagine you were on the star labeled I. What happens to your distance relative to all other stars?
9. How is the model you used different from the Universe?
10. Imagine you were on the star labeled N. What would have happened to all of the galaxies in relationship to your location?
11. How could your findings from this lab make the study of galaxies confusing or troublesome?
12. What other peculiarities or oddities might occur due to the expansion of the Universe?

Additional information on the discovery of the accelerating expansion of the Universe can be found by watching a short video at http://spacerip.com/why-the-runaway-universe-discovery-won-the-nobel-p/

Exoplanets Reading

Question: What are exoplanets and why do we study them?

Background: *(write a few things that you already know pertaining to about the question above)*

Vocabulary:
Exoplanet
Hot Jupiters
Wiggle Method
Transit

Materials:
This reading

Procedure:
Read through the following passage.

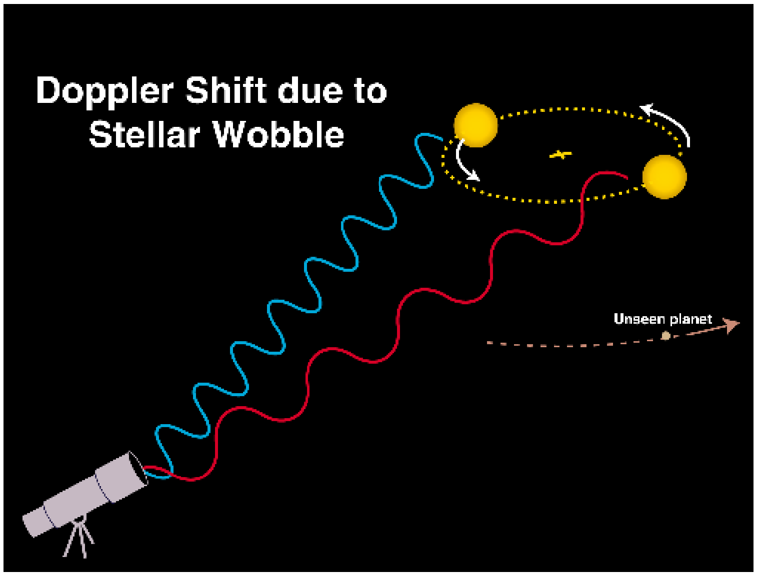
Eight planets and a swarm of smaller objects surround our star, the Sun. We can see these planets (some with our eyes, some only with telescopes) because they reflect the light of the Sun and are close enough to us that a measurable part of that light reaches Earth. Astronomers had long wanted to know whether the Sun's planetary system was unique, or whether other stars also had families of planets circling them.

It was one of the most challenging questions in astronomy. The stars we see in the night sky are so far away that the faint reflected light of their planets was much to dim to see, even with the largest light-gathering telescopes on Earth. And, to make things worse, each faint planet orbits a comparatively bright star. Like a firefly darting among the bright lights of an evening rock concert, the faint planet would simply be lost in the glare. Twenty years ago, the prospects for finding such distant planets seemed, if you'll pardon the expression, rather dim!

The Wiggle Method comes to the rescue
In 1995 Swiss astronomers using a French telescope announced the discovery of the first such extra-solar planet ever detected – around a star called 51 Pegasi (located in the constellation named after Pegasus, the flying horse). The discovery, soon confirmed by American astronomers, was pivotal even in the history of astronomy. More planet discoveries soon followed, until today, 12 years later, the number of planets known around other stars has reached almost 800 and is growing rapidly.

The first observations of exoplanets used the gravity of the planet – and not its light – to show it was there. A planet with substantial mass (such as Jupiter in our own system) that orbits a nearby star causes a very slight pull on that nearby star. We can't see the planet, but we can see the star just fine. As the planet moves in orbit, from one side of the star to the other, its gravity will pull on the star. The effect is very subtle, because the star is big and the planet is much, much smaller. Nevertheless, the planets gravity changes the position and movement of the star very slightly. If we monitor the motion of the star from Earth with very sensitive equipment, we can pick up the "wiggling" (shifting back and forth) of the stars motion caused by the orbiting planet.

