Earth & Space Sciences

Laboratory Manual

with

Performance Assessments

Acknowledgments

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Cover Photo,
"Milky Way Over Joshua Tree National Park" May 11, 2021
Swati Ray, PhD

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ABOUT THIS LABORATORY HANDBOOK

Welcome to Earth & Space Sciences. You are about to embark on an exciting course of study to help you understand the workings of your home planet. Earth Science is an applied science. That means you will learn about your home using many different science disciplines. There will be physical science, geography, chemistry, and physics.

There are forty investigations in this book related to and intrinsically linked to the Earth & Space Sciences. Each investigation is just that, a puzzle that must be solved with information from your knowledge of Earth Science.

Each investigation is followed by ten questions. Each question is more in depth than the previous one. All questions are to be answered in complete sentences. Single word answers do not fully explain your understanding of the material.

At the end of each unit is a ***cluster based Performance Assessment*** with 5 short answer and extended response questions.

Each lab contains the following:

Investigative Statement: After reading the opening passage, one would make a single statement that sums up the passage and is the lens in which the investigation is solved. After the Investigative Statement, one needs to gather their thoughts and sketch a model of what one would do to verify the investigative statement. There are prompts to help with the sketch.

Clarifying Questions: The clarifying questions are based on the results of your investigation as well as the pre-lab readings. Some questions call on your knowledge of Earth & Space Sciences as well your ability to read the Earth & Space Sciences Reference Tables.

Claim: Make a statement about what you learned. It may be a response to your Investigative Statement, or a contradiction. How ever it is couched, you learned something so say what it is.

Conclusion: This fully explains your claim. This includes the understanding of the material, the processes that lead to the Claim.

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Biology: the Science of Life in Its Living Environment

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Earth & Space Sciences
Table of Contents

Earth & Space Sciences
Table of Contents

1 Why is the Sky Blue?

How To Use This Lab Book: The investigation will be annotated. It will show how the lab is and what is expected of the Earth Science Student.

Investigative Statement: *The following passage has information that will help you to perform an investigation. Read the following passage carefully and determine what specific aspect is to be solved. The Investigative Statement describes an aspect of the passage that you will focus on.*

Our closest star, the Sun, emits most of its light in what is called the visible spectrum, or all the colors of the rainbow. Most organisms that live on the land or near the surface of the water, can interpret the light based on the visible spectrum. The light, in its various wavelengths, energizes different areas of our eyes. Some animals, such as bumble bees, can see ultraviolet. This helps bees find the part of the flower that the bee is looking for. Snakes such as pit vipers can see infrared light. This is a light that is associated with the heat seeking predators. The heat seeking sidewinder missile is named after the pit viper. Both of these wavelengths of light are not visible to humans. What differentiates the different segments of the electromagnetic spectrum are the wavelengths.

One of the earliest scientific questions children ask is, “Why is the sky blue?” Some people have an answer that at first seems logical, but after giving it some thought, it doesn’t make sense.

Light can behave in different ways. Light can reflect, refract, or scatter. Reflection is light bouncing off a surface because that light was not absorbed. The best example of reflection is the light reflected off a mirror. Refraction is how light behaves when the colors of white light are separated. The best example of refraction is when a rainbow is formed from water droplets in the sky.

The Visible Light Spectrum is on the back cover of this lab book. The set of clarifying questions will be referencing this page for answers. The visible light spectrum includes the color, hue, and wavelength of each of the segments we call light.

The Sun’s light reaches our planet at a range that is greatest in the range of 4.0×10^{-5} and 7.0×10^{-5}. The sun intensity peaks at 4.5×10^{-5} and 4.9×10^{-5}. This light can reflect, refract, or scatter.

Scattering is more complex. Each particle that light hits scatters the light in all directions. Each molecule in the atmosphere scatters completely in all directions when light strikes it. Rayleigh (rah-LAY) scattering occurs when the light is separated and scattered in all directions for each molecule. The shorter the wavelength, the more the intense the scattering. Other wavelengths do not scatter as readily. The intensity of the scatter is related to the short atmospheric distance. The more that light travels through the atmosphere, the longer wavelengths are expressed.

Vocabulary:

Rayleigh Scattering: A form or scatter where only the shortest wavelengths of white light are uniformly scattered in all directions. This occurs when light strikes an object smaller in size to the wavelength.

Reflection: When light is not absorbed, it bounces off whatever the light struck.

Refraction: When white light is separated into its individual wavelengths.

> ***Science, Technology, and Engineering Practices:*** *In the following space, you will be "Asking Questions" based on the passage that you read. You will find a segment of the phenomenon that is intriguing and you will want to investigate it. The statement regarding what you are investigating will be written in the area "Phenomenon."*
>
> *Follow the prompts written in the space, as they will be different in other investigations. For purposes of this investigation, it is using the Science, Technology and Engineering Practice, "Asking Questions." See the prompts that describe what is to be addressed in the space below. In the model that is sketched, Ask a question, determine its testability, include labels, and predict outcomes.*

Asking Questions

Investigative Statement: _____

_____

In the space provided: *ask a question – sketch a model – label model – identify variables*

Activity: *In the following section you will be asked to perform tasks that will assist you in clarifying your Phenomenon. Follow the tasks and describe that which you have learned.*

1. Review the Visible Light Spectrum on the back cover of the book to fill in the chart below.

2. The wavelength of ultraviolet light 0.1×10^{-5} to 4.0×10^{-5}. You will see that filled in already.

3. Complete the rest of the chart using the Visible Light Spectrum found on the back cover.

Chart: *Notice that the range, listed above, includes the notation 10^{-5}. It is not necessary to include it in the space provided.*

Visible Light Spectrum Wavelength x 10^{-5}

Color	Ultraviolet	Violet	Blue	Green	Yellow	Orange	Red
Wavelength	0.1 - 4.0						

Each lab has clarifying questions to serve as a guide for understanding the observations. Answers must be in complete sentences and should mirror the question in each answer.

Clarifying Questions: Answer the following questions in complete sentences and explain your reasoning.

