Senior High School

DepED
DEPARTMENT OF EDUCATION

Physical Science

Quarter 1 – Module 1:

Formation of Heavy Elements

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Introductory Message

This Self-Learning Module (SLM) is prepared so that you, our dear learners, can continue your studies and learn while at home. Activities, questions, directions, exercises, and discussions are carefully stated for you to understand each lesson.

Each SLM is composed of different parts. Each part shall guide you step-by-step as you discover and understand the lesson prepared for you.

Pre-tests are provided to measure your prior knowledge on lessons in each SLM. This will tell you if you need to proceed on completing this module or if you need to ask your facilitator or your teacher's assistance for better understanding of the lesson. At the end of each module, you need to answer the post-test to self-check your learning. Answer keys are provided for each activity and test. We trust that you will be honest in using these.

In addition to the material in the main text, Notes to the Teacher are also provided to our facilitators and parents for strategies and reminders on how they can best help you on your home-based learning.

Please use this module with care. Do not put unnecessary marks on any part of this SLM. Use a separate sheet of paper in answering the exercises and tests. And read the instructions carefully before performing each task.

If you have any questions in using this SLM or any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator.

Thank you.

What I Need to Know

This module will walk you through the beginning of everything. It focuses on how some elements known today were formed same as when stars were born right after the universe existed. You will be provided with activities such as filling out graphic organizer, reading story board and illustrations which make you remember the lesson. Make sure to answer first the pretest before going through this module and the posttest at the end of the module.

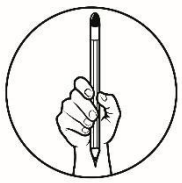
The module consists of:

- Lesson 1 – Stellar Nucleosynthesis: Rise of the Stars!

After going through this module, you are expected to:

1. explain stellar nucleosynthesis;
2. describe the different stages of life cycle of stars;
3. cite the different heavy elements formed in each stages of star cycle.

Have you also wondered what stars are made of? What keeps them shine so bright? Are there also stars that do not spark? You might also be asking the same questions ever since you were little that until now you still seek answers for, right? Well, this module will help you understand some of the important concepts about stars. Are you ready? Let's go!



What I Know

Choose the letter of the best answer in each item and write it on a separate sheet of paper.

1. The most accepted theory about the formation of the universe which explains that it continues to expand
   a. big bang theory
   b. divine creation theory
   c. steady state theory
   d. oscillating theory

2. The following are light elements EXCEPT;
   a. helium
   b. hyd
   c. lithium
   d. iron

3. The process of forming elements is known as;
   a. generation
   b. genesis
   c. nucleosynthesis
   d. synthesis

4. Light elements such as hydrogen and helium are formed through the process of _____ nucleosynthesis.
   a. big bang
   b. fusion
   c. stellar
   d. supernova

5. Which element is the lightest and at the same time the most abundant in outer space?
   a. hydrogen
   b. helium
   c. lithium
   d. iron

6. A reaction in which two or more nuclei combine to form heavier nuclei.
   a. combustion
   b. nuclear fission
   c. nuclear Fusion
   d. nuclear synthesis

7. What element can be formed when three atoms of helium are fused?
   a. carbon
   b. hydrogen
   c. oxygen
   d. silicon

8. Which of the following elements DOES NOT belong to the group?
   a. beryllium
   b. silicon
   c. iron
   d. oxygen

9. The process in which elements are formed at the center of a star.
    a. big bang nucleosynthesis
    b. nuclear fusion
    c. stellar nucleosynthesis
    d. supernova nucleosynthesis

10. Elements bigger than Iron are formed through_____.
    a. big bang nucleosynthesis
    b. nuclear fusion
    c. stellar nucleosynthesis
    d. Supernova nucleosynthesis

11. When Carbon atom is combined with Helium atom, the element _____ will be formed.
    a. magnesium
    b. neon
    c. oxygen
    d. silicon

12. Average stars have longer life span than massive stars. This is because_____.
    a. they have less fuel to burn
    b. they have more fuel to burn
    c. they burn their fuel at faster rate
    d. they burn their fuel at slower rate

13. Our sun is in what phase of its life cycle?
    a. main sequence star
    b. planetary nebula
    c. red giant
    d. white dwarf

14. Which of the following contains only heavy elements?
    a. carbon, lithium, neon
    b. carbon, silicon, magnesium
    c. carbon, beryllium, helium
    d. helium, carbon, hydrogen