With modern telescopes and spectroscopes, astronomers can measure such a small change in a stars motion by using the so-called Doppler shift. The motion of a star toward us or away from us causes very subtle changes in the colors of the light we observe in the star (when astronomers spread out the colors to measure them, we call it a spectrum) – which we call a blue-shift. When the star moves away from us, the shift is the other way – toward the red end – and we call it a red-shift. As the orbiting planet tugs the star (ever so slightly) toward us and then away from us, we see alternating blue and red shifts in the stars spectrum.

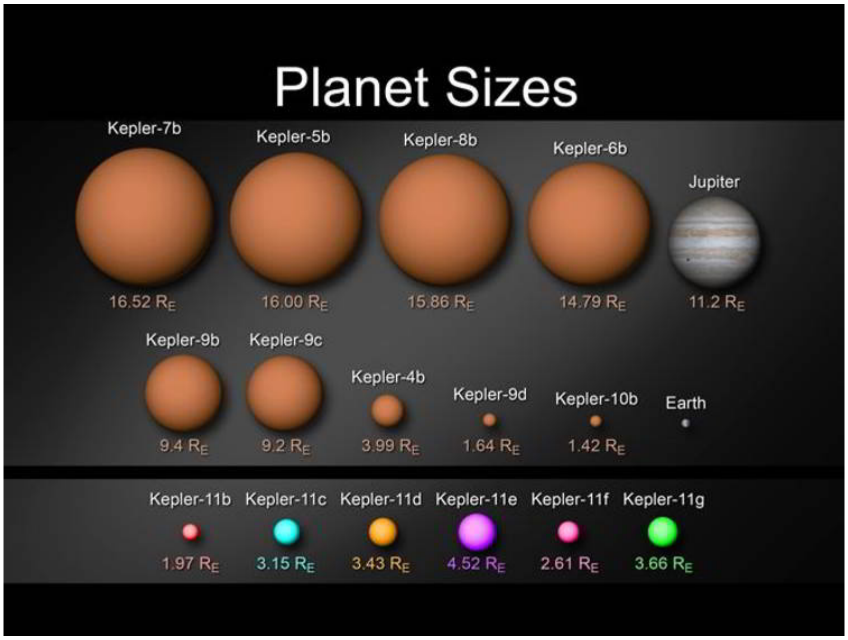


The changes in a stars speed caused by a planet are very small indeed – our own Sun moves back and forth because of the pull of Jupiter (its largest planet) by only about 30 miles per hour, roughly the speed with which most of us drive around town. From many light years away, such changes become very difficult to measure – which is why it took until 1995 for this technique to lead to a successful discovery.

Hot Jupiters

One big surprise about the first planet discovered (which had at least half the mass of Jupiter) is that it took only four days to orbit its star. By contrast, little Mercury, the innermost planet in our own system, takes 88 days to go around. Since 1995, dozens of substantial planets have been found orbiting their stars in two days, three days, four days, or ten days. Astronomers have nicknamed these planets "Hot Jupiters" and still have a way to go toward understanding how such giant gas and liquid planets can be so close to their stars.

However, in one way, we should not be surprised that the hot Jupiter's were the first to be found. The "wiggle" method relies on measuring the pull of the planets gravity. The planets that will have the strongest pull on their stars are the ones that are big and close – the hot Jupiters if such planets exist, they will be the easiest to find with this method.

