

Senior High School

# Physical Science

## Quarter 1 – Module 1: Formation of Heavy Elements



**Personal Development  
Alternative Delivery Mode  
Quarter 1 – Module 1: Title  
First Edition, 2020**

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# **Physical Science**

## **Quarter 1 – Module 1:**

### **Formation of Heavy Elements**

# Introductory Message

For the facilitator:

Welcome to the Physical Science Alternative Delivery Mode (ADM) Module on  
Formation of Heavier Elements!

This module was collaboratively designed, developed and reviewed by educators both from public and private institutions to assist you, the teacher or facilitator in helping the learners meet the standards set by the K to 12 Curriculum while overcoming their personal, social, and economic constraints in schooling.

This learning resource hopes to engage the learners into guided and independent learning activities at their own pace and time. Furthermore, this also aims to help learners acquire the needed 21st century skills while taking into consideration their needs and circumstances.

In addition to the material in the main text, you will also see this box in the body of the module:



## ***Notes to the Teacher***

This contains helpful tips or strategies that will help you in guiding the learners.

As a facilitator, you are expected to orient the learners on how to use this module. You also need to keep track of the learners' progress while allowing them to manage their own learning. Furthermore, you are expected to encourage and assist the learners as they do the tasks included in the module.

For the learner:

Welcome to the Physical Science Alternative Delivery Mode (ADM) Module on Formation of Heavier Elements!

The hand is one of the most symbolic parts of the human body. It is often used to depict skill, action and purpose. Through our hands, we may learn, create and accomplish. Hence, the hand in this learning resource signifies that as a learner, you are capable and empowered to successfully achieve the relevant competencies and skills at your own pace and time. Your academic success lies in your own hands!

This module was designed to provide you with fun and meaningful opportunities for guided and independent learning at your own pace and time. You will be enabled to process the contents of the learning resource while being an active learner.

This module has the following parts and corresponding icons:



***What I Need to Know***

This will give you an idea of the skills or competencies you are expected to learn in the module.



***What I Know***

This part includes an activity that aims to check what you already know about the lesson to take. If you get all the answers correctly (100%), you may decide to skip this module.



***What's In***

This is a brief drill or review to help you link the current lesson with the previous one.



***What's New***

In this portion, the new lesson will be introduced to you in various ways such as a story, a song, a poem, a problem opener, an activity or a situation.



***What is It***

This section provides a brief discussion of the lesson. This aims to help you discover and understand new concepts and skills.



***What's More***

This comprises activities for independent practice to solidify your understanding and skills of the topic. You may check the answers to the exercises using the Answer Key at the end of the module.



***What I Have Learned***

This includes questions or blank sentence/paragraph to be filled in to process what you learned from the lesson.



### ***What I Can Do***

This section provides an activity which will help you apply your new knowledge or skill into real life situations or concerns.



### ***Assessment***

This is a task which aims to evaluate your level of mastery in achieving the learning competency.



### ***Additional Activities***

In this portion, another activity will be given to you to enrich your knowledge or skill of the lesson learned. This also tends retention of learned concepts.



### ***Answer Key***

This contains answers to all activities in the module.

At the end of this module you will also find:

### ***References***

This is a list of all sources used in developing this module.

The following are some reminders in using this module:

1. Use the module with care. Do not put unnecessary mark/s on any part of the module. Use a separate sheet of paper in answering the exercises.
2. Don't forget to answer *What I Know* before moving on to the other activities included in the module.
3. Read the instruction carefully before doing each task.
4. Observe honesty and integrity in doing the tasks and checking your answers.
5. Finish the task at hand before proceeding to the next.
6. Return this module to your teacher/facilitator once you are through with it.

If you encounter any difficulty in answering the tasks in this module, do not hesitate to consult your teacher or facilitator. Always bear in mind that you are not alone.

We hope that through this material, you will experience meaningful learning and gain deep understanding of the relevant competencies. You can do it!



## ***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:

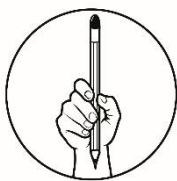
- Lesson 1 – Stellar Nucleosynthesis: Rise of the Stars!

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;
4. describe how heavier elements formed during stellar nucleosynthesis and evolution.