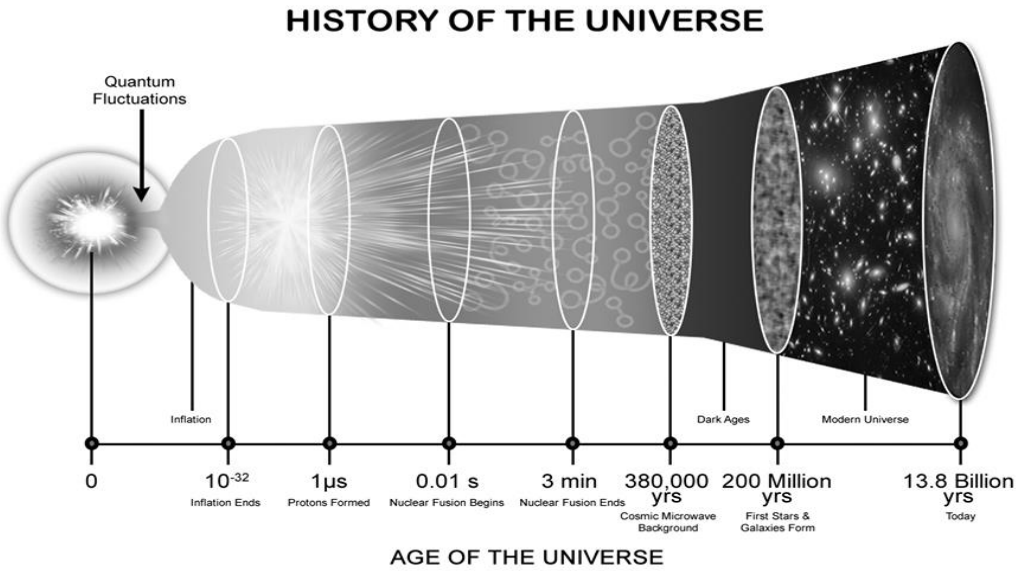
15. In which stage do massive stars explode and release large amount of energy?
    a. main sequence
    b. protostar
    c. super nova
    d. white dwarf

Lesson 1 Stellar Nucleosynthesis: Rise of the Stars!

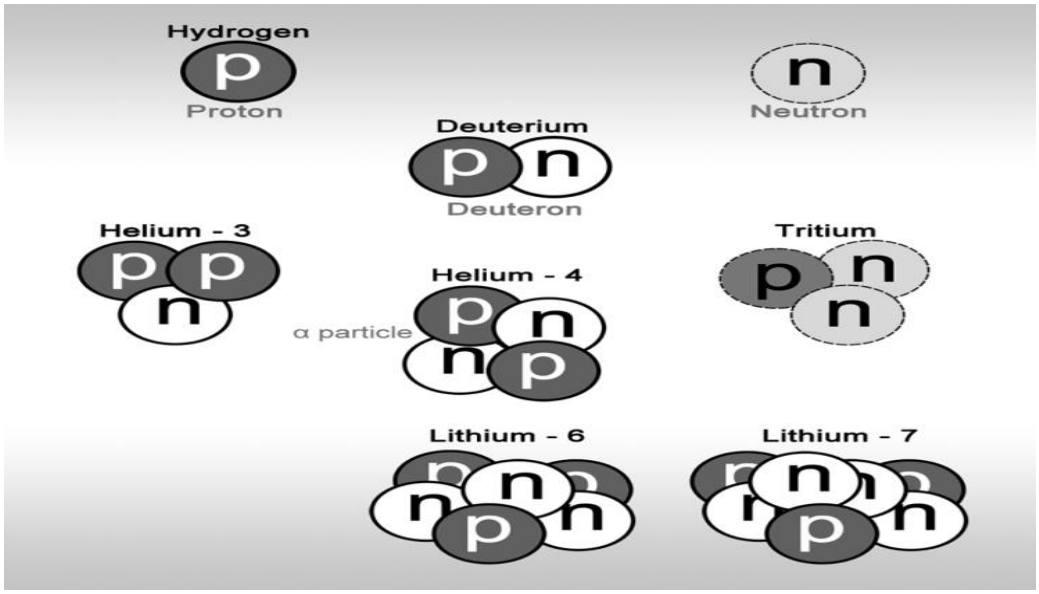
The world where we live today is just a small part of our universe. In your previous years, you have learned about the different theories of the origin of the universe that eventually led to the formation of galaxies, solar system and other heavenly bodies. This lesson will focus on one of those wonderful things present in outer space, the stars. Although stars are millions of light years away from us, we can still see them twinkling in the night sky. Let's find out how they emit light and what keeps them shining for a long time.

What's In

Scientists believe that the formation of the universe began through the explosion of a primordial atom which happened 13 billion years ago. It is known as the **Big Bang**. It became a theory that also explains the continuous expansion of the universe.



Right after Big Bang, protons and neutrons combined together and formed light elements **Hydrogen and Helium** in the process of **Big Bang Nucleosynthesis.** Other light elements such as Lithium and Beryllium were also formed during this process.