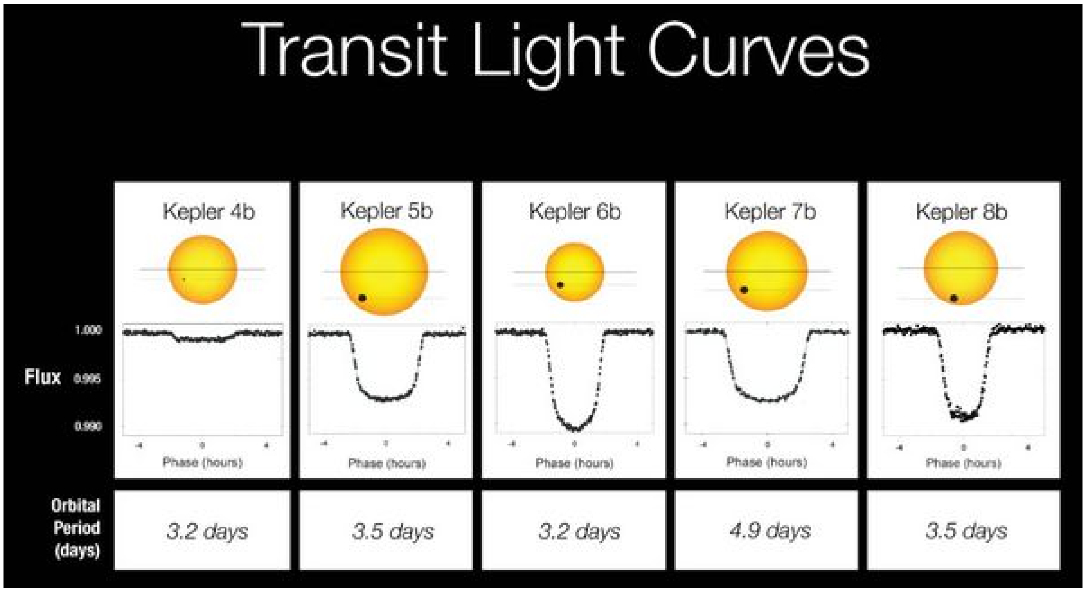


Also, astronomers generally want to wait and measure the full orbit of a planet before announcing a discovery. A planet like Saturn takes abut 30 years to orbit the sun, so it would take alien astronomers 30 years to measure the full cycle of its pull on the Sun. At first, we only were able to confirm planets that orbited their stars in a short time. As more time passes (and our ability to measure small wiggles improves), astronomers are indeed finding more and more planets that are farther away from their stars and taking a decade or more to around them.

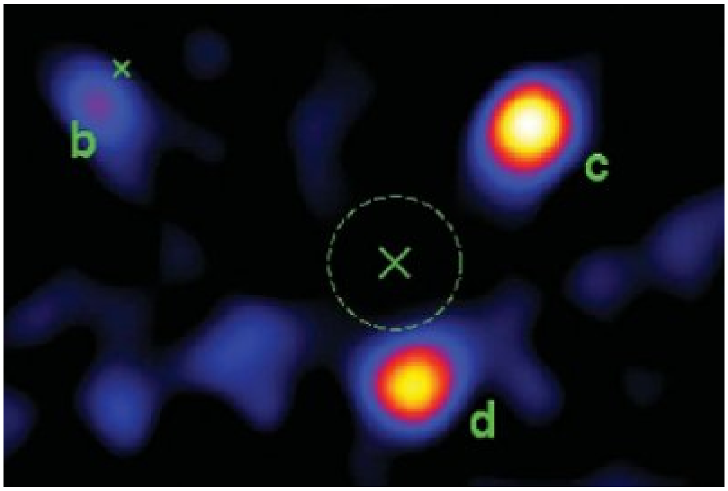
Starting in 1999, astronomers began to find second and third planets around a few of the stars they had been measuring, confirming that planetary systems (not just single planets) existed out there. As of the spring of 2011, 117 stars are known to have more than one planet around them. It's remarkable to consider that in a period of decade and a half, we have gone to knowing one planetary system in the universe (our own) to knowing more than 100!

Tracking Transits

While most of the planets have been found using the "wiggle" method, there is another way to identify a planet around another star. When such a planet crosses the face of its star as seen from Earth, the stars light output drops by a tiny fraction. Called a transit, such a mini-eclipse can not only tell us that the planet exists, but even allows us to measure the planet's size (diameter). Amazingly, we can measure drops in the intensity of star light of 0.1% (a thousandths of the stars light) and hope to do much better with specialized instruments in space. (Only a small fraction of planets will be circling their stars in such a way that we can see a transit from Earth, but if we look at a large number of stars we increase our chances of catching a transit.)



