5.4 Stars & Starlight Lab

January 13, 2019 10:05 AM

NAME: Key PERIOD:

STAR CYCLE NOTES

Nebula
A giant cloud of gas and dust, it is made mostly of hydrogen and helium, but can also have heavier stuff if recycled stardust is in the area.

Protostar
Parts of the nebula begin to collapse and become denser. These clumps start heating up, but it is still not a star until nuclear fusion begins in the core.

Main Sequence
The moment that temperatures get hot enough for nuclear fusion a star is born. This is the longest stage of a star's life and is spent fusing hydrogen into helium. This is the stage that our sun is in. A star leaves the main sequence when it runs out of hydrogen. High mass stars use up their hydrogen faster than low mass stars.

Gravity pulling in — Pressure pushing out

Stars must constantly be balancing the forces of **gravity** (from the mass of the star) and **pressure** (from the nuclear fusion) in order to survive. If either one overpowers the other the star will die.

Red Giant
When low mass stars run out of hydrogen, gravity starts to win. The star shrinks until the center becomes hot enough to fuse helium into carbon. The star then grows 10x bigger and glows red.

Planetary Nebula
Pressure eventually wins over gravity and the outer layers of the star get puffed away from the core in beautiful patterns. The leftover core eventually becomes a white dwarf.

White Dwarf
Gravity condenses the leftover core of a planetary nebula until it is very dense and about the size of Earth. There is no nuclear fusion, so it will eventually burn out and grow cold over billions of years.

Red Super Giant
Same as red giants, but these stars were bigger to begin with. They become some of the biggest stars in the universe. The core is so hot and dense that it can fuse elements all the way up to iron.

Supernova
Nuclear fusion stops after a star fuses up to iron in its core. Without pressure from fusion to balance gravity the stars collapses and then explodes, creating all of the elements heavier than iron. Awesome!

Neutron Star / Pulsar
Neutron stars are leftover remnants of large exploded stars. They are very small (6 miles wide) but very dense. They often spin and shoot energy into space. When they do this we call it a pulsar.

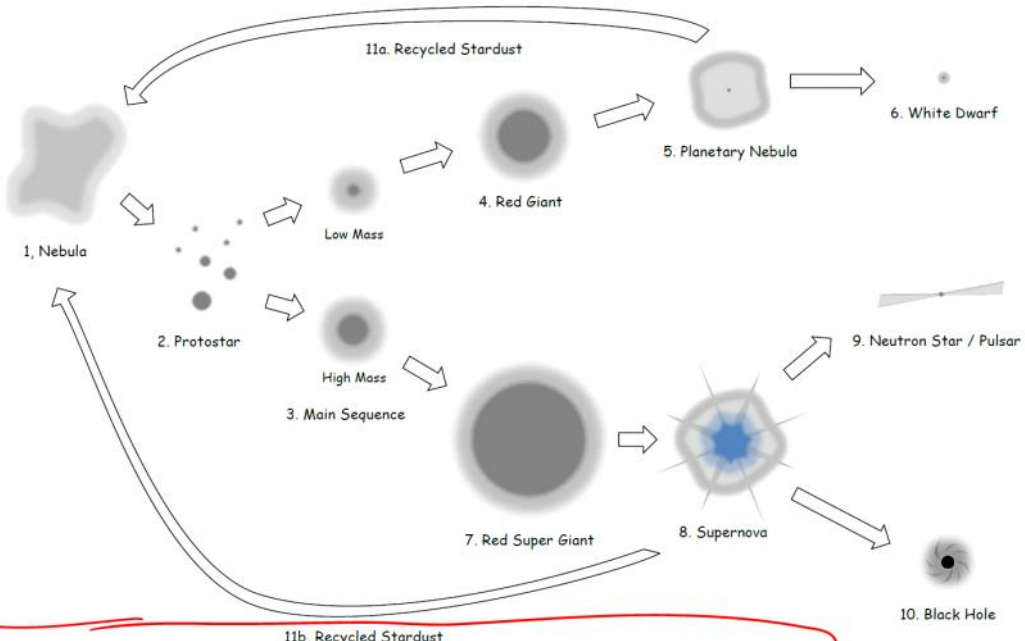
Recycled Stardust
Matter from exploded stars and p. nebs gets reused in the universe. New stars forming in areas with a lot of recycled stardust have a higher chance of forming with planets around them.