1. Look at the Visible Light Spectrum on the back cover. What is the wavelength range of visible light?

_____

_____

_____

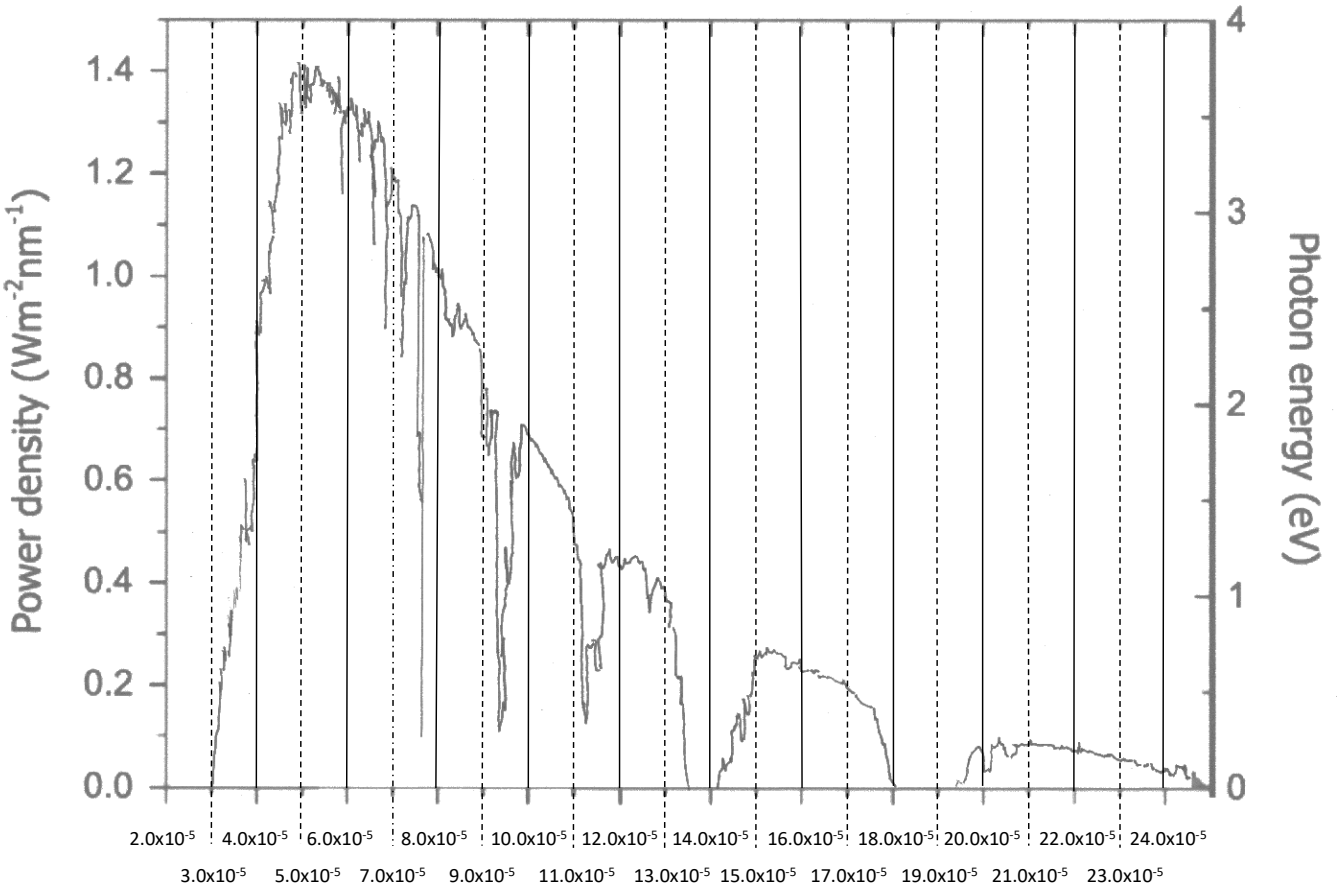
2. What color is the shortest wavelength range of visible light?

_____

_____

_____

Solar Output in the Atmosphere



3. Look at the model above. Referencing your Visible Light Spectrum Chart, what is the wavelength range that is the peak solar output of energy striking the atmosphere?

_____

_____

_____

4. What is the color that is the Sun's greatest output?

_____

_____

_____

5. Which has a greater outcome, quantity or quality?

_____

_____

_____

6. Look at the Solar Output in the Atmosphere model. There is a sudden peak and a sudden drop of solar output dropping to less than 0.5 photon energy. Note that range and record it below.

_____

_____

7. Refer to the Visible Light Spectrum chart on the back cover. Express a correlation, if any.

_____

_____

_____

_____

8. Longer wavelengths pass through increased atmosphere. Which is the longest wavelength of the visible spectrum?

_____

_____

9. The Sun appears to travel across the sky throughout the day. The amount of atmosphere that the Sun's light passes though is the lowest at solar noon and greatest at sunset. Why are sunsets red?

_____

_____

_____

10. Why is the sky blue?

_____

_____

_____

_____

Cross Cutting Concepts: *Now that you have completed much of this investigation, you will make a statement regarding what you have learned. Your statement will be a simple claim, a one sentence declarative statement. In the space provided, you will be describing the functions of light energy; the behavior of light when it interacts with material in the atmosphere. Determine how the functions work to produce an effect. You will be describing these functions and sketch a model of your findings. Variables and their relationship should be included in the Cross Cutting Concept.*

Claim: _____

_____

The way an object is shaped or structured determines many of its properties and functions.

(What have you learned)

Conclusion: Fully explain your conclusion in terms of structure and function, in citing evidence from your investigation.

(How you learned it)

_____

_____

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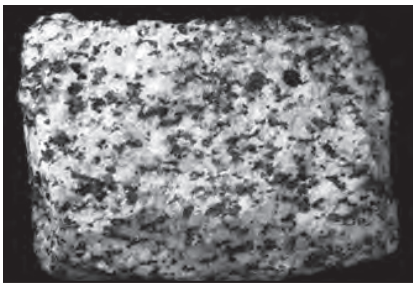
9 Igneous Rock Identification



Igneous rocks are rocks that form when lava or magma cools. Lava and magma are both molten minerals. Lava is magma that has come out of the volcano.

The subtlty of where a rock forms determines what type of rock it will become. This is called origin of formation.

Rock that is formed when lava cools is called extrusive or volcanic. Lava on the exterior of the volcano is exposed to the air or water (underwater volcanoes) and cools quickly. These rocks sometimes don't even have time to form crystals; this is called glassy. Sometimes, gas gets trapped in the rock, giving the rock an appearance of being spongy. Rock that is formed when magma cools is called intrusive or plutonic.

Magma is in the interior of the volcano. The rock surrounding the volcano is an excellent insulator, making the magma cool very slowly. The mineral crystals can grow very large.

Geologists also classify igneous rocks based the minerals in the rock. As you study the Mineral Composition of Igneous Rock Identification chart, on the following page, you will infer that light colored and less dense rocks are called felsic, while denser, darker colored rocks are called mafic. Ultramafic rocks have only a few minerals. If a rock has only one mineral, it is called monomineralic.

Since the internal arrangement of atoms is the critical factor in determining the properties of minerals, how the magma cools determine what type of mineral forms.