Have you also wondered what stars are made of? What keeps them shining 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. 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. Which of the following is the most accepted theory about the formation of the universe that explains why it continues to expand?
  - a. big bang theory
  - b. divine creation theory
  - c. steady state theory
  - d. oscillating theory
2. Which of the following is not considered as light elements?
  - a. helium
  - b. hydrogen
  - c. lithium
  - d. iron
3. Which of the following is TRUE about nucleosynthesis?
  - a. It is the division of atomic particle
  - b. The combination of elements to form compound
  - c. It is the creation of everything including all matter in universe
  - d. It is the process of creating new atomic nuclei from pre-existing nuclei
4. Which process is responsible for the formation of light elements such as Hydrogen and Helium?
  - a. big bang nucleosynthesis
  - b. stellar nucleosynthesis
  - c. supernova nucleosynthesis.
  - d. terrestrial nucleosynthesis
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. How do heavier elements formed?
  - a. Through combustion
  - b. Through nuclear fission
  - c. Through nuclear fusion
  - d. Through nuclear synthesis
7. Which 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. Which process is responsible for the formation of elements at the center of star?
- a. big bang nucleosynthesis
  - b. nuclear fusion
  - c. stellar nucleosynthesis
  - d. supernova nucleosynthesis
10. How Elements heavier than iron are formed?
- a. big bang nucleosynthesis
  - b. solar nucleosynthesis
  - c. stellar nucleosynthesis
  - d. supernova nucleosynthesis
11. Which element will be formed when Carbon atom is combined with Helium atom?
- a. magnesium
  - b. neon
  - c. oxygen
  - d. silicon
12. Why do average stars have longer life span than massive star?
- 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. Which phase of star life cycle is our sun?
- 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!**

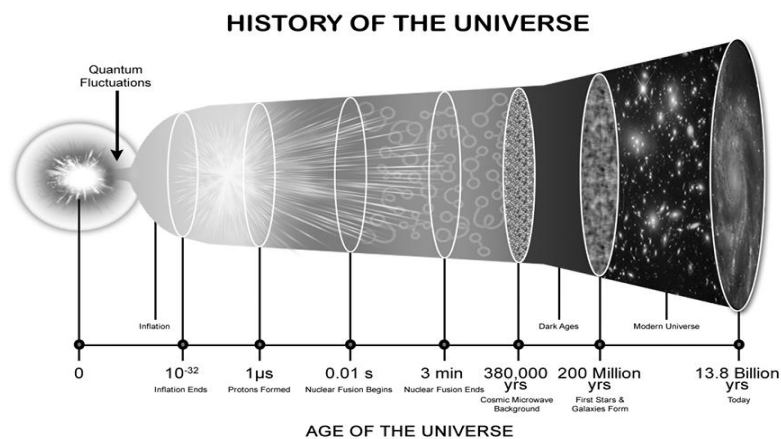
The world where we live today is just a small part of our universe. In your previous years, you have learned about the different theories of the origin of the universe that eventually led to the formation of galaxies, solar system and other heavenly bodies. This lesson will focus on one of those wonderful 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.



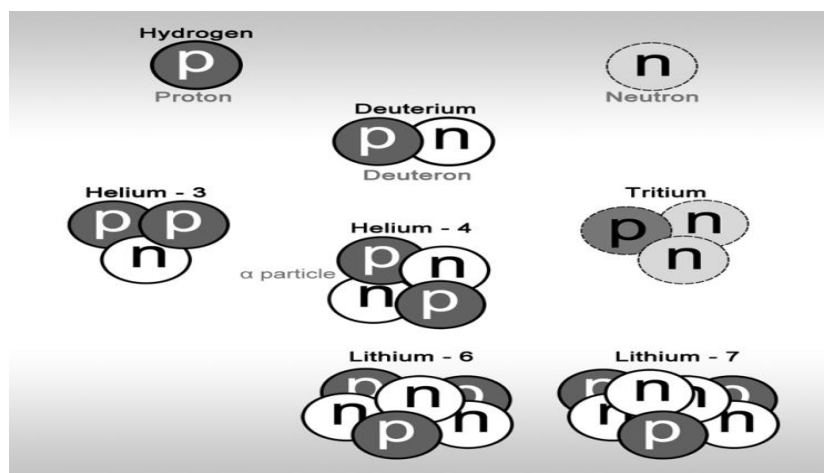


## What's In

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.