Black Hole
An object with such strong gravitational force that not even light can escape it. Black holes are only created when the most massive of stars explode.

BACK TO THE BEGINNING...

The most important term to remember when talking about stars is... *NUCLEAR FUSION!*
Nuclear Fusion is when two or more atoms slam together to make a heavier element, giving off light and heat in the process.

An illustrated representation of the star life cycle



The path of our sun:

Nebula → Protostar → Main Sequence Star (Low Mass) → Red Giant → Planetary Nebula → White Dwarf

H-R Diagrams

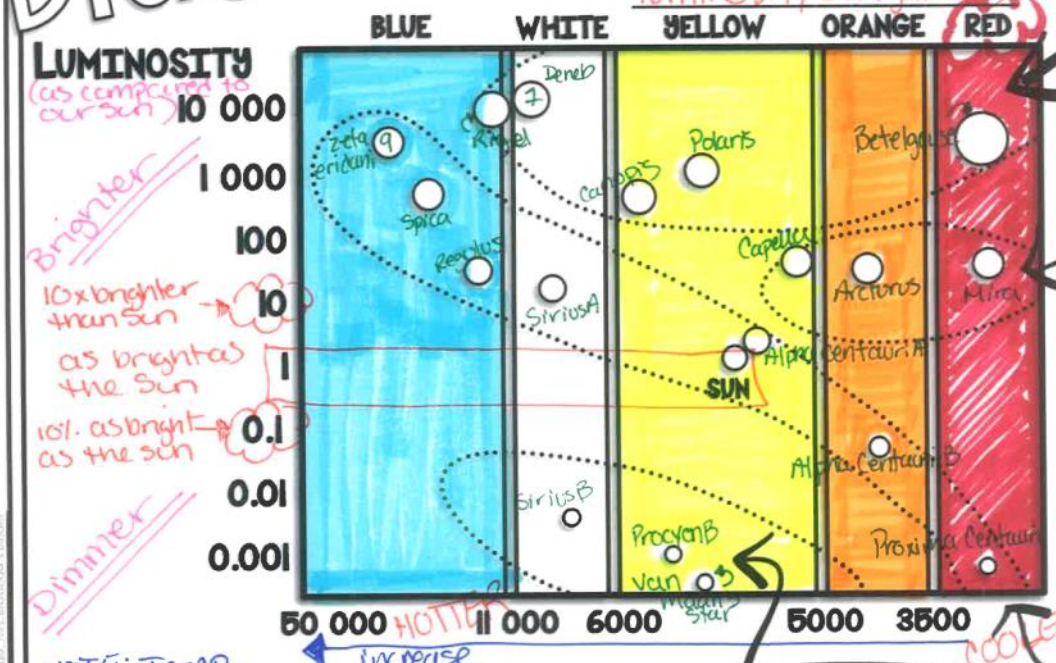
The Hertzsprung-Russell Diagram is a scatterplot showing the relationship between a star's temperature and its luminosity (brightness)

SUPERGIANTS

Supergiants are massive stars that burn through their fuel so QUICKLY they die off relatively faster than other stars

H-R Diagrams

The Hertzsprung-Russell Diagram is a scatterplot showing the relationship between a star's temperature and its luminosity (brightness)



NOTE: Temp. decreases from left → right (unlike most graphs)

SUPERGIANTS

Supergiants are massive stars that burn through their fuel so quickly they die off relatively faster than other stars.

GIANTS

Giants are very large stars that tend to be cooler because they are not as dense.

MAIN SEQUENCE

90% of stars lie on the main sequence, a band that shows the large, high-mass stars are brighter than the small, low-mass stars. As mass increases, so does a star's temperature and brightness. Larger stars die quicker because they burn fuel faster.