A new orbiting telecope and camera combination in space, called the Kepler Mission, is doing exactly that. Launched in March 2009, Kepler is now monitoring the brightness of about 100,000 stars in the constellations of Cygnus and Lyra to see if any will show repeating decreases in brightness cause by a planet transit. The system is so accurate; it should be able to find planets as small as the earth crossing the disk of their home stars. Already, as we write, there are tantalizing hints in the early data that show many new potential planets out there.



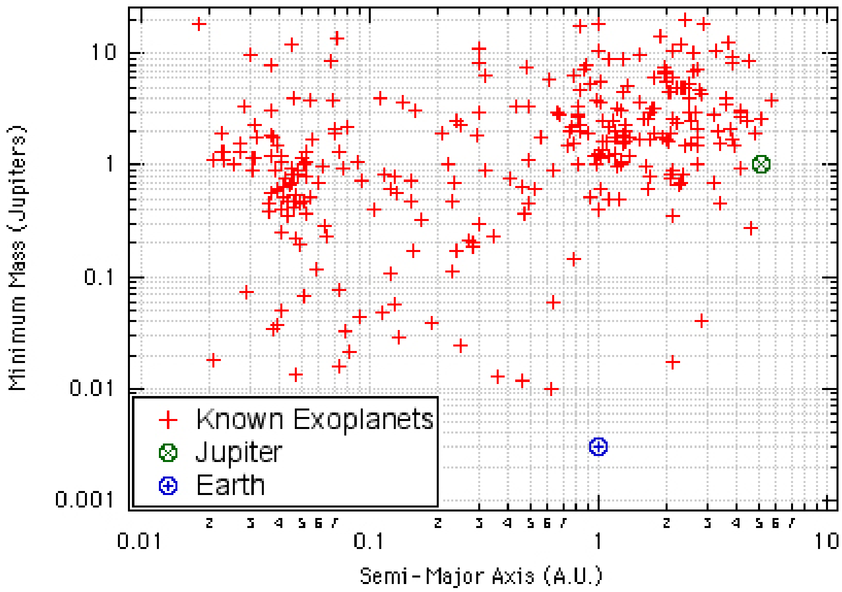
In a few exceptional cases, astronomers have more recently even been able to take a photograph of an extra-solar planet. It takes a planet far from its tars glare, instruments like the Hubble Space telescope, or an image of the planets heat rays (and not just light) to make so difficult a photographic feat possible.

Photography was used to confirm the existence of three already known exoplanets

Naming Exoplanets

The names that are given to exoplanets are quite simple; the first name is given to the exoplanet is the name of the star that it orbits. Any following letters represent the orbit of the exoplanet. For example, Kepler 21b is an exoplanet that orbit the star Kepler 21 and is the second object from the center of that solar system (the letter a denotes the star itself). If another exoplanet is found orbiting Kepler 21 then it will receive the name Kepler 21c and so forth.

As a result of all these discoveries, astronomers now believe that planets may be quite common among the stars and that many stars could have a family of Jupiter's and Earths accompanying them. Finding all those planets around even the nearest stars is a task that will take decades of work, but it is work that many teams of astronomers around the world are now tackling with new excitement.



Analysis:

Answer the following questions on lined paper in complete sentences which restate the question in your answer.

1. Why is finding exoplanets an important step forward for astronomy?
2. Describe how the wiggle method works in finding new exoplanets.
3. What is Doppler shift?
4. Other than being hot, what is unique about Hot Jupiters?
5. Why is finding 2nd and 3rd exoplanets around stars an important step for astronomers?
6. What is the transit method for finding exoplanets?
7. Why are exoplanets almost impossible to photograph?
8. How are exoplanets named?

Using the graph above, answer the following questions

9. How does the mass of most known exoplanets compare to the mass of Earth?
10. How does the mass of most known exoplanets compare to the mass of Jupiter?
11. How does the orbit size of most known exoplanets compare to that of Earth?
12. How does the orbit size of most known exoplanets compare to that of Jupiter?
13. Even though we will never be able to (realistically) visit an exoplanet, do you think we should keep searching for them?
14. Why do you think non-scientists are so excited about the finding of exoplanets?