Planning and Carrying Out Investigations

Investigative Statement: _____

_____

In the space provided: *sketch a plan – label – planning – data collection – variables – evaluate investigation*

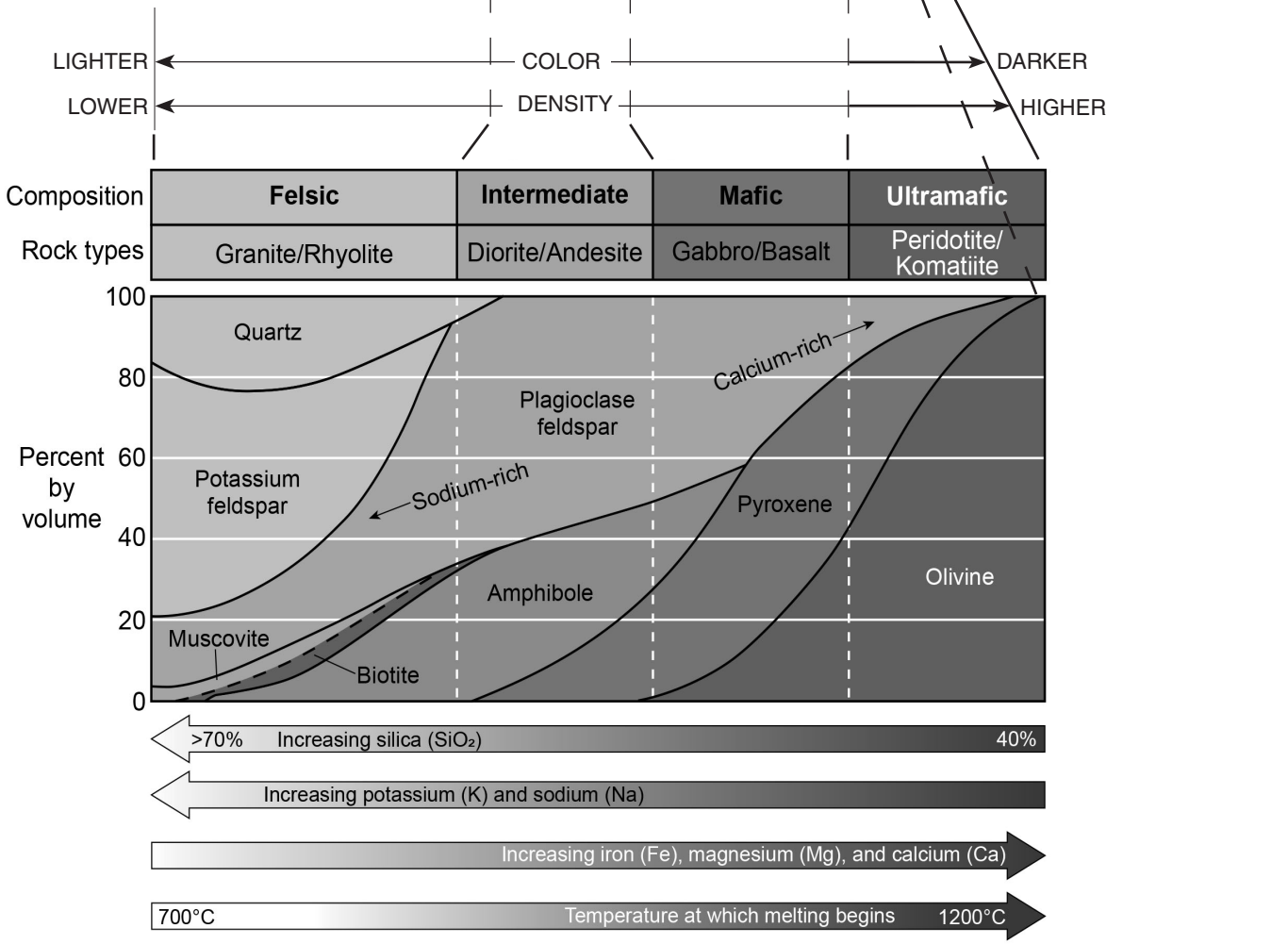
Materials: • Igneous rocks kit • Magnifying lens • Metric ruler

Procedure:

Use the Scheme for Igneous Rock Identification and Mineral Composition of Igneouse Rock chart below, the Model of Bowen's Reaction Series on the following page, magnifying lens, and metric ruler to identify the rocks and map out your findings using the dichotomous keys.

Scheme for Igneous Rock Identification

ENVIRONMENT OF FORMATION						CRYSTAL SIZE	TEXTURE	
EXTRUSIVE (Volcanic)		Obsidian (usually appears black)		Basaltic glass		non-crystalline	Glassy	Non-vesicular
		Pumice		Scoria				Vesicular (gas pockets)
		Vesicular rhyolite	Vesicular andesite	Vesicular basalt		less than 1 mm	Fine	
		Rhyolite	Andesite	Basalt				Non-vesicular
INTRUSIVE (Plutonic)				Diabase				
		Granite	Diorite	Gabbro	Peridotite / Dunite	1 mm to 10 mm	Coarse	
		Pegmatite				10 mm or larger	Very coarse	



Rock # 1

1. What is the crystal texture? (circle one) Glassy – Vesicular – Non-Vesicular
2. The grain size is: non-crystalline / < 1mm / 1mm – 10mm / 10mm or larger
3. Looking at questions 1 and 2 the rock is (extrusive / intrusive).
4. The rock is (light colored pink to light grey / dark colored dark grey to green).
5. Looking at question number 4, the rock is (felsic / mafic).
6. Looking at question 2, 3 & 5, the rock is _____.

Rock # 2

1. What is the crystal texture? (circle one) Glassy – Vesicular – Non-Vesicular
2. The grain size is: non-crystalline / < 1mm / 1mm – 10mm / 10mm or larger
3. Looking at questions 1 and 2 the rock is (extrusive / intrusive).
4. The rock is (light colored pink to light grey / dark colored dark grey to green).
5. Looking at question number 4, the rock is (felsic / mafic).
6. Looking at question 2, 3 & 5, the rock is _____.

Rock # 3

1. What is the crystal texture? (circle one) Glassy – Vesicular – Non-Vesicular
2. The grain size is: non-crystalline / < 1mm / 1mm – 10mm / 10mm or larger
3. Looking at questions 1 and 2 the rock is (extrusive / intrusive).
4. The rock is (light colored pink to light grey / dark colored dark grey to green).
5. Looking at question number 4, the rock is (felsic / mafic).
6. Looking at question 2, 3 & 5, the rock is _____.