WHITE DWARFS

Dwarf stars have less mass but are denser than giants so they are hotter

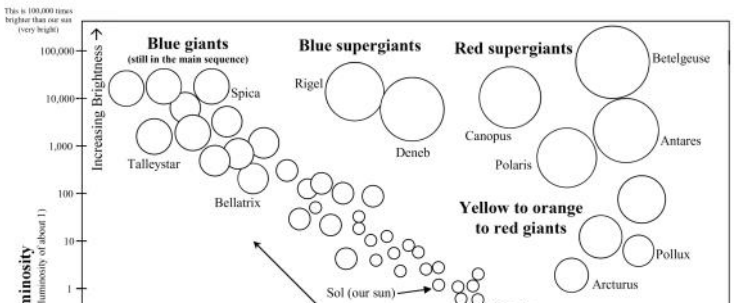
name:

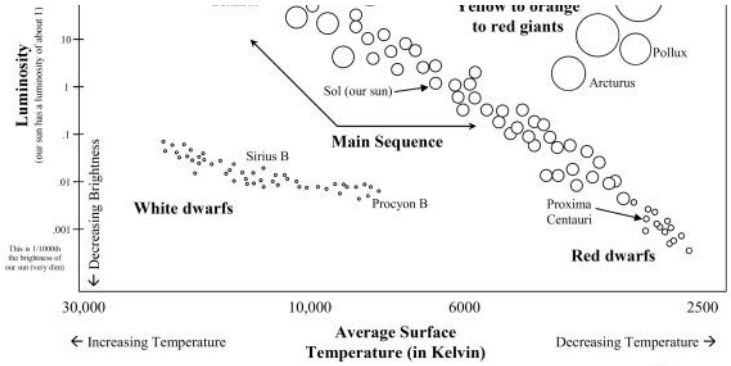
Homework — **Assignment #5.4 Complete the Periodic Table Assignment in the space provided.**

The Hertzprung-Russell Diagram

The Hertzprung-Russell diagram (HR Diagram) is a graph that shows the relationship between the average surface temperature of stars and their brightness. When we talk about brightness we need to realize that we are pretending as if all of the stars were the same distance away from Earth. Obviously the sun is the brightest star in the sky for Earthlings, but if the sun were the same distance from Earth as all of the other stars out there, then it would seem rather dim by comparison. The word "luminosity" is used on your graph. Luminosity is a measure of how much energy leaves a star in a certain period of time. Usually the more luminous a star is, the brighter it is as well. Our sun (Sol) has a luminosity of about one. The luminosity of all other stars is compared to this number. Some of the brightest stars in the universe are over 100,000 times brighter than our sun!

The luminosity of stars is affected not only by temperature, but also by size. The most luminous stars would be those that are large and hot. Those that are the least luminous would be small and cool. The temperature on the surface of the star will also determine what color that star is. Study the HR Diagram below and then use it to answer the questions on the back of this page.





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Analysis Questions (1 point each)

1. What is the approximate surface temperature of our sun?
   6500 Kelvin or so
2. What is the approximate luminosity of Procyon B?
   Around .01
3. Name one star that is brighter than our sun, but not hotter.
   Canopus, Polaris, Antares, Betelguese, Pollux, Arcturus
4. What happens to the luminosity of stars in the main sequence as temperature decreases?
   It also decreases
5. Which has higher average surface temperatures, white dwarfs or supergiants?
   White Dwarfs
6. What color are the stars on the diagram with the highest surface temperatures?
   Blue
7. What color are the stars on the diagram with the lowest surface temperatures?
   Red
8. Name one star from the diagram that is fusing hydrogen into helium.
   Proxima Centauri, Sol, Bellatrix, Spica, Talleystar
9. Name one star from the diagram that has run out of hydrogen.
   Anything other than those listed on number 8
10. Name one star from the diagram that is not performing nuclear fusion at all
    (hint: it will be in a stage where it's only shining because of billions of years of built up energy)
    Sirius B and Procyon B

Application (worth 20 points – 10 for the info, 10 for adding it to the HR Diagram)
Go online and research any five stars that are not already on your diagram. Write the name of each star in the table below along with its average surface temperature and luminosity. After you have filled out the table then draw and label these stars on the HR Diagram.