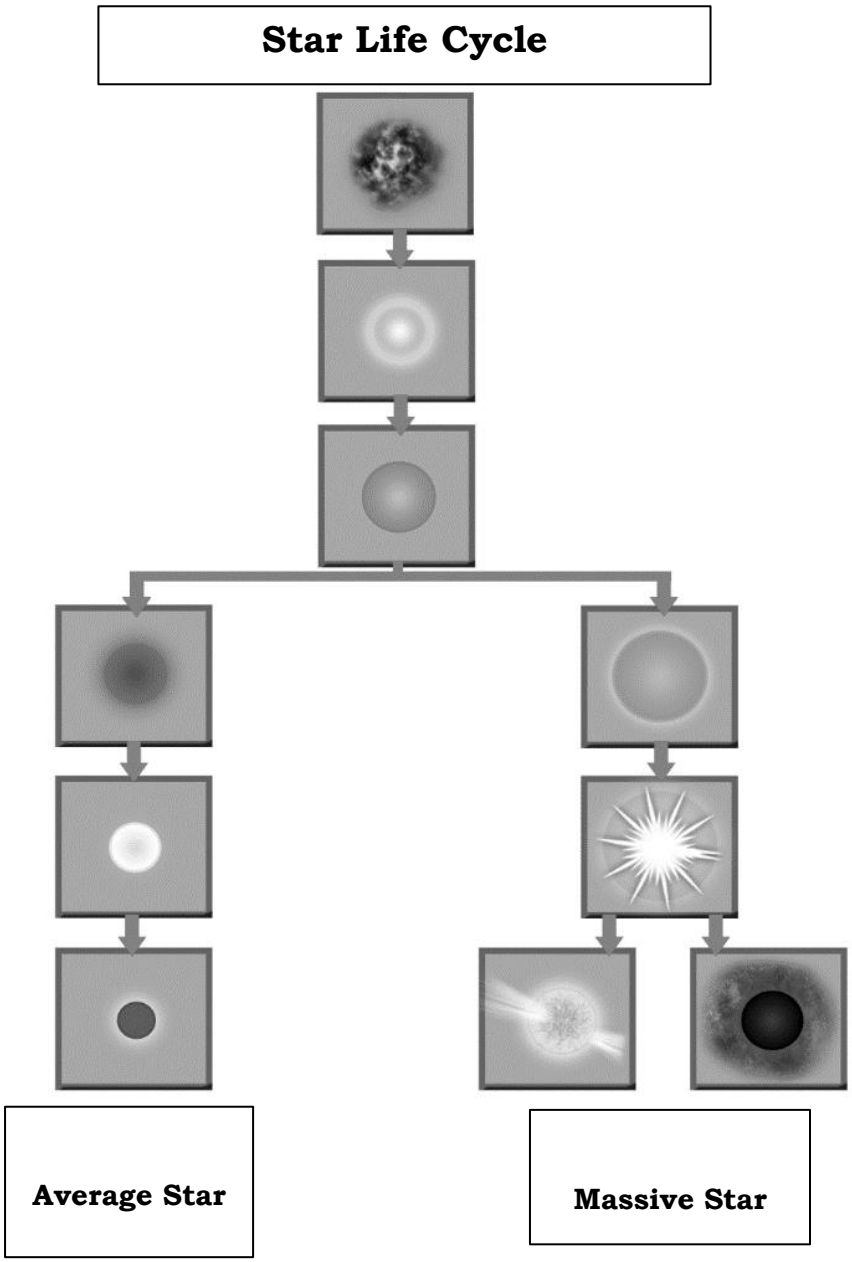


What's New

Stellar Nucleosynthesis

The word "stellar" means star and the formation of elements in the center of the star is called stellar nucleosynthesis. Carl Sagan said that "We are made of star stuff." What did he mean by that? If we know how some important heavy elements were formed same as stars, that maybe a clue.

Label the sequence of star life cycle. Use the hints/clues found in the table below this diagram.



Hints/ Clues

Average Star

The star is unable to generate heat when it runs out of hydrogen in its core leading to its contraction and expansion. It cools down and glows red. The Helium fused into Carbon. The star is now **RED GIANT**

Red giant star becomes exhausted of nuclear fuel, the outer material is blown off into space leaving the inert Carbon. The remnant is known as **WHITE DWARF.**

Giant cloud of gas and dust known as **NEBULA.**

It is formed from nebula due to the gravity that pulled Hydrogen gas together until it spins faster and faster and becomes ignited. A **PROTOSTAR** rises.

MAIN SEQUENCE STAR starts to form when nuclear fusion occurs at the core of the star, it begins to contract, glow and become stable. Hydrogen is converted into Helium.

This is said to be the remain of the white dwarf that cooled down and no longer emits light and heat. The hypothetical **BLACK DWARF.**

Massive star

It is believed that a **NEUTRON STAR** is formed from supernova explosion. This is also the smallest star

Explosion of star or **SUPERNOVA** releases large amount of energy**.** Because of that, elements are dispersed into the space.

BLACK HOLE is a region in space where gravity is too strong that no matter can escape from it.

A more massive main sequence star evolves, cools and expands faster than low mass star and will turn into **RED SUPER GIANT** star, the largest known star. Carbon fusion still occurs and Oxygen formed.

Notes to the Teacher

Guide them in this activity and clarify any misconceptions.

The teacher can also ask the students to illustrate the stages of star cycle using their art materials in a separate bond paper for better retention.

What is It

Were you able to label all the stages of star? Review the hints/clues in the previous activity. You will notice that following the sequence will reveal what happens in each stage of star.

To understand further, answer the following questions below.