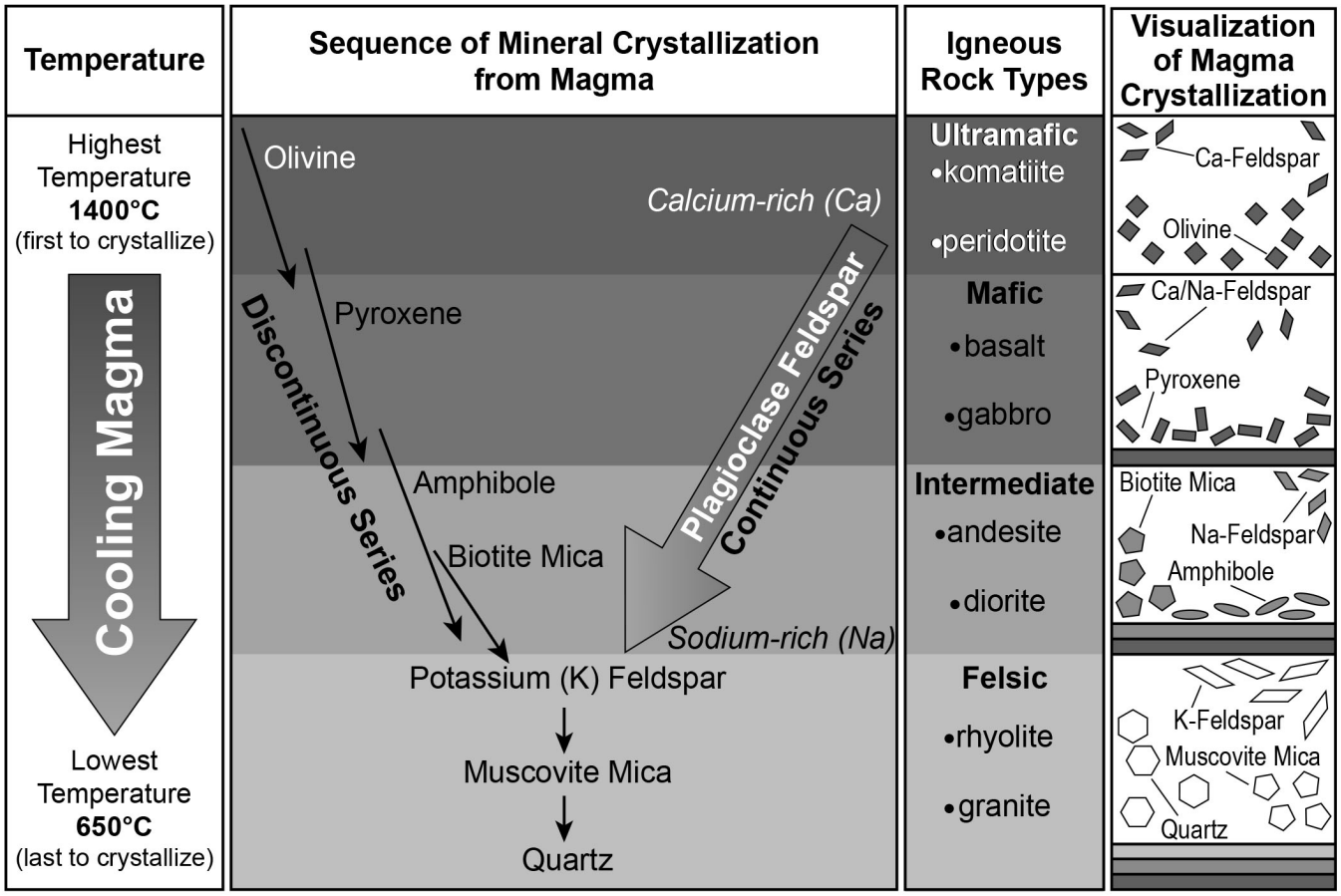
Rock # 4

1. What is the crystal texture? (circle one) Glassy – Vesicular – Non-Vesicular
2. The grain size is: non-crystalline / < 1mm / 1mm – 10mm / 10mm or larger
3. Looking at questions 1 and 2 the rock is (extrusive / intrusive).
4. The rock is (light colored pink to light grey / dark colored dark grey to green).
5. Looking at question number 4, the rock is (felsic / mafic).
6. Looking at question 2, 3 & 5, the rock is _____.

Rock # 5

1. What is the crystal texture? (circle one) Glassy – Vesicular – Non-Vesicular
2. The grain size is: non-crystalline / < 1mm / 1mm – 10mm / 10mm or larger
3. Looking at questions 1 and 2 the rock is (extrusive / intrusive).
4. The rock is (light colored pink to light grey / dark colored dark grey to green).
5. Looking at question number 4, the rock is (felsic / mafic).
6. Looking at question 2, 3 & 5, the rock is _____.

Model of Bowen's Reaction Series



Clarifying Questions: Answer the following questions in complete sentences and explain your reasoning.

1. What is the melting / solidification temperature of olivine?

_____

2. What mineral has the lowest melting / solidification temperature?

_____

3. What does vesicular mean?

_____

_____

4. Are mafic rocks more or less dense than felsic rocks?

_____

_____

5. Describe the differences between felsic and mafic rocks.

_____

_____

_____

6. What is the mineral content of diorite?

_____

_____

7. What is the mineral content of vesicular rhyolite?

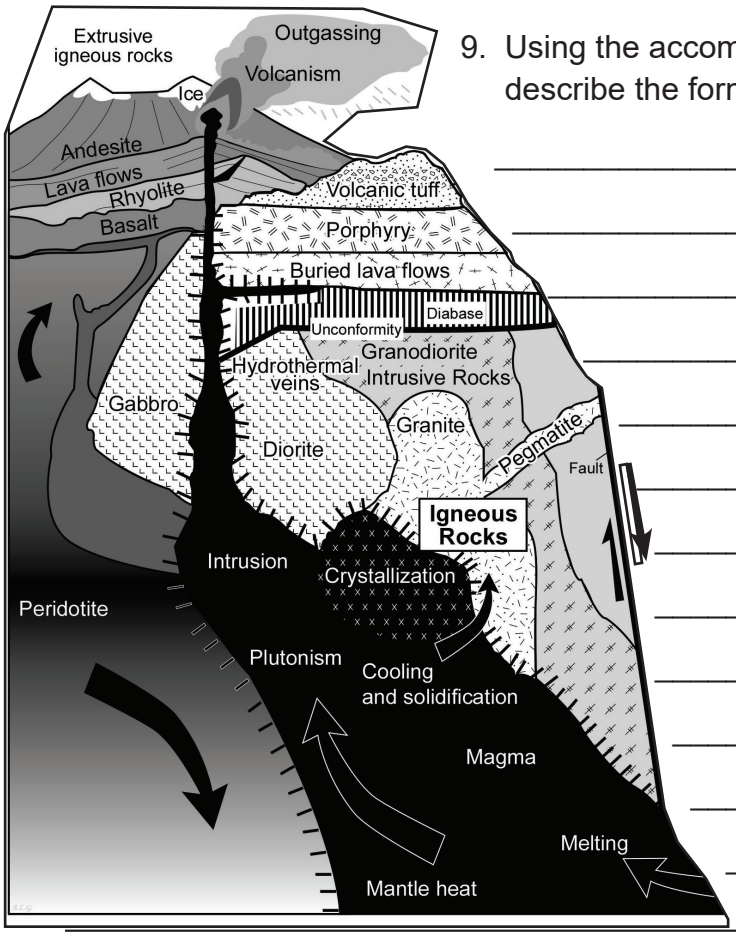
_____

_____

8. What are the elements that make mafic rocks dense?

_____

_____



9. Using the accompanying Igneous Rock Cycle Infographic, describe the formation of igneous rocks.

_____

_____

_____

_____

_____

_____

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_____

_____

_____

10. How does knowing rocks' properties help you to identify rocks?

_____

_____

_____

Claim:_____

_____

_____

The way an object is shaped or structured determines many of its properties and functions.