NEED HELP? Try searching for things like "list of well-known stars" or "list of stars in the main sequence." Once you see a star that isn't on your diagram, try looking it up on Wikipedia or a similar site for more detailed information.

NOTE: You may find stars that have higher temperatures or luminosity than your HR Diagram covers. You do not have to draw these stars on the HR Diagram. For full points at least 3 out of your 5 stars must fall somewhere within the range of the HR diagram.

Name of star	Average Surface Temperature	Luminosity

Answers will vary. I grade it according to the instructions. 10 points for the chart. 10 points for adding their stars to the diagram.

** Don't forget to draw these stars on the HR Diagram on the other side of this page **

Analyzing Starlight Lab Part I

NAME: _____

Score

Background: Fill in the blanks below (1 point for each blank)

Astronomers can take starlight and split it up using a device similar to a prism. This device is called a _____. You will be using a simple version of a spectroscope today to observe the light given off from several elements. Using a spectroscope, observe the spectrum of white light from the overhead classroom lights and draw what you see below:

red orange yellow green blue violet

(1 point for completion)

Each element absorbs certain _____ of light and reflects others and each element is different from the others. It's like each element has its own unique _____ or fingerprint. When astronomers look at starlight and analyze it with a spectroscope, they can determine what _____ the star is made of! Use your spectroscope to observe the different tubes of gas that your teacher will show to you. Draw the spectrum for each element below:

Element Name
(1 point for writing all of the names)

Red Orange Yellow Green Blue Violet

Red Orange Yellow Green Blue Violet

Red Orange Yellow Green Blue Violet

Red Orange Yellow Green Blue Violet

Red Orange Yellow Green Blue Violet

(1 point for each completed spectrum)

*** Don't forget to answer the analysis questions on the back side of this page ***

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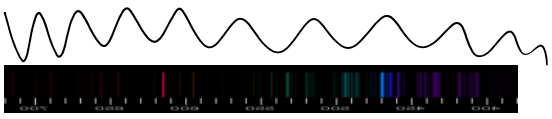
Hydrogen

Helium

Nitrogen

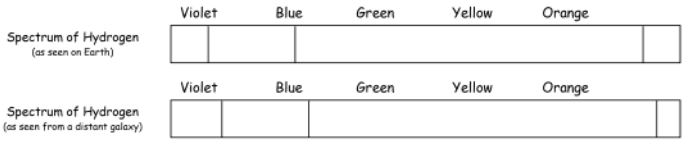
Argon



1. Which was your favorite element ***and why***? (1 point)

2. Name three things that we can know about a star by studying its light. (3 points)

When astronomers observe starlight from distant galaxies using spectroscopes they find that all of the absorption lines are shifted towards the red side of the spectrum. The illustration below demonstrates this phenomenon (known as "red shift").



3. What causes red shift? (3 points)

Analyzing true starlight is a little bit more complicated than what we did in this lab because stars contain more than one element. Part of an astronomer's job is separating the "barcodes" for all of the elements found in a star. Luckily they have computers to help them, but you're going to do things the old fashioned way. Use the element key on the right to determine what elements are found in the stars being analyzed for questions 4 and 5.