Check out more about these discoveries on NASA's Planetquest web site:
http://planetquest.jpl.nasa.gov

Journey to the Edge of the Universe – NatGeo *(This video can also be watched on YouTube)*
2nd part of video (start at 42:45)

Answer the following questions on a separate sheet of paper. You do not need to answer them in complete sentences. Questions are spaced out with enough time for you to answer each (1-3 minutes apart).

1. What is the first solar system beyond our own? What is different about it from our sun?
2. What is unique about the star Epsilon?
3. What is thought to possibly be around Glisa 581?
4. How did we find Blarifin if we can't see it?
5. Why does Algar appear to blink?
6. What is going on inside Orion's (Dark Cloud) Nebula?
7. Why will nebula take so long to disperse?
8. What causes the different colors of planetary nebulae
9. What is unique about white dwarfs?
10. How much would a pin-head of a pulsar weigh?
11. What happens as an object approaches a black hole?
12. What are the Pillars of Creation?
13. What is the most violent star death of all?
14. In the 1970's, astronomers sent a message to the great cluster. How long will it take for the message to get there?
15. What is the area beyond the edge of our galaxy called?
16. About much of the universe is made of dark matter?
17. How long would it take to get to the Magelenic Clouds via spaceship?
18. How far away is the Andromeda galaxy?
19. According to the video- there are possibly more stars than what?
20. Why is a quasar the deadliest thing in the Universe?
21. How are the galaxies in the outer parts of the Universe different than closer to us?
22. How far is it to the edge of the Universe?
23. How can we see or hear the energy first given off by the big bang
24. Do you think that one of the other 200+billion stars in our galaxies has a planet that has life or do you feel that life is only here on Earth? (Explain and support your answer)

Space Exploration Activity

Introduction:
Almost 50 years ago, we humans took our first tentative steps away from Mother Earth. After the Soviet lunch of Sputnik on October 4th, 1957, the Space Race, as it was called, was on. On May 25, 1961 before a joint session of Congress, JFK stated that the United States should set as a goal the "landing a man on the moon and returning him safely to the earth" by the end of the decade. Not only did we land a man on the moon and return him safely, NASA's Apollo missions were all designed, planned, and executed without the use of computers any better than a basic graphing calculator!

When the Eagle landing craft set down on the Moon on July 20, 1969 as part of the Apollo 11 space mission, it was the result of years of planning, designing, testing and hoping. Six-hundred million people (1/6 of the world population at that time) tuned in their television sets to watch astronauts Neil Armstrong and Edwin “Buzz” Aldrin become the first humans to set foot on the Moon, as Michael Collins piloted the rendezvous spacecraft overhead. Armstrong and Aldrin spent almost 22 hours on the Moon's lunar surface collecting rocks and samples.

Six more Apollo missions (including the doomed Apollo 13 mission) and 10 more astronauts returned to the Moon to further study Earth's only natural satellite. The Apollo 17 mission in December 1972 was the last time anyone walked on the Moon. Since then, the Moon has been explored by lunar rovers—computerized or mechanically-operated vehicles—that collect samples and send pictures back to Earth.

It is almost an irony that most of the original aerospace engineers and physicists who put man on the Moon are now since passed. With the launch of the last Space Shuttle mission, a new age opens in the exploration of space. The decreased costs in getting goods into space using rockets and aging Space Shuttle technology have led to the end of the shuttle program and a rethinking of how we get people into space.

Today, five decades after we first stepped foot on the Moon, more a thousand satellites orbit Earth and provide a steady stream of information on weather, navigation, and communications back to the ground. The International Space Station orbits overhead with a crew from a number of countries working together. We have sent robotic spacecraft to investigate all the planets of our solar system – and even dwarf Pluto will have a spacecraft flying by it in 2015. In 2003, the Japanese Space Agency was able to send a probe on a billion mile journey to a comet, take a sample, and safely bring that sample back to Earth in 2010! Other unmanned craft have flown past comets and asteroids, sending back detailed pictures and information.