1. What element from space is pulled by gravity and turn into a protostar?
_____

2. What will happen if a low massive main sequence star runs out of hydrogen fuel?
_____

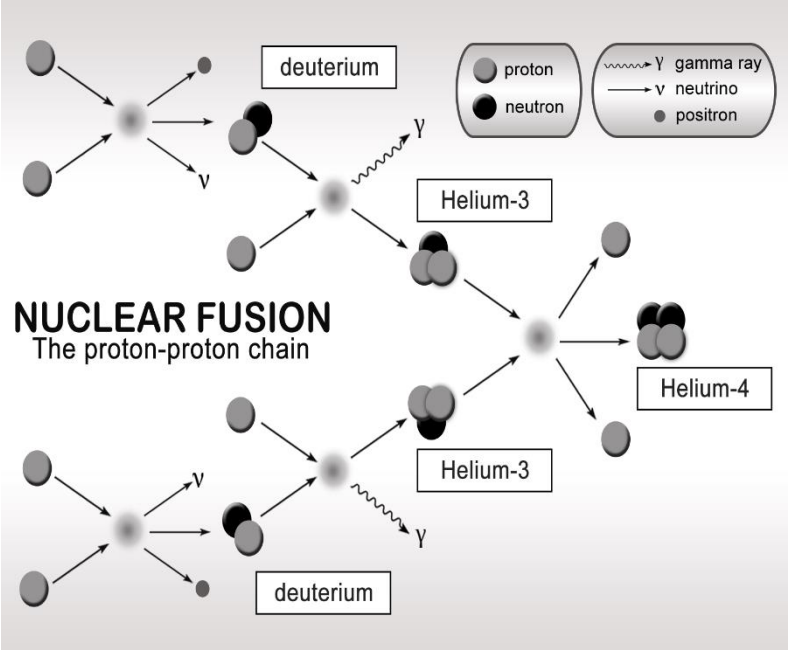
3. How are heavy elements such as Carbon, Oxygen and Neon formed during star formation?
_____

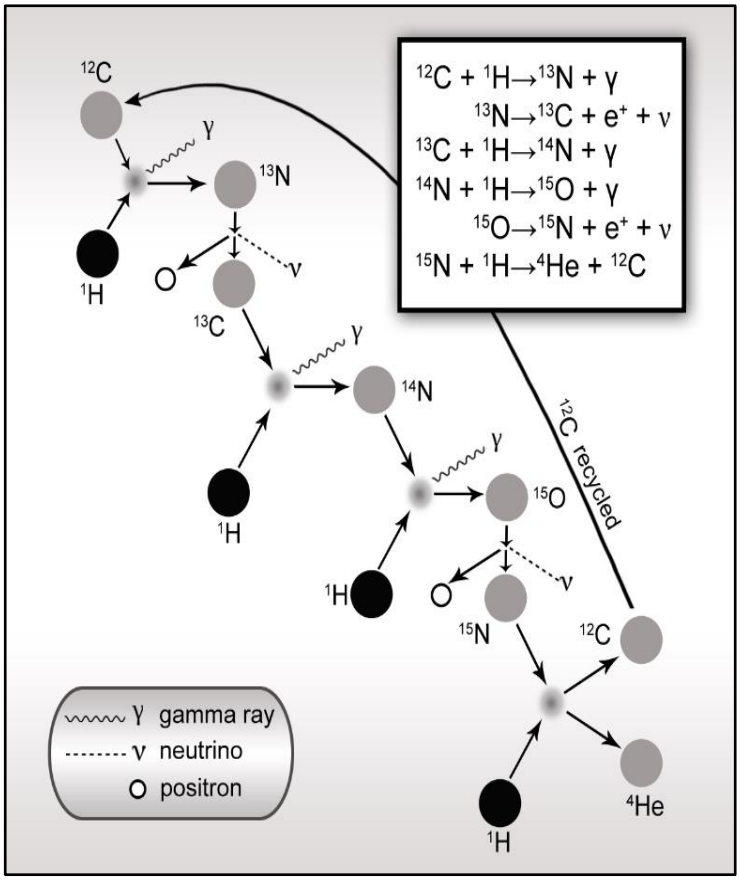
4. Why is it impossible for any matter such as light and radiation to escape from a black hole?
_____

5. Why do you think massive star has shorter life span than average star?
_____

Look at the diagrams below. These will explain how stars are formed into different stages because of nuclear fusion (combination of nuclei to form heavier one) among heavy elements