4. This is what you see when you analyze a star:

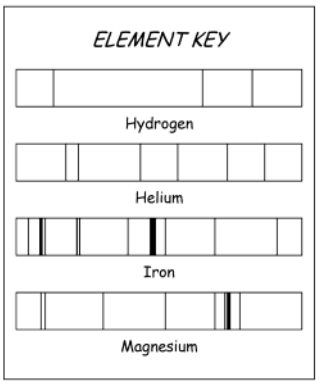
a. Which elements are found in this star? (2 points)

b. Is this star younger or older and **why**? (2 points)

5. This is what you see when you analyze a star:

a. Which element(s) are in this star? (2 points)

b. Is this star younger or older and **why**? (2 points)



6. **Conclusion** – In *complete sentences*, tell me two things you learned from this activity (5 points)

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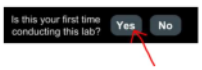
ANALYZING STARLIGHT LAB PART II:
VIRTUAL SPECTROSCOPY & FLAME TESTS

Introduction: *Scientists can determine the composition of stars by analyzing the light they give off. In this lab we will utilize our prior knowledge of how excited electrons behave during a flame test, and combine this with our new understanding of the visible light spectrum to identify the unknown samples.*

Procedure:

1. Collect a Chromebook and go to: http://www.bigrocketproductions.com/portfolio-item/spectroscopy-simulation/
2. Be sure to click "YES" when asked "Is this your first time conducing this lab?" in order to run the tutorial and LEARN about using the spectroscope. This step is ***ESSENTIAL*** to completing the lab correctly.



3. After you have put on your safety gloves, follow the audio prompts in order to learn how to complete the lab. *(steps are not written here, and your teacher will not be available to assist you…so DO THE TUTORIAL!)*
4. Record ***all results*** (including the tutorial sample) in the results table below.
5. ***NOTE*** There are 13 Slides to test in the Spectroscope. You should google "metal ion flame test colours" to make a prediction of what the element could be in order to narrow the number of spectral slides that you have to test each time.

Tutorial Analysis Questions:

1. What determines the colour of the flame?
2. When looking through the Spectroscope and using the pre-made filters, what do the **black** spectral lines represent?
3. When looking through the Spectroscope and using the pre-made filters, what does it mean if you DO NOT see **black** spectral lines?
4. If the flame colour becomes too faint to be able to re accurately through the spectroscope, what should you do?
5. Why can you NOT reuse the same wire loops when testing different samples?

Data & Results:

Table 1:_____

Sample	Flame Test Colour	Element Prediction	Matching Spectra Filter	Confirmed	
				Element Symbol	Element Name
Table salt					
Sample A					
Sample B					
Sample C					
Sample D					

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Universe 101 – Review Sheet

Be familiar with the following topics for your upcoming QUIZ (…and Final Exam)

- *THE BASICS ABOUT ATOMS, ELEMENTS, AND THE PERIODIC TABLE*
  - Know the basic parts and arrangements of an atom
    - Proton – positively charged particle in the nucleus of the atom
    - Neutron – neutral particle in the nucleus of the atom
    - Electron – negatively charged particle orbiting around the nucleus of the atom
  - Understand the difference between atoms and elements.
    - Atoms are the basic building blocks of matter. Elements are substances made up entirely of one type of atom. You change elements by changing the number of protons in the atom.
    - I prefer an ice cream analogy. The elements are like the different flavors available at an ice cream shop while the atoms are like the smallest size of scoop available for purchase.
  - Know that when you organize all of the elements by their characteristics you get the periodic table.