Humankind still yearns for the need to explore space but before we move on, we must first revisit where it all started, the Moon.

Question: What are the difficulties of exploring space?

Background: *(write a few things that you already know pertaining to about the question above)*

Vocabulary:
Weightlessness
Apollo Missions

Materials:
This packet

Procedure:
Read through the following sections, answering questions as they come along.

The spacesuits worn by the astronauts on the Apollo 11 mission were self-contained life support systems that weighed 180-pounds. The NASA spacesuit has not changed drastically over the past three decades—it still has a large "bubble" helmet that attaches to the suit. Astronauts still wear caps with radios and microphones and a bodysuit with special tubing to keep cool in extreme heat.

During NASA's four decades of space travel and exploration, many inventions and tools that have been designed for astronauts have made their way into the mainstream in order to make people's everyday lives easier. For instance, the cordless drill was first developed for astronauts who didn't have an outlet on board their spacecraft. Have students research other NASA inventions that have improved life for those of us on Earth.

NASA employs over 400,000 people in a variety of positions, including researchers, scientists, engineers, computer programmers, technicians, personnel specialists, and spokespersons. But the most popular and well-known of all of NASA's employees are the astronauts. NASA's latest group of astronaut candidates includes schoolteachers, doctors, scientists, and engineers.

Here's your mission:
Take this quiz to see if you could make the cut to be an astronaut, or if your skills and interests could lead to another important job at NASA or another space center around the world. Read each question and tally the point (0-5) on your assignment sheet. Find the total scores where indicated. When finished, read the job categories below to learn more about a NASA job that might be right for you.

1. Would you swim 75 meters wearing a flight suit and tennis shoes?	Yes (5) No (0) 1. ____
2. Can you tread water for 10 minutes without stopping?	Yes (5) No (0) 2. ____
3. Do you enjoy flying?	Yes (5) No (0) 3. ____
4. Are you able to read in a moving vehicle?	Yes (5) No (0) 4. ____
5. Would you ride NASA's "Vomit Comet" to train for weightlessness?	Yes (5) No (0) 5. ____
6. Would you eat dehydrated food for weeks at a time?	Yes (5) No (0) 6. ____
7. Can you live and work closely with several others in confined spaces?	Yes (5) No (0) 7. ____
	#1-7 Total ____
8. Do you feel comfortable speaking in front of groups?	Yes (4) No (0) 8. ____
9. Do you love to travel?	Yes (4) No (0) 9. ____
10. Are you comfortable working independently?	Yes (4) No (0) 10. ____
11. Would you enjoy working with educators, students, and the public?	Yes (4) No (0) 11. ____
	#8-11 Total ____
12. Do you enjoy making things and testing how well they work?	Yes (3) No (0) 12. ____
13. Are you interested in how machines work?	Yes (3) No (0) 13. ____
14. Do you learn new technology easily?	Yes (3) No (0) 14. ____
15. Do you like to take things apart and then put them back together?	Yes (3) No (0) 15. ____
16. Do you have an interest in technology, space, physics and/or math?	Yes (3) No (0) 16. ____
17. Are you interested in robotics and artificial intelligence?	Yes (3) No (0) 17. ____
18. Do you enjoy making things and testing how well they work?	Yes (3) No (0) 18. ____
19. Would you like to work in a lab performing experiments?	Yes (3) No (0) 19. ____
	# 12-19 Total ____

20. Are you good at reading maps and diagrams? Yes (2) No (0) 20. ____
21. Can you follow oral directions? Yes (2) No (0) 21. ____
22. Can you manage many tasks at once? Yes (2) No (0) 22. ____
20-22 Total ____

23. Do people call you a nature lover? Yes (1) No (0) 23. ____
24. Do you like to explore outdoors? Yes (1) No (0) 24. ____
25. Are you interested in biology? Yes (1) No (0) 25. ____
#23-25 Total ____

Questions 1-7: If your total score for these questions is between 30 and 35, then you might have what it takes to be an astronaut! U.S. astronauts train for up to two years at the Johnson Space Center in Houston, Texas. They come from many different backgrounds, all of them scientific or technical. You may want to get your start as a jet pilot, which could lead to a career as an astronaut pilot.