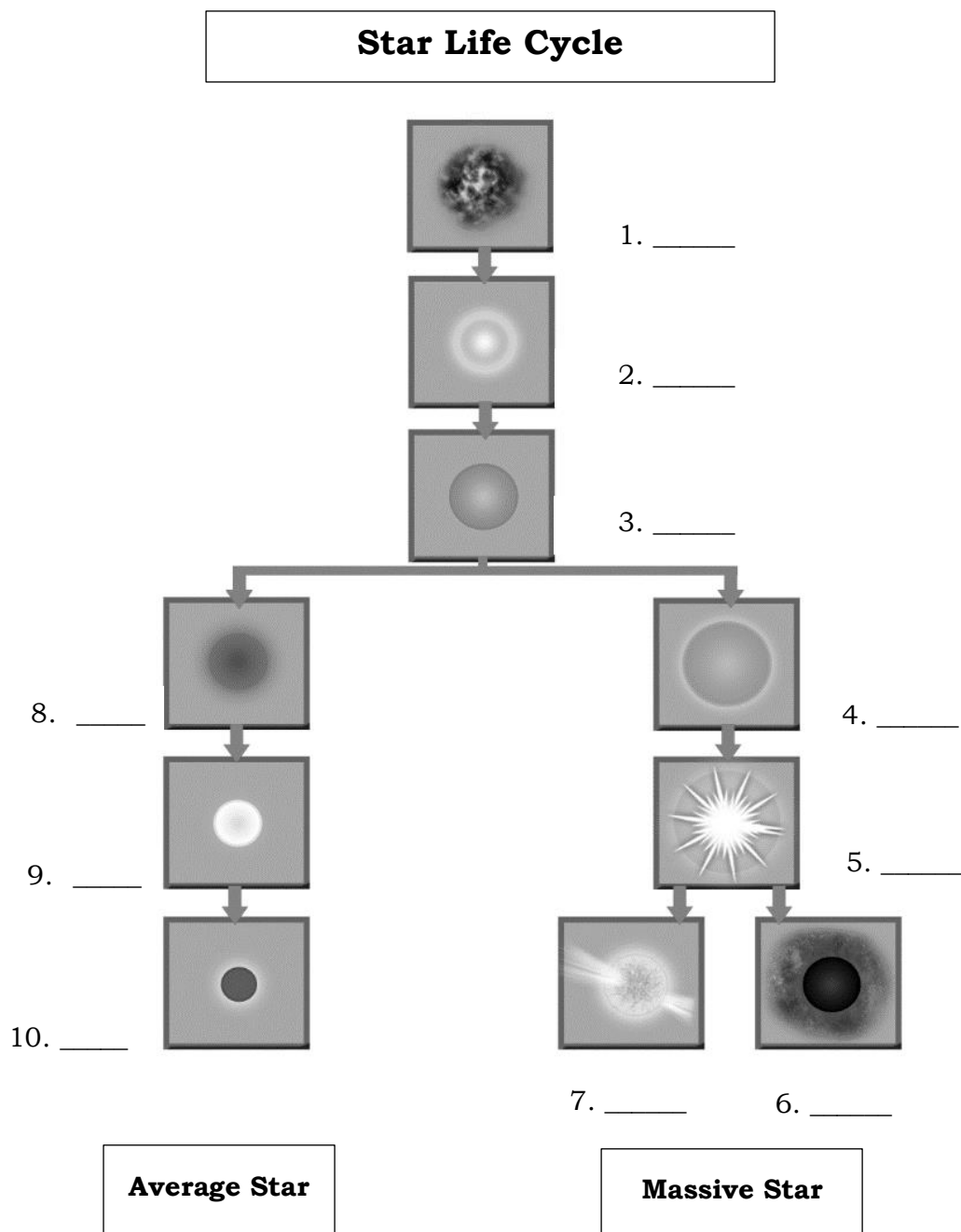


## What's New

### 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

1. 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**
2. 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**.
3. Giant cloud of gas and dust known as **NEBULA**.
4. 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.
5. **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.
6. 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