Conclusion: Fully explain your conclusion in terms of structure and function, in citing evidence from your investigation.

_____

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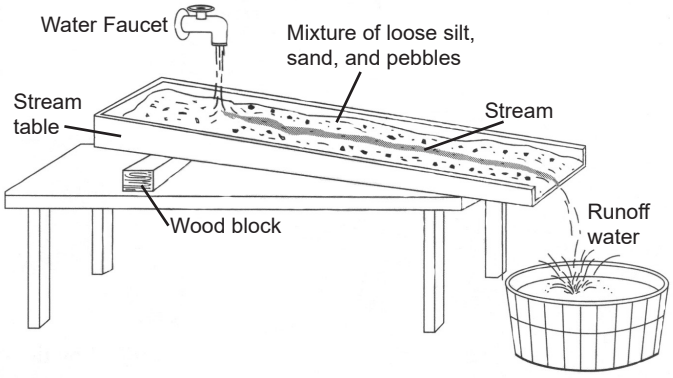
21 Stream Beds



Running water is a major agent of erosion. The stream bed is affected by its shape and the angle in which it flows. The stream flow then carves out the stream channel. The water in the stream travels at a speed dependent on the angle of the slope. The channel in which the stream travels is affected by the slope. Young streams tend to be straight and have steep slopes. As streams mature in their landscapes, the stream will begin to meander. Fully mature streams have flood plains in areas the stream bed gets pinched and forms oxbow lakes.

Analyzing and Interpreting Data

Investigative Statement: _____

_____

In the space provided: *organize data – relationships in data sets – variables – interpret data*

Materials:
- Stream table with adjustable height
- Water
- Mixture of gravel and sand

Procedure 1 - Slight Angle - Straight Channel:

1. Set up the stream table so that it is at a ***slight*** angle.
2. Add the gravel and sand mixture in the middle of the stream table. Smooth out the sediments, producing a slightly sloping landscape. Do *not* put any sediments in the lower end of the stream table.
3. Add water to create a “lake” at the upper end of the stream table. Add water to the lower end to produce a “quiet body of water”.
4. Make a shallow ***straight*** channel through the sediment mixture.
5. Slowly add water into the lake area so that it flows through the channel to the “quiet body of water”.
6. Continue adding water for 5 minutes while recording observations.

Observations:

_____

_____

_____

_____

Draw the final results of your stream table in the box below.

Procedure 4 - Evaporation:

Your teacher will select one of the stream tables to observe the results after evaporation.

Observations:

_____

_____

_____

_____

_____

_____

Draw the final results of your stream table in the box below.

Clarifying Questions: Answer the following questions in complete sentences and explain your reasoning.

1. Which stream had the greatest water velocity?

_____

_____

2. Which stream had the deepest channel?

_____

_____

3. What happened to the sides of the channel as far as erosion and deposition?

_____

_____

4. What are some ways in which the stream channel could be adjusted?

_____

_____

Directions: Use the Relationship of Transported Particle Size to Water Velocity chart for questions 5–8.

5. What is the minimum stream velocity of water needed to transport the coarse sand?

_____

_____

_____

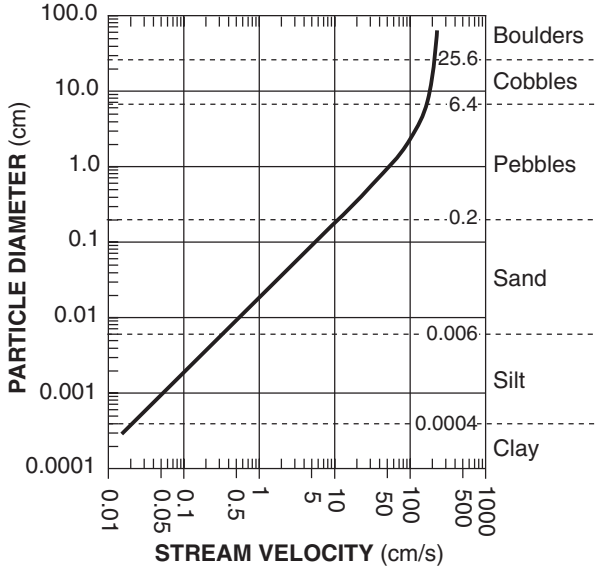
6. If you had your stream traveling at a velocity of 100 cm per second, what is the largest particle that could be transported?

_____

_____

_____

Relationship of Transported Particle Size to Water Velocity



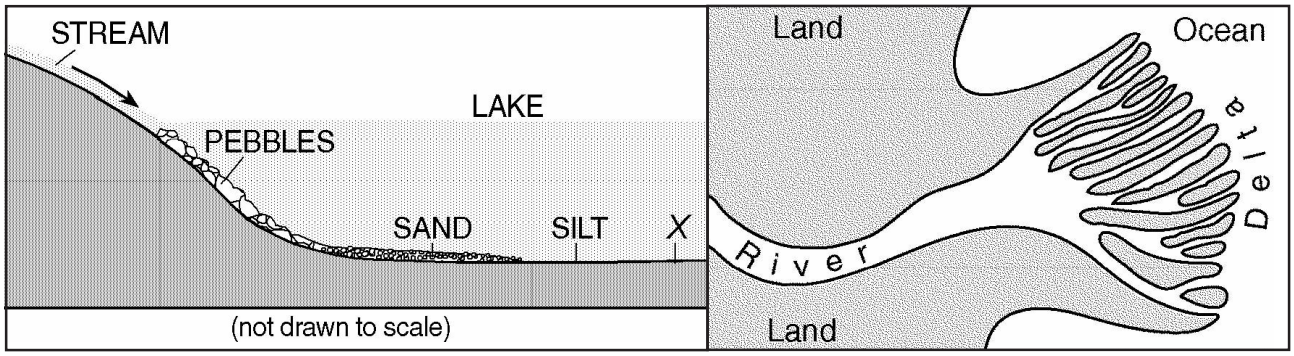
This generalized graph shows the water velocity needed to maintain, but not start, movement. Variations occur due to differences in particle density and shape.

7. As water slows to still water, what happens to the sediment that was being transported?

_____

_____

8. The illustration below depicts the method in which materials deposit in horizontal sorting.



Explain the processes illustrated in the chart above and the formation of the delta using the Relationship of Transported Particle Size to Water Velocity chart on the previous page.