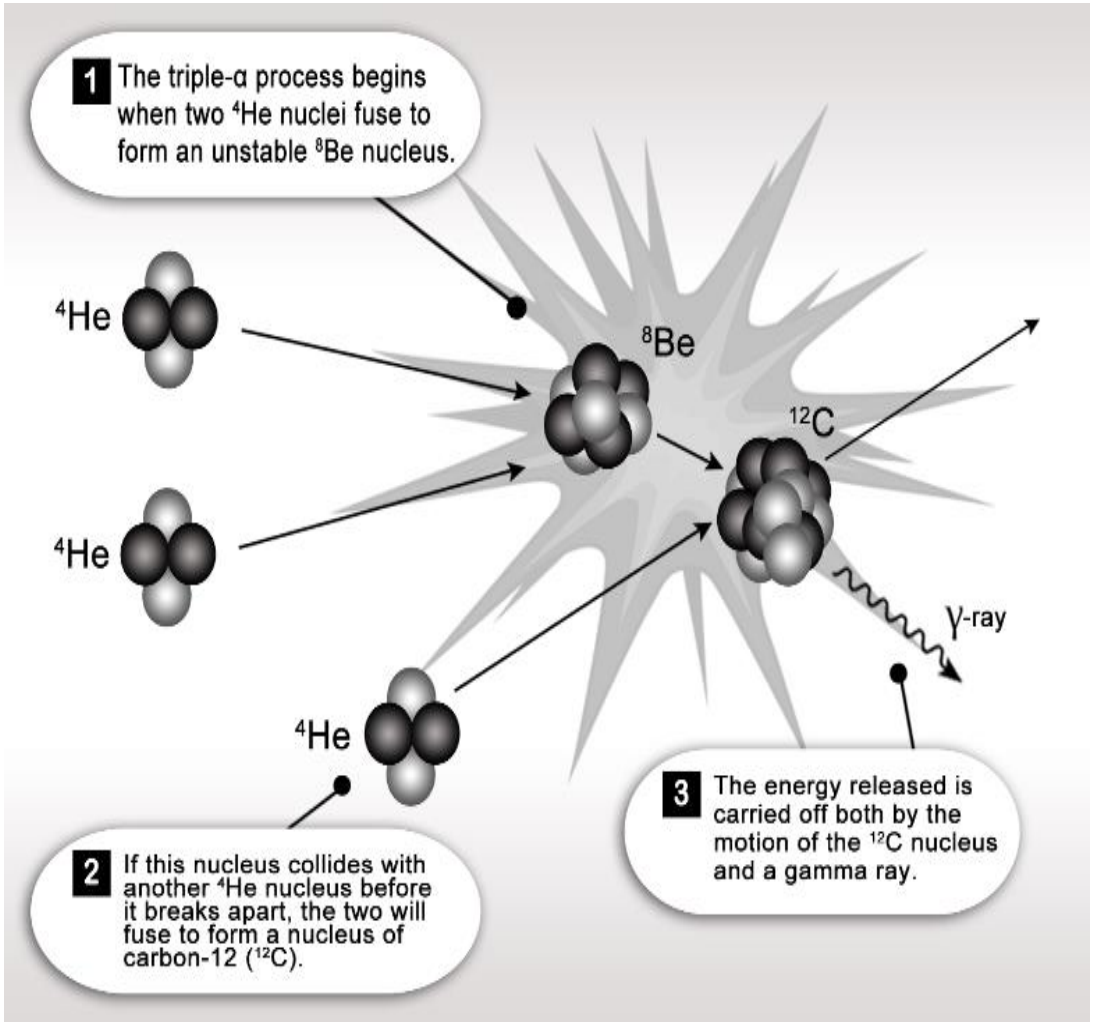
The diagram shows the **Proton-Proton Chain reaction** in main sequence star. This is the process by which average star gets their energy and convert Hydrogen into Helium. It starts with proton and neutron fused together to form **deuterium**. When one proton collides with deuterium, **Helium-3** is formed. Two Helium-3 collided will form **Helium-4.**