Questions 8-11: If your total score for these questions is between 12 and 16, then you might make a great NASA Spokesperson, NASA Outreach Coordinator, or Aerospace Educator. These people speak on behalf of NASA and educate students, teachers, and the public about what NASA does, including important missions and initiatives.

Questions 12-19: If your total score is between 18 and 24, then you might enjoy these NASA careers: Research Engineer, Research Model Technologist, Architect or Avionics Engineer. NASA employees in these positions create model spacecrafts, flight simulators, robotic parts, hardware, and spacesuits.

Questions 20-22: If you scored a total of 6 for all of these questions, then you might want to pursue a career as a Mission Manager, Mission Controller, or Systems Safety Engineer. Their job is to successfully navigate spacecrafts to destinations. They manage the mission way before liftoff by assuring all of the mission hardware, checking with engineers, and performing system safety activities.

Questions 23-25: If you scored a total of 3 for all of these questions, then you would be a great astrobiologist! Astrobiologists seek to understand the origin of cells, how parts of cells combine to create life, how the environment affects the way cells form and grow. Today, astrobiologists are working to learn whether life exists beyond our planet—and how it began! Check out http://education.nasa.gov or www.nasajobs.nasa.gov for more information on NASA's student internship and employment programs.

Analysis:
Answer the following questions on lined paper in complete sentences which restate the question in your answer.

1. What was the purpose of the Apollo Missions?
2. Draw a flow chart showing 5 events in the exploration of space.
3. From your own experience, what are some of the most dangerous problems for astronauts in space?
4. What problems exist for humans in space but not on Earth?
5. Make a list of what specific things must be taken into consideration when designing a spacesuit.
6. What do you think astronauts would eat in space?
7. Why must astronauts have to be particularly careful with liquids in space?
8. What might be some of the difficulties with going to the bathroom in space?
9. List three advantages of weightlessness in space?
10. List three disadvantages of weightlessness in space?
11. What do astrobiologists do?
12. Why should we revisit the Moon before visiting Mars if we've already been there?
13. Would you travel to Mars if given the opportunity? Why?
14. Should we invest the billions of dollars necessary to travel to Mars and beyond? Why?

The Universe – Colonizing Space *(This video can also be watched on Netflix Streaming)*

Answer the following questions on a separate sheet of paper. You do not need to answer them in complete sentences. Questions are spaced out with enough time for you to answer each (1-3 minutes apart).

1. What things would you need to bring with you on your mission to colonize space?
2. Why is Mars likely to be the next planet colonized?
3. Why is Venus not a good candidate for colonization?
4. When does NASA plan to return man to the moon by?
5. Where does NASA want to 'park' a 6 man crew in order to see if we're ready to colonize another planet?
6. According to Mars Society, what would the ERV do on Mars before humans ever get there?
7. At their closest, how long would it take a rocket to get to Mars?
8. What is the name of the spacecraft headed to the Moon? How much larger is it than the Apollo missions?
9. What happens to urine once collected on the space station?
10. Why would we have to use nuclear energy and not solar panels on Mars?
11. What is one of the major problems astronauts will encounter in extended weightlessness?
12. How would you create artificial gravity on a space vehicle?
13. What role would the 4 astronauts sent to Mars be?
14. How long is the radio delay between Earth and Mars?
15. Why do scientists train on Devon Island in the Arctic?
16. How many gallons per day does an average American use? What is the minimum amount needed by an astronaut?
17. What would be the best place to set up a base camp on Mars?
18. W hat would be the primary objective for missions to Mars?
19. What is the primary reason a Mars mission will be fundamentally different from a Lunar mission?
20. Why do scientists think it would be better to eventually move the Martian colony underground?
21. What is terra-forming?
22. How would we create the first generation of Martians?
23. Why do some people not want us to colonize Mars?
24. Should we colonize Mars? Why?
25. Would you be willing to take the 2.5 year trip to visit Mars? Why?