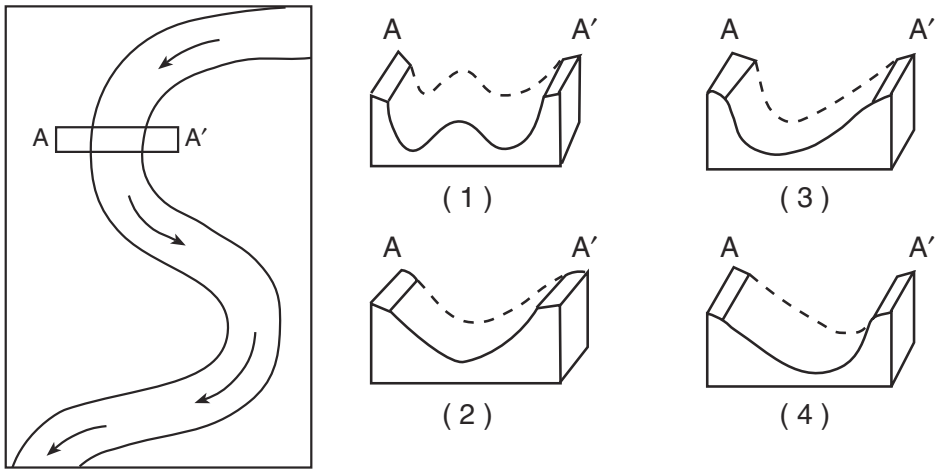
_____

_____

_____

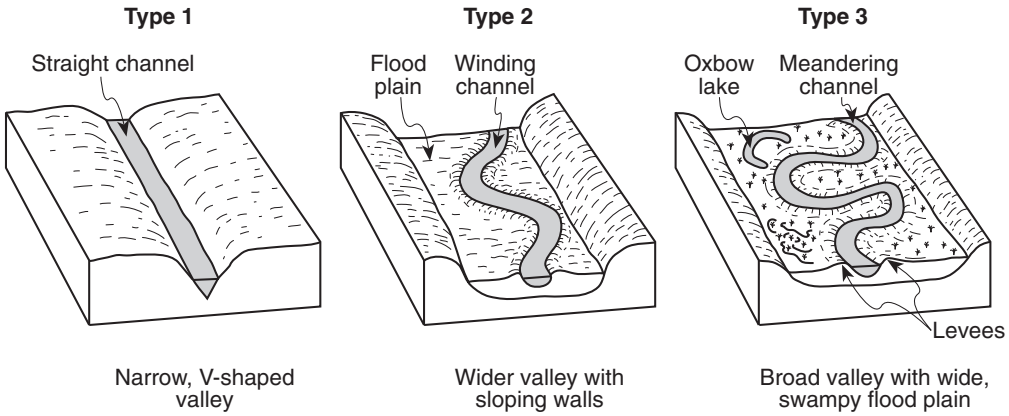
_____

9. In the following stream pattern, please determine the stream bed from *A* to *A′*.



9 _____

10. Shown below are three stages of stream development. Think of the three different types of stream channels that you created, compare your streams to the three types below.



Claim: _____

Modern civilization depends on major technological systems, and new technologies can have deep impacts on society and the environment, including some that were not anticipated.

Conclusion: Analysis of costs and benefits is a critical aspect of decisions about technology.

22 Landscapes

A landscape is a region on Earth's surface. The shape and makeup of the landscape is formed by the climate, local bedrock, and human activities. The relief of landscapes is described as mountains, plateaus and plains. In New York State, the landscape is not only determined by geology and climate but has also been deeply affected by the glaciers. When we look at the landscape regions of New York State, we must look to see the underlying geology. Mountainous regions have metamorphosed bedrock in New York State. What appear to be mountains may not, in fact, be mountains and areas that appear to be small foothills are the remains of once tall mountains. To truly determine the landscape region, we must look underneath the surface.

Obtaining and Communicate Information

Investigative Statement: _____

_____

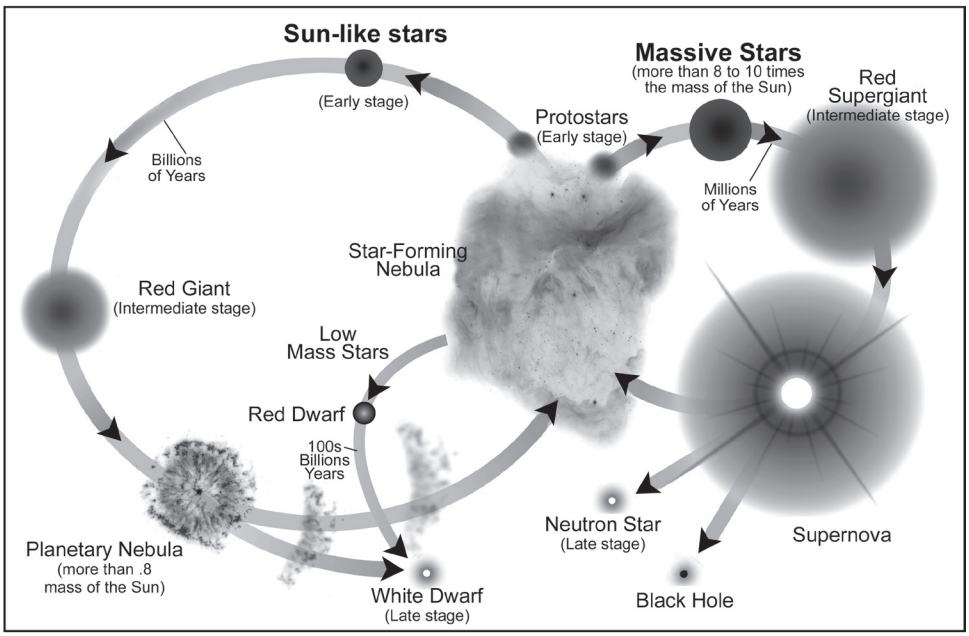
In the space provided: *thinking of information – obtain – sketch – evaluate – communicate – plan*