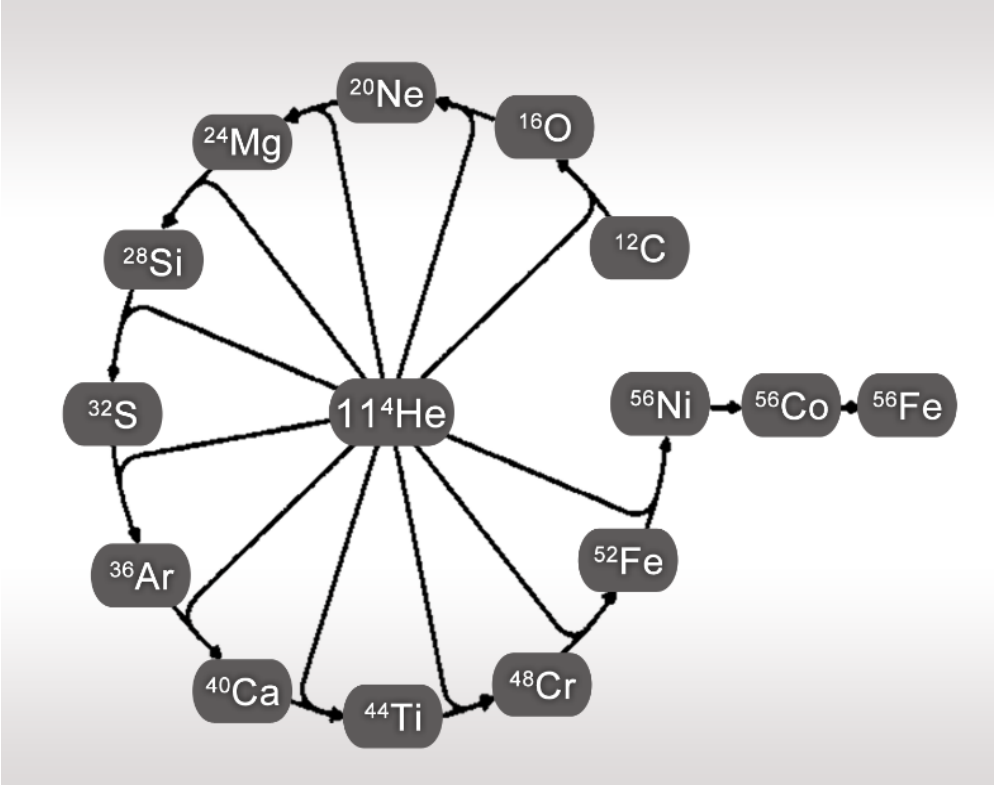


The case is different in massive star or star eight times larger than solar mass. They undergo **CNO (Carbon, Nitrogen, Oxygen) cycle** to convert Hydrogen into Helium. You can see at the right how Carbon 12 fused with proton (H) and form Nitrogen-13. Nitrogen-13 undergoes beta decay to form Carbon-13. Carbon-13 captures proton (H) and Nitrogen 14 is formed. Nitrogen 14 captures proton and Oxygen-15 is produced. Oxygen-15 undergoes beta decay and produces Nitrogen-15. Nitrogen-15 fused with proton gives off Helium and ends up with Carbon-12. Then the process repeats again.

Tri alpha process happens in red giant star once they leave the stage of main sequence star. This is how three Helium-4 are converted into Carbon.



A star accumulates more mass and continues to grow into red super giant. Alpha particle fusion happens at its core and creates more heavy elements until elements called Iron is formed. This process is known as the **Alpha ladder**



How are elements heavier than Iron formed? As the energy at the core of the star decreases, nuclear fusion cannot produce elements higher than Iron. Different pathway is needed for heavier elements to be formed.

Neutron capture, a neutron is added to a seed nucleus. Below is the representation of how neutron is captured and heavier nucleus is formed.

Example**:**

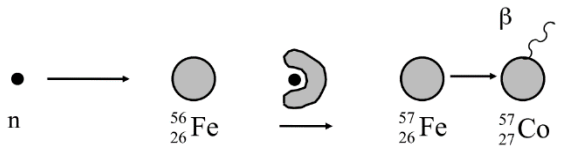
$$^{A}_{Z}x + {}^{1}_{0}n \rightarrow {}^{A+1}_{Z}y$$

$$^{56}_{26}Fe + 3\,{}^{1}_{0}n \rightarrow {}^{59}_{26}Fe$$

Neutron capture can be slow or rapid;

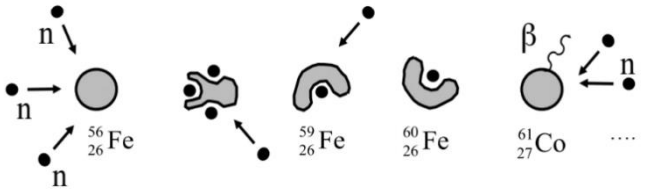
S-process or slow process happens when there is a slow rate of capturing neutron while there is a faster rate of radioactive decay hence increasing the proton by 1.

Example:

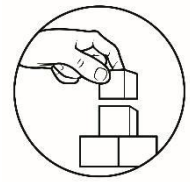


R-process or rapid process means that there is faster rate of capturing neutron before it undergoes radioactive decay thus, more neutrons can be combined at the nucleus. This is what happens in a supernova forming heavier elements than Iron with the process known as **supernova nucleosynthesis.**

Example:



The explosion of star or supernova is believed to be the source of other elements heavier than Iron. During the explosion, these heavy elements are dispersed into the space. Aside from gases Hydrogen and Helium in space, other evidence of star formation is the energy emitted during nuclear reaction. It is also the energy emitted by different forms of radiation such as UV, Infrared, X-ray, radio wave and microwave.



What's More

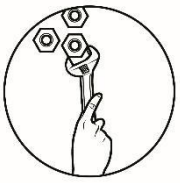
Match the terms in column **A** with its description in Column **B**

A	**B**
_____1. Alpha ladder process	There is faster rate of capturing neutron before it undergoes radioactive decay.
_____2. Big Bang Nucleosynthesis	Nuclear fusion that happens in red super giant star and creates heavier element such as Iron.
_____3. CNO cycle	It happens when there is a slow rate of capturing neutron while there is a faster rate of radioactive decay.
_____4. Neutron Capture	It is a process wherein light elements such as Helium and Hydrogen formed.
_____5. Proton- Proton Chain	This is how three Helium-4 is converted into Carbon in red giant star.
_____6. R- rocess	It is a process where elements heavier than Iron are formed.
_____7. S- process	It is a Nuclear fusion reaction where Hydrogen is converted to Helium
_____8. Stellar Nucleosynthesis	It is an addition of neutron to form heavier nuclei.
_____9.Supernova Nucleosynthesis	It is a process by which elements are created within the star.
_____10. Tri alpha process	This happens in massive star which converts Hydrogen into Helium.

What I Have Learned

Read the paragraph then fill in the blanks with the correct word/s.