1. It is believed that a **NEUTRON STAR** is formed from supernova explosion. This is also the smallest star
2. Explosion of star or **SUPERNOVA** releases large amount of energy. Because of that, elements are dispersed into the space.
3. **BLACK HOLE** is a region in space where gravity is too strong that no matter can escape from it.
4. 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***

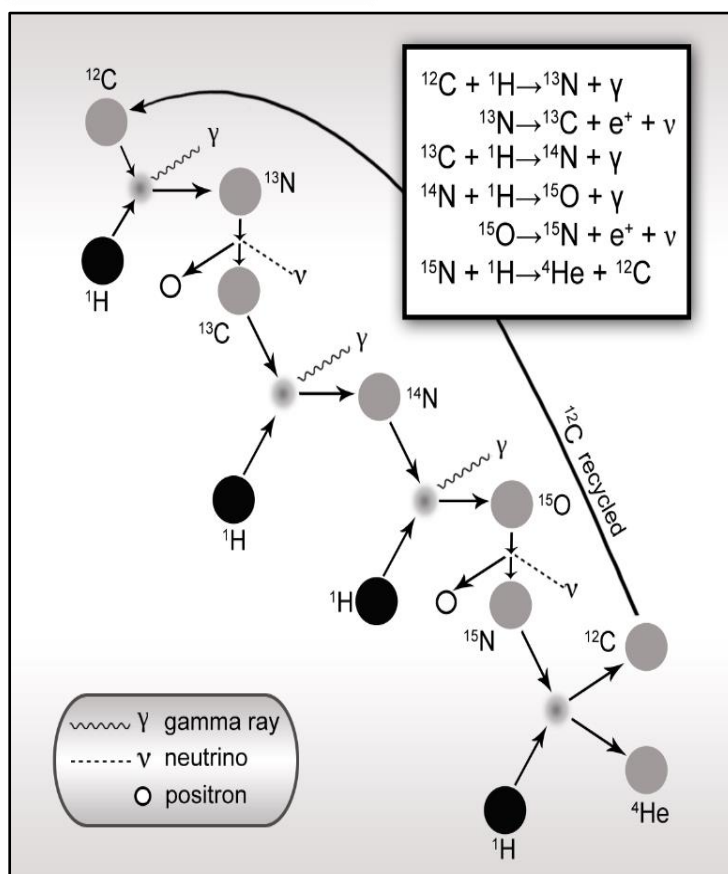
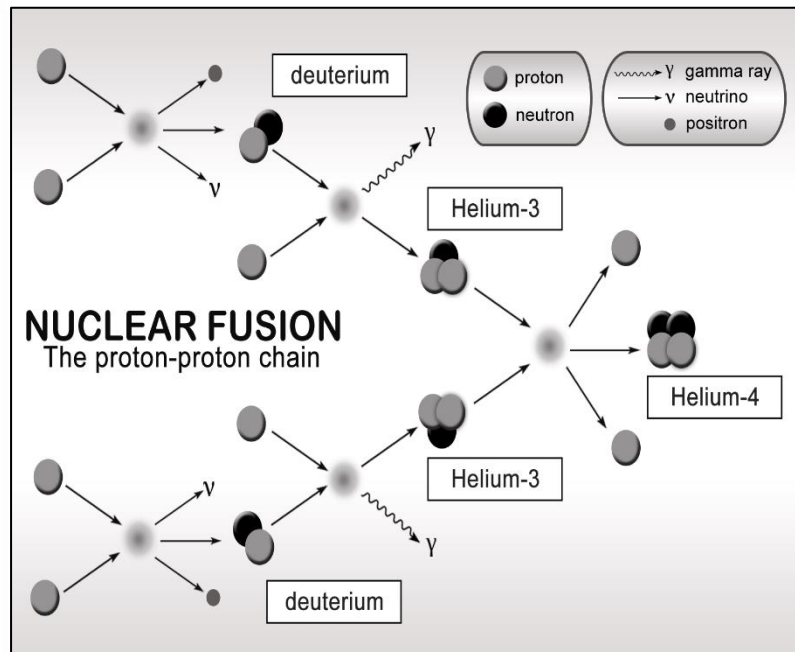
Were you able to label all the stages of star? Review the hints/clues in the previous activity. You will notice that following the sequence will reveal what happens in each stage of star.