Materials: • Colored pencils

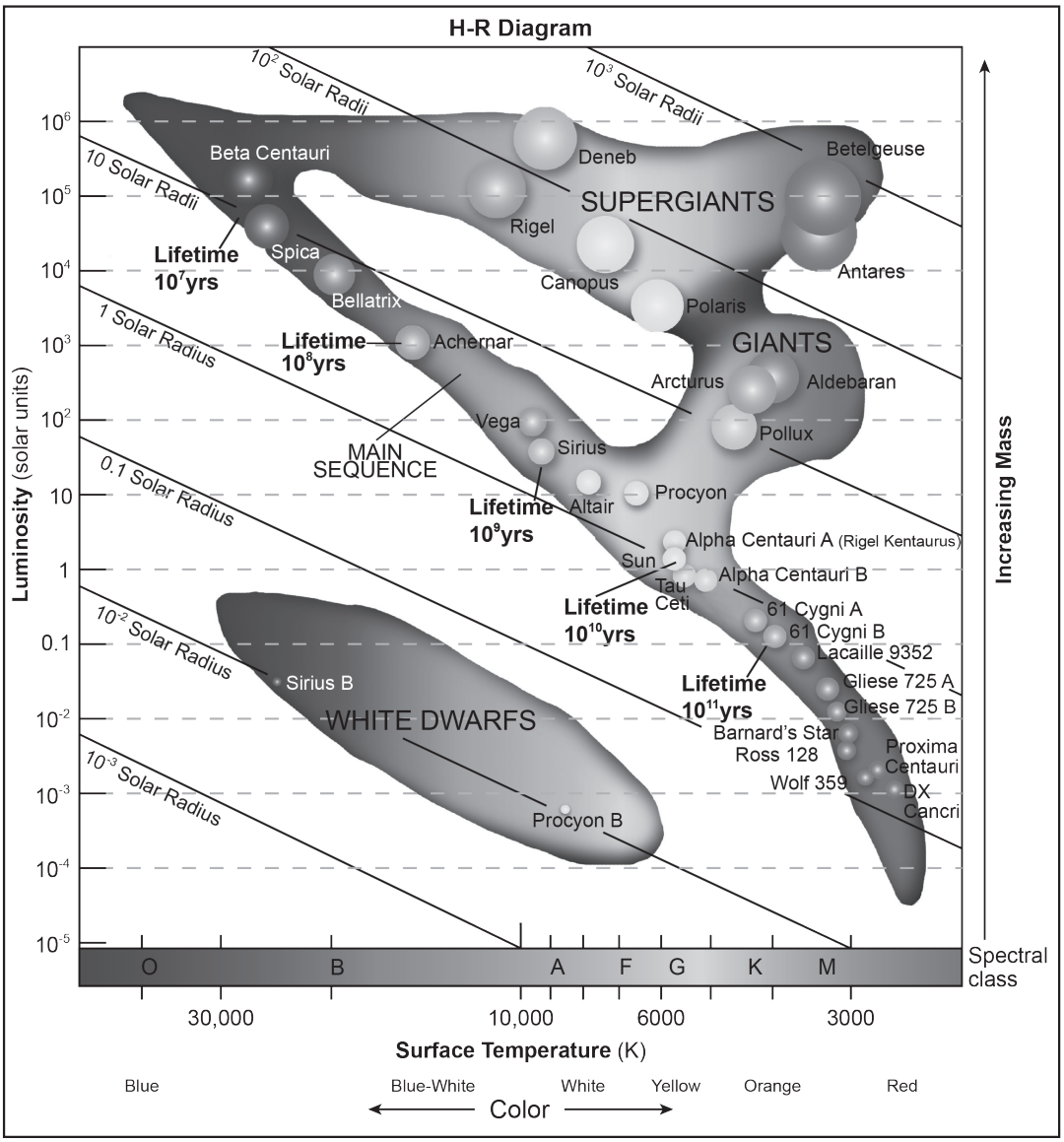
Procedure:

1. On the following pages, compare the bedrock of various areas of New York State.
2. Compare the landscape regions based on the underlying bedrock.
3. On the Landscape Regions map, color the mountain regions red, the plateau regions green and the plains regions blue.

Life Cycles of Stars Model



H-R Diagram



Directions: In the following exercise, we will classify sun-like stars in using the Life Cycles of Stars Model and the H-R Diagram on the previous page.

Sun-like Stars

Early Stage

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Expected next stage of selected star: _____

Intermediate Stage

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Expected next stage of selected star: _____

Late Stage

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Low Mass Stars (0.8 the mass of the sun)

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Expected next stage of selected star: _____

Massive Stars

Early Stage

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Expected next stage of selected star: _____

Intermediate Stage

Star: _____

Classification: _____ Color: _____

Temperature: _____K Spectral Class: _____

Size: _____ x the solar radius Luminosity: _____ solar units

Expected next stage of selected star: _____

Clarifying Questions: Answer the following questions in complete sentences and explain your reasoning.

1. Why is it that we cannot see the night sky as seen when Starry Night was painted?

   _____

   _____

   _____

2. What is the color of Beta-Centauri? _____

   _____

3. Bellatrix and Sirius, although different colors, are both classified as what kind of stars?

   _____

   _____

4. Describe the limiting factor when determining the early-stage sun-like star.

   _____

   _____

   _____

5. According to the H-R Diagram, what is the size of Pollux, relative to the sun?

_____

_____

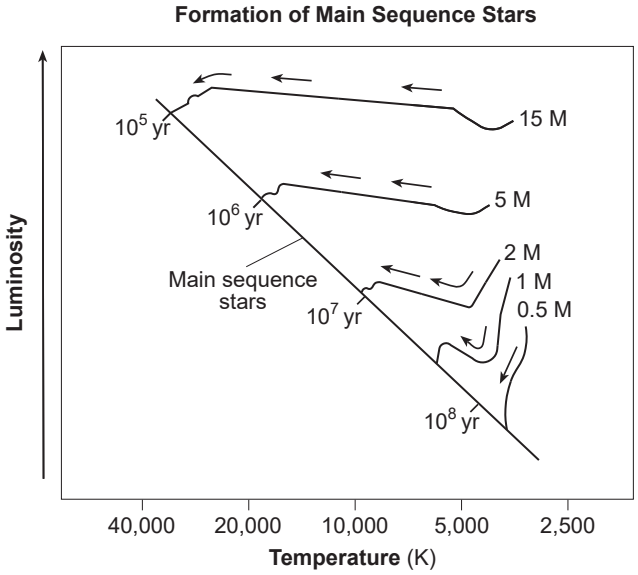
6. Describe the brightest star by name and luminosity in terms of solar units.

_____

_____

_____

Base your answers to questions 7 through 10 on the graph, which shows the early formation of main sequence stars of different masses (M). The arrows represent temperature and luminosity changes as each star becomes part of the main sequence. The time needed for each star to develop into a main sequence star is shown on the main sequence line.



Key
1 M = 1 Sun's mass

7. Describe the relationship between the original mass of a star and the length of time necessary for it to become a main sequence star.

_____

_____

_____

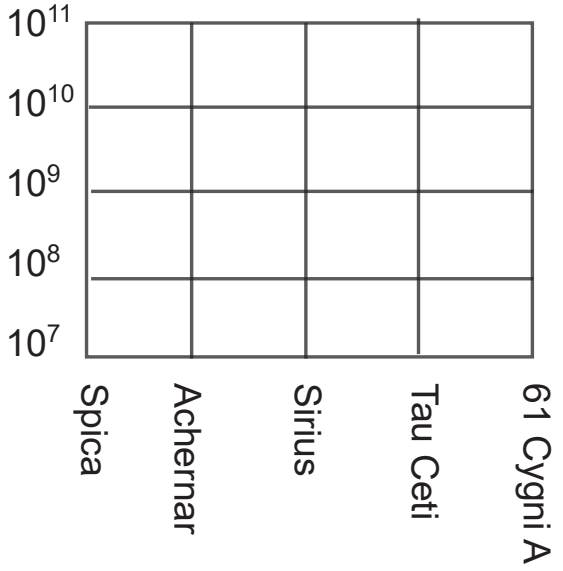
8. Describe the change in luminosity of a star that has an original mass of 0.5 M as it progresses to a main sequence star.