It all starts with 1. _____, cloud of gas and dust particle in outer space. Due to the force of gravity, the 2. _____ gas is pulled together and eventually became a protostar. Nebular fusion occurs at the center of the protostar and becomes stable. During this time, hydrogen is converted into 3. _____ forming main sequence star. The size of the star can be average or massive. A massive main sequence star that runs out of hydrogen fuel will begin to expand and cool down. This is 4. _____, the biggest star in the universe. The red super giant continues to fuse with heavy elements and stops when 5. _____ is converted in the core of the star. At this point, red super giant will become a supernova after hundreds of years.



What I Can Do

Now, you have learned how stars are formed and evolve from one stage to another and its connection with heavy elements from Carbon through Iron. There are many processes that stars have to undergo before they evolve from one stage to another.

For your next task, you will write a story which relates the events of your life from past, present and future to the life cycle of a star. Use also those elements which could symbolize something or anything in your story. (Use another sheet of paper for this task).

_____
_____
_____
_____
_____
_____
_____
_____

Rubrics for Story of Your Life

Criteria	Excellent (5pts)	Fair (3pts)	Poor (1pt)
Overall effort	Work shows time, effort and neatness that enhances the overall written output.	Work shows time and effort put into it	Lacks effort and cleanliness
Background context	The student's output contains background and context and shows how world events have significantly affected his/her life.	The project contains discussion of world events but it is unclear how they have affected the student's life.	No background or contextual information is included.
Grammar and Spelling	The student does not commit error when it comes to grammar and spelling.	The student commits 1- 3 grammar mistakes and spelling.	The student commits more than 4 mistakes in grammar and spelling
Content	Student includes information about birth, friends, family, hobbies and is able to tie his/her story to the topic given.	Student includes very few details. Output is somewhat tied up with the topic	Information included is not related to the task or no attempt was made.

Assessment

Multiple Choice. Choose the letter of the best answer. Write the chosen letter on a separate sheet of paper.

1. Which of the following is **NOT** an evidence of star formation?
    a. hydrogen
    b. helium
    c. infrared Radiation
    d. rocks

2. Which process produced Star's energy?
    a. combustion
    b. decomposition
    c. nuclear fission
    d. nuclear fusion

3. Which of the following will sun's evolve when reaches the end of red giant phase?
    a. black hole
    b. supernova
    c. red super giant
    d. white dwarf

4. These are the biggest stars in the universe.
    a. main sequence star
    b. red giant
    c. red super giant
    d. white dwarf

5. Which of the following gases are major components of star?
    a. carbon and oxygen
    b. helium and carbon
    c. hydrogen and carbon
    d. hydrogen and helium

6. Which of the following statements is FALSE?
    a. The core of red giant star is made up of carbon
    b. The average star has shorter life span
    c. The more massive the star is the faster it burns its fuel
    d. No elements heavier than Iron can be produced in a massive star

7. Which is the first stage of a star's life cycle?
    a. black hole
    b. nebula
    c. protostar
    d. white dwarf

8. In main sequence star, Hydrogen fuses and converted to Helium and Helium is converted into _____ at its core.
    a. carbon
    b. iron
    c. neon
    d. silicon

9. This element is produced through Big Bang Nucleosynthesis second most abundant element in the universe.
    a. carbon
    b. helium
    c. hydrogen
    d. oxygen

10. What object is formed from gas and dust particles which are pulled together by gravity and no nuclear fusion has happened yet?
    a. nebula
    b. main sequence star
    c. protostar
    d. red supergiant star

11. Who stated that we are made of star stuff?
    a. Carl Sagan
    b. Edwin Hubble
    c. Galileo Galilei
    d. Stephen Hawking

12. What is the sign that a protostar will transform into the next stage?
    a. Protostar will transform when it starts to spin faster.
    b. Protostar will transform when it starts to glow.
    c. Protostar will transform when Hydrogen nuclear fusion begins.
    d. Protostar will transform when it increases temperature igniting the Hydrogen.