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?  
\_\_\_\_\_

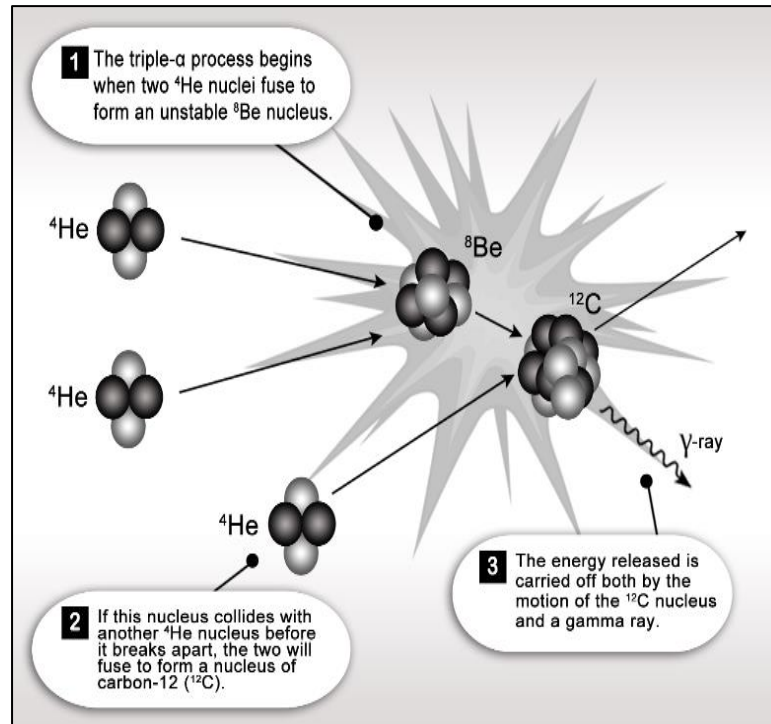
Look at the diagrams below. These will explain how stars are formed into different stages because of nuclear fusion (combination of nuclei to form heavier one) among heavy elements.

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**.

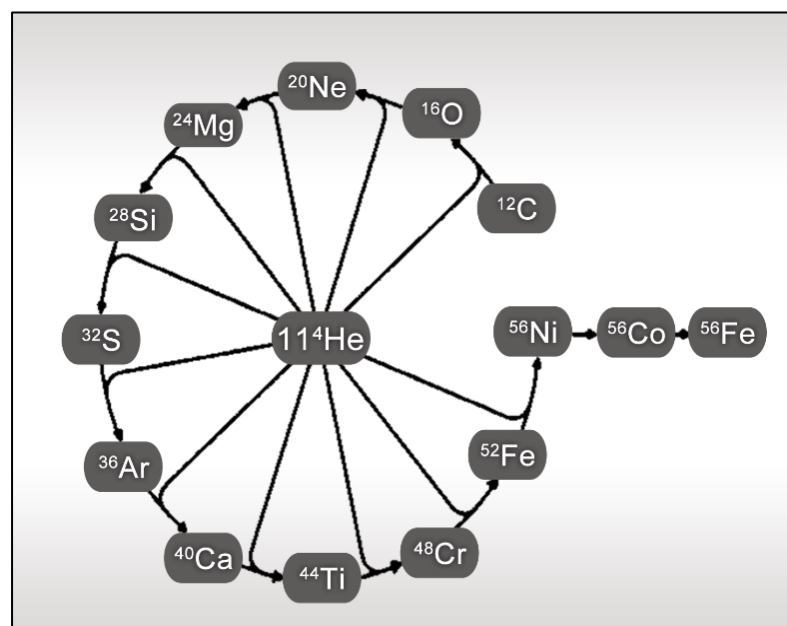


Case is different in massive star or star eight times larger than solar mass. They undergo **CNO (Carbon, Nitrogen, Oxygen) cycle** to convert Hydrogen into Helium. You can see at the right how Carbon 12 fused with proton (H) and form Nitrogen-13. Nitrogen-13 undergoes beta decay to form Carbon-13. Carbon-13 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.



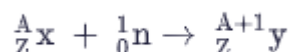
A star accumulates more mass and continues to grow into red super giant. Alpha particle fusion happens at its core and creates more heavy elements until Iron. This is known as the **Alpha ladder process**.