_____

_____

_____

9. Plot the relationship between life span and relative age of stars in the main sequence.



10. Based on the information above, and your Earth and Space Sciences Reference Tables, describe Alpha Centauri. Include its age, color, and relative size. Also include its likely life cycle.

_____

_____

_____

Claim: _____

_____

The concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.

Conclusion: Fully explain your conclusion in terms of scale, proportion, and quantity, in citing evidence from your investigation.

_____

_____

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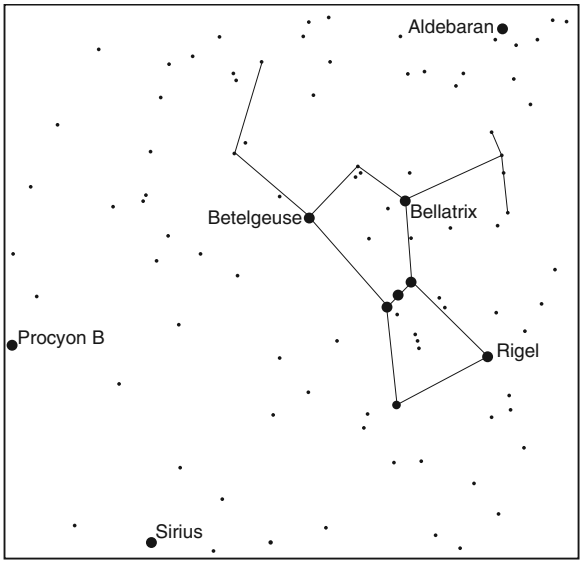
39 Orion



Stars are wildly different in size, brightness, color, and temperature. Smaller stars are called dwarfs, sun-like stars are referred to as Main Sequence stars, there are Giants and Supergiants. The giants are also known as massive stars. Massive stars are at least 8 times the size of the sun.

People saw patterns of stars in the night sky and interpreted them as images of mythology. We call them constellations. To the right, we see the constellation Orion the Hunter. Many of these images are rather recognizable as either zodiacal signs or other constellations.

Stars are very distant, measured in light years. A light year is how far light can travel in a year. Light from distant stars are sometimes only detectable by telescopes. The greatest distance we can detect is 4.7 billion light years.

Astronomers study the light that stars emit. Starting with the closest and most familiar, we study the Sun. We now know the stars produce light by means of nuclear fusion; hydrogen is fused to create helium. The Sun is our closest star, but the next closest star would take far too long to go to under current space travel means.

Obtaining, Evaluating, and Communicating Information

Investigative Statement: _____

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In the space provided: *thinking of information, obtain – sketch – evaluate – communicate – plan*

Performance Assessment - HS-ESS1-1

A Comet's Journey

Read the following the passage and determine the conditions of the solar system in which this comet travels.

Phenomenon

Comets are objects in our solar system that orbit the sun. Comets do have regular paths, yet very different from the orbits of planets, planetoids, and asteroids. Comets orbit the sun in long ellipses.

Comets are made up of rock, ice, and frozen gases. Comets have three parts. The core, or nucleus, of a comet is made up of rock and ice. The core is surrounded by a cloud of gas and dust. This cloud is the coma. The nucleus and coma form the head of the comet. The tail forms as the comet comes near the sun. The tail is made up of glowing gas and dust streaming out from the head. A comet's tail always points away from the sun.

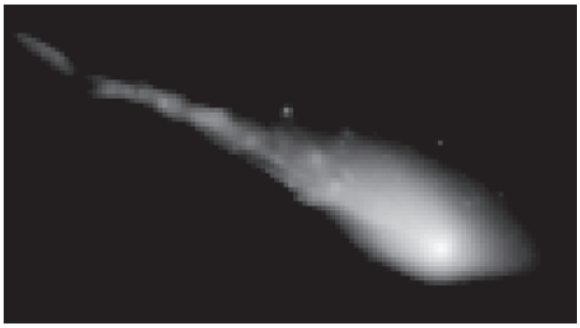
Comets are believed to originate in the Oort Cloud and the Kuiper Belt. The Kuiper Belt, is a region of the solar system where material is believed to be remnants from the solar system's early formation. The Kuiper Belt is past the orbit of Neptune. The Oort Cloud lies far beyond Pluto and the most distant edges of the Kuiper Belt. It is believed to be a giant spherical shell surrounding the Sun, planets and Kuiper Belt Objects.

Hailey's Comet is a regular comet passing by Earth approximately every 76 years. It is so well documented, that it could be found in ancient texts. While comets were believed to make only one pass though the solar system, English astronomer Edmund Hailey predicted the appearance of the comet using gravitation and planetary motion theories from Sir Isaac Newton.

The understanding is that the trajectory of Hailey's comet is approximately 17.35 AU in the semi-minor axis while its semi-major axis is approximately 17.93 AU. These numbers were derived by observations of the comet. Notice it is a semi-axis, which means half.

The comet is predicted to return to our view on July, 2061. It is an object roughly 11 km across. It travels at a rate of speed of 65 km per second. It travels close to Earth on its path to the sun, but takes a wider sweep on its journey through the solar system.

Stimulus



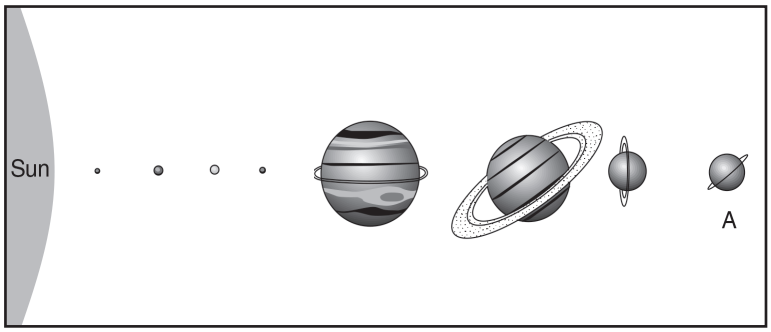


Photo by Dan Bartlett

1. Determine the eccentricity of Halley's Comet. $\text{Eccentricity} = \frac{\text{semi minor axis}}{\text{semi major axis}}$

For Questions 2 and 3 refer to the Solar System Objects Data Table in Lab 40 (Kepler's Law).

2. Observe the eccentricity of those objects as compared to Hailey's Comet. If orbits of those objects are somewhat circular, describe the shape of Hailey's Comet.

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3. If Haley's Comet major axis is 5,379 million km, determine whether Halley's comet is a Kuiper Belt Object or from the Cloud or Oort. Explain and defend your conclusion.

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4. During the Great Bombardment, 4 billion years ago, it is believed that comets crashed into our planet. Knowing a comet's composition, explain the outcome of this.

5. In 2014, NASA (National Aeronautic and Space Administration) and ESA (European Space Agency) landed on Comet 67P/Churyumov-Gerasimenko. What data do you think these agencies were looking for?