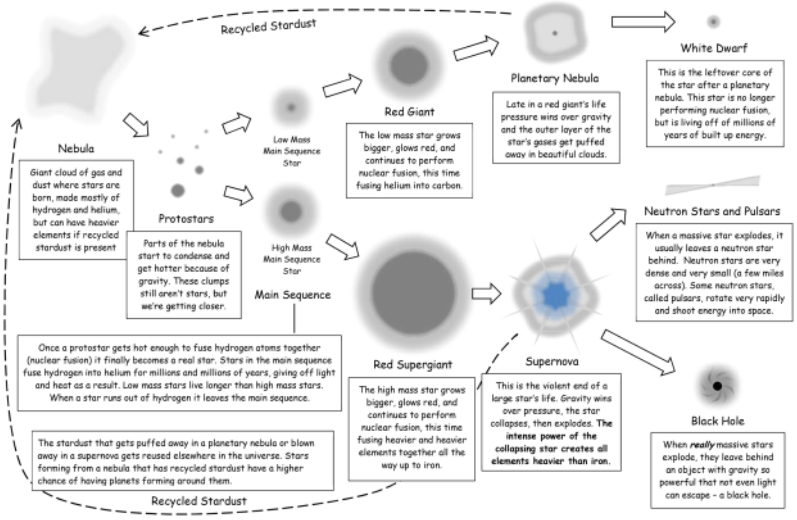
- *THE BIG BANG*
  - Know how old the universe is (13.7 billion years old), and be able to identify that age on a timeline.
  - Understand what the big bang theory says
    - The universe is expanding.
    - If you rewind the clock there was a time when the universe was very small, hot, and dense.
    - The universe is cooling down.
  - Understand the evidence that supports the big bang theory
    - Red-shifted starlight – it tells us that the universe is expanding.
    - Cosmic Background Radiation – it is the faint energy that is found everywhere in space. Any theory about the start of the universe would need to explain this energy. The big bang does.
  - Know what the Doppler effect is and how it relates to red or blue shifting of starlight.
    - It's when a wave (sound or light) appears to change in pitch / color because of the movement of the object giving off the wave compared to the position of the person hearing or seeing it. For sound, you get NEEEEEEEYEEOOOOOWWW, for light you see a red shift when an object is moving away, you see a blue shift when an object is approaching. The fact that we see red-shifted starlight nearly everywhere we look is evidence of an expanding universe.

- *NUCLEAR FUSION*
  - Know what nuclear fusion is – a process that takes place in stars where two or more atoms moving at high speeds collide and fuse together to create a new atom, giving off light and heat in the process. This process is so powerful that even 93 million miles away we can feel the sun's heat and have to avoid looking directly at it because of its intense brightness.
  - Know at which point nuclear fusion begins in a star and how it changes over time. The table below sums it up…

Stage of the Star Cycle	Nuclear Fusion
Protostar	Once the protostar gets hot enough, nuclear fusion begins in the core. Once nuclear fusion begins, you leave the protostar stage and become a real star, entering the main sequence.
Main Sequence	All main sequence stars, regardless of size or mass, fuse **hydrogen into helium.**
Red Giant (low mass stars)	The star runs out of hydrogen but can now fuse **helium into carbon.** The star does not have a high enough mass to consistently fuse elements much heavier than carbon.
Red Super Giant (high mass stars)	The star runs out of hydrogen and starts fusing **elements together all the way up to iron.** It can't fuse any higher and once the star becomes unstable, it explodes in a supernova.

- *COMPOSITION OF STARS*
  - Remember that each element has a unique pattern or "barcode" when viewed with a spectroscope.
  - Be able to draw a red or blue shift on a spectrum
    - Basically you just draw all of the same lines, just shifted a little towards the red or blue sides of the spectrum depending on the situation (see starlight lab for an example).
    - Remember ***red shift*** is observed when an object is moving away, ***blue shift*** when moving towards
  - Be able to identify combinations of elements given the data and a key (see starlight lab for examples).
  - Be able to say whether or not a star is young or old depending on which elements it has
    - Light elements like hydrogen and helium mean that a star is young and still in the main sequence.
    - Heavy elements like iron mean that a star is old and about to explode in a supernova.
  - Know the major things that astronomers can tell about a star just by analyzing its light
    - They can tell how far away the star is
    - They can tell what elements that star is made of
    - They can tell how old a star is and when it will likely die based on the elements that it has
    - They can tell how large a star is
    - They can tell how hot a star is

- *STAR LIFE CYCLE*
  - Know that gravity and pressure must be in a constant balance in order for a star to survive.
  - Know the general order of the star life cycle and what is happening at each stage.
  - Be able to correctly interpret an HR Diagram displaying stars in various stages of life.



  - Know how the life cycle of our sun compares to the life cycle of other stars.
    - Nebula → Protostar → Main Sequence → Red Giant → Planetary Nebula → White Dwarf
    - Our sun is a very average star. It is currently in the ***main sequence*** stage of the star life cycle.

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