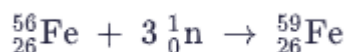


How do elements heavier than Iron form? As the energy at the core of the star decreases, nuclear fusion cannot produce elements higher than Iron. Different pathway is needed for heavier elements to be formed.

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



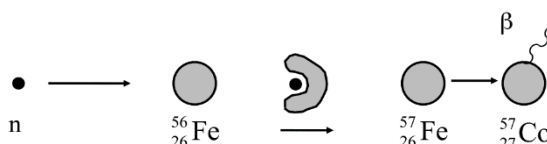
Example:



Neutron capture can be slow or rapid;

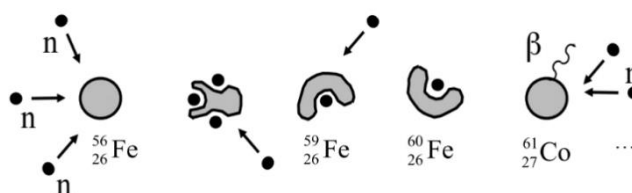
- a. **S-process or slow process** happens when there is a slow rate of capturing neutron while there is a faster rate of radioactive decay hence increasing the proton by 1.

Example:

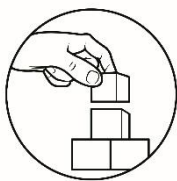


- b. **R-process or rapid process** means that there is faster rate of capturing neutron before it undergoes radioactive decay thus, more neutrons can be combined at the nucleus. This is what happens in a supernova forming heavier elements than Iron with the process known as **supernova nucleosynthesis**.

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**

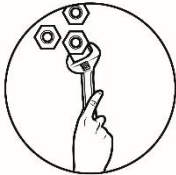
A	B
_____ 1. Alpha ladder process	a. There is faster rate of capturing neutron before it undergoes radioactive decay
_____ 2. Big bang nucleosynthesis	b. Nuclear fusion that happens in red super giant star and creates more heavy elements until Iron.
_____ 3. CNO cycle	c. Happens when there is a slow rate of capturing neutron while there is a faster rate of radioactive decay
_____ 4. Neutron capture	d. Process wherein light elements such as Helium and Hydrogen form.
_____ 5. Proton- proton chain	e. This is how three Helium-4 is converted into Carbon in red giant star
_____ 6. R- process	f. A process where elements heavier than Iron are formed.
_____ 7. S- process	g. Nuclear fusion reaction where Hydrogen is converted to Helium
_____ 8. Stellar Nucleosynthesis	h. Addition of neutron to form heavier nuclei
_____ 9. Supernova Nucleosynthesis	i. Process by which elements are created within the star
_____ 10. Tri alpha process	j. This happens in massive star which convert 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).

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### Rubrics for Story of Your Life

<b>Criteria</b>	<b>Excellent (5pts)</b>	<b>Fair ( 3pts)</b>	<b>Poor (1pt)</b>
<b>Overall effort</b>	Work shows time, effort and neatness that enhances the overall written output.	Work shows time and effort put into it	Lacks effort and cleanliness
<b>Background context</b>	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.
<b>Grammar and Spelling</b>	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
<b>Content</b>	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.