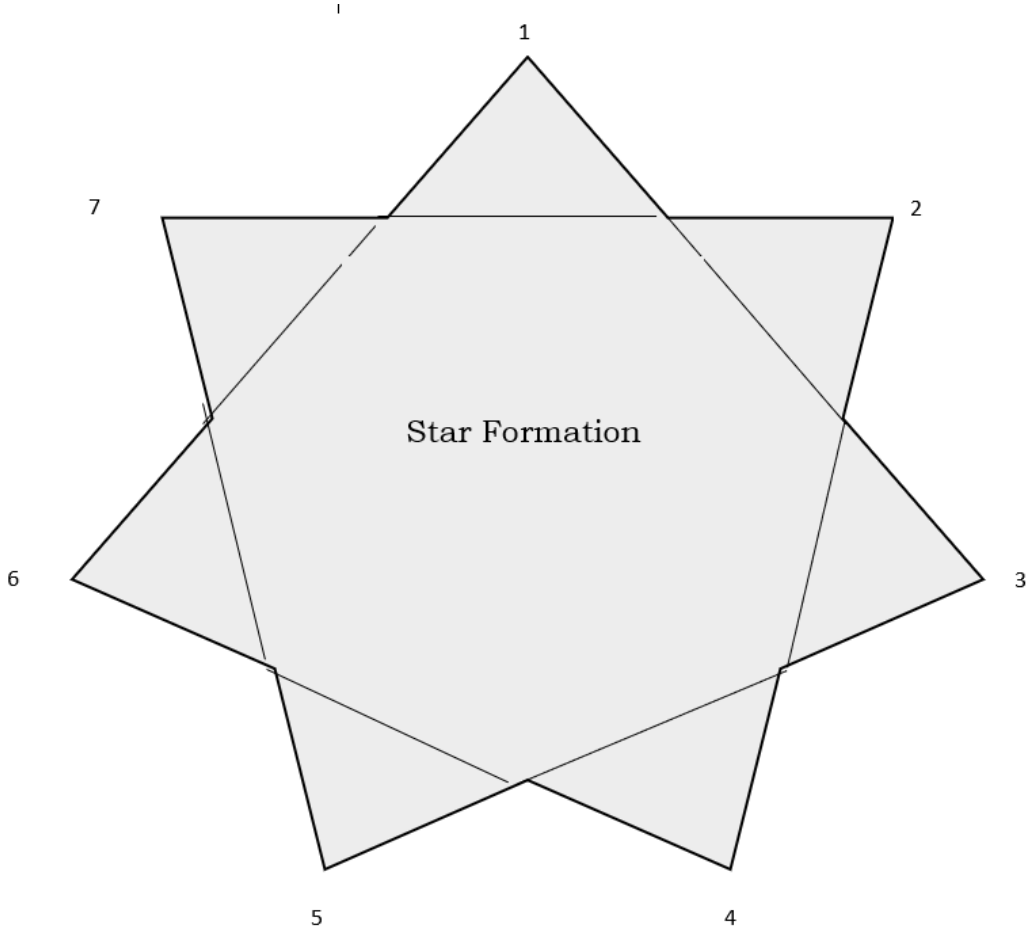
13. When does a star become unstable?
    a. Star become unstable when it runs out of fuel.
    b. Star become unstable when it contracts and expands.
    c. Star become unstable when its core is converted to Iron.
    d. Star become unstable when the outer shell of star is pulled by the gravity from the center.

14. Which fusion of elements does Iron come from?
    a. carbon fusion
    b. neon fusion
    c. magnesium fusion
    d. silicon fusion

15. This is a huge luminous ball of hot gas such as Hydrogen and Helium.
    a. comet
    b. moon
    c. planet
    d. star

Additional Activities

On this activity, you will see a star with the topic written on its center. Fill out the parts of the stars with all the concepts you have learned in this module.



Answer Key

What I Know

1. A
2. D
3. C
4. A
5. A
6. C
7. A
8. A
9. C
10. D
11. C
12. B
13. A
14. B
15. C

What's More

1. B

7. C
8. I
9. F
10. E

Assessment

1. D
2. D
3. D
4. C
5. D
6. B
7. B
8. A
9. B
10. C
11. A
12. C
13. A
14. D
15. D

What I Have Learned

2. Hydrogen
3. Helium
4. Red super giant
5. Iron

What's New

2. Protostar
3. Main sequence star
4. Red super giant
5. Supernova
6. Black hole
7. Neutron star
8. Red giant
9. White dwarf
10. Black dwarf

References

Dhaliwal, J and Moore,J. (n.d).Stellar Nucleosynthesis and The Periodic Table. Retrieved from https://earthref.org/SCC/lessons/2012/nucleosynthesis/#materials

National Aeroautics and Space Administration. (2015, May 7).Imagine the Universe. Retrieved from https://imagine.gsfc.nasa.gov/educators/lifecycles/LC_main_p2.html

The Elements: Forged in Stars.(n.d). Retrieved from https://www.pbslearningmedia.org/resource/ess05.sci.ess.eiu.fusion/the-elements-forged-in-stars/

Toogood, O (n.d).Hubbles Law and the Big Bang. Retrieved from http://www.alevelphysicsnotes.com/astrophysics/big_bang.html#

Cain, F. (2009, February 5). Red Super Giant Star. Retrieved from https://www.universetoday.com/
Quipper. (n.d). Nucleosynthesis: The beginning of Elements. Retrieved from https://link.quipper.com/en/organizations/547ff9a8d2b76d0002001cf8/curriculum#curriculum

Cantor, K. (n.d). Asrtonomy Portfolio. Retrived from https://sites.google.com/a/wnesu.com/astronomy-portfolio-kennycantor/big-bang-theory

Wiess, A. (2006). “Big Bang Nucleosynthesis: Cooking up the first Light Elements”. Retrieved from https://www.einstein-online.info/en/spotlight/bbn/

Strassler, M. (2013, March 4). What Holds Nuclei Together?. Retrived from https://profmattstrassler.com/articles-and-posts/particle-physics-basics/the-structure-of-matter/the-nuclei-of-atoms-at-the-heart-of-matter/what-holds-nuclei-together/

Esiegel. (2014, February 28). Burn Baby Burn! https://scienceblogs.com/startswithabang/2014/02/28/ask-ethan-26-burn-baby-burn

Canoy, W.Z. (2019, November 10). We Are all Made of Star Stuff. Retrieved from https://www.facebook.com/notes/physical-science/lesson-2-we-are-all-made-of-star-stuff-formation-of-the-heavy-elements/302463924088561 4/

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