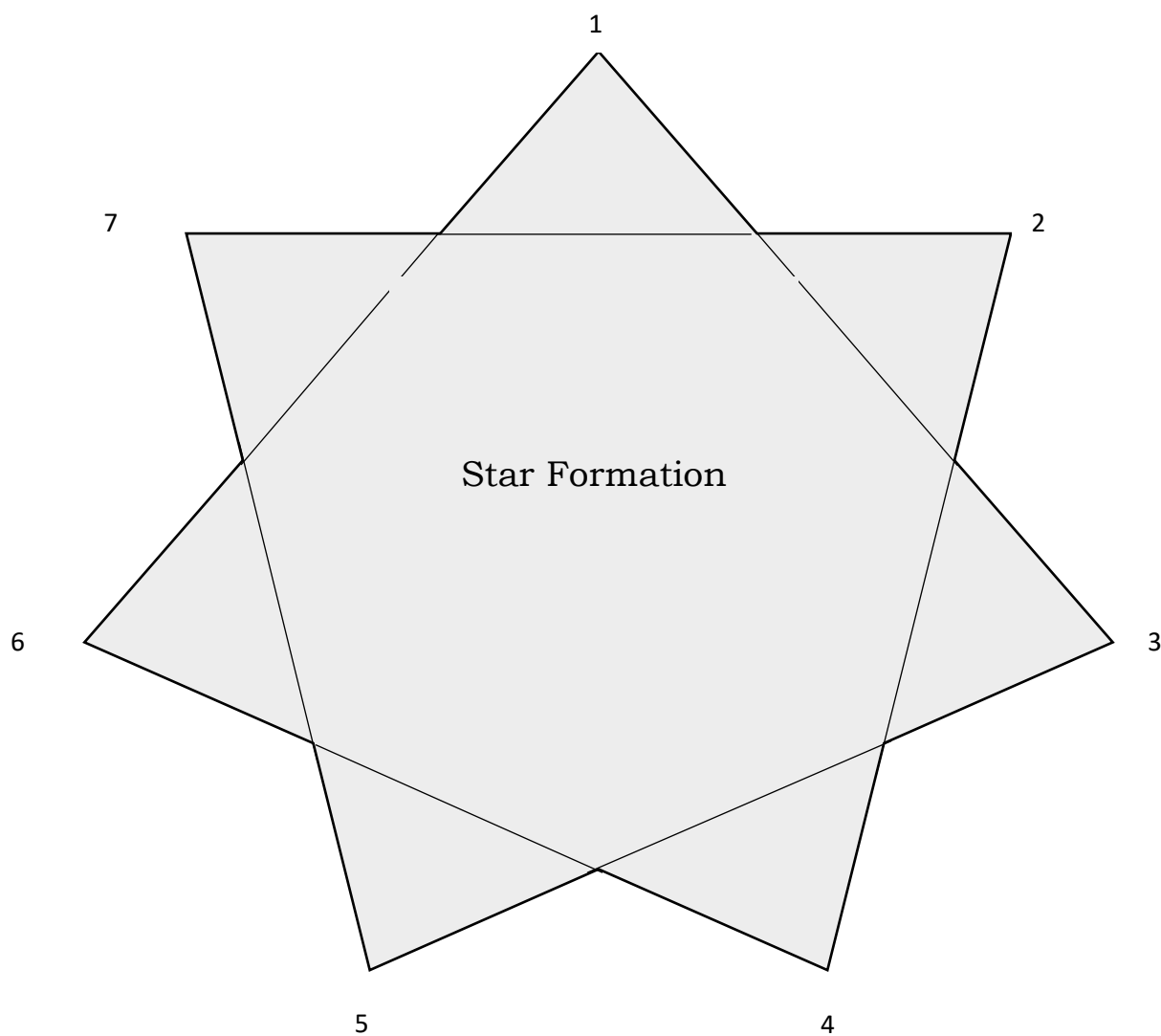
1. Which of the following is **NOT** an evidence of star formation?
  - a. hydrogen
  - b. helium
  - c. infrared Radiation
  - d. rocks
2. How is the energy of star produced?
  - a. By combustion
  - b. By decomposition
  - c. by nuclear fission
  - d. by nuclear fusion
3. Which phase of star will be created after the end of red giant?
  - a. black hole
  - b. red super giant
  - c. supernova
  - d. white dwarf
4. Which is known as 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. What element is produced from Helium gas at its core??
  - a. carbon
  - b. iron
  - c. neon
  - d. silicon

9. Which is the 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. Which of the following is the sign that a protostar will transform into the next stage?
- a. When it starts to spin faster
  - b. When it starts to glow
  - c. When Hydrogen nuclear fusion begins
  - d. When it increases temperature igniting the Hydrogen
13. When does a star become unstable?
- a. When it runs out of fuel
  - b. When it contracts and expands
  - c. When its core is converted to Iron
  - d. 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. Which 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***

<b>What I Know</b> 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	<b>What's More</b> 4. B 2. D 3. J 4. H 5. G 6. A 7. C 8. I 9. F 10. E	<b>Assessment</b> 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
<b>What I Have Learned</b> 1. Nebula 2. Hydrogen 3. Helium 4. Red super giant 5. Iron	<b>What's New</b> 1. Nebula 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	



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