Science & Literacy Activity

GRADES 9-12

OVERVIEW

This activity, which is aligned to the Common Core State Standards (CCSS) for English Language Arts, introduces students to scientific knowledge and language related to the life cycles of stars. Students will read content-rich texts, visit the Cullman Hall of the Universe and use what they have learned to complete a CCSS-aligned writing task, creating an illustrated text about the life cycles of stars.

Common Core State Standards:
WHST.9-12.2, WHST.9-12.8, WHST.9-12.9
RST.9-12.1, RST.9-12.2, RST.9-12.7, RST.9-12.10

New York State Science Core Curriculum:
PS 1.2b

Next Generation Science Standards:
PE HS-ESS1-1
DCI ESS1.A: The Universe and Its Stars
The star called the Sun is changing and will burn out over a lifespan of approximately 10 billion years.

Materials in this activity include:

- Teacher instructions for:
    - o Pre-visit student reading
    - o Visit to the Cullman Hall of the Universe and student worksheet
    - o Post-visit writing task
- Text for student reading: "The Life Cycle of Stars "
- Student Worksheet for the Cullman Hall of the Universe visit
- Student Writing Guidelines
- Teacher rubric for writing assessment

SUPPORTS FOR DIVERSE LEARNERS: An Overview
This resource has been designed to engage all learners with the principles of Universal Design for Learning in mind. It represents information in multiple ways and offers multiple ways for your students to engage with content as they read about, discuss, view, and write about scientific concepts. Different parts of the experience (e.g. reading texts, or locating information in the hall) may challenge individual students. However, the arc of learning is designed to offer varied opportunities to learn. We suggest that all learners experience each activity, even if challenging. We have provided ways to adapt each step of the activities for students with different skill-levels. If any students have an Individualized Education Program (IEP), consult it for additional accommodations or modifications.

1. BEFORE YOUR VISIT

This part of the activity engages students in reading a non-fiction text about the life cycle of stars. The reading will prepare students for their visit by introducing them to the topic and framing their investigation.

Student Reading
Have students read "The Life Cycle of Stars." Have them write notes in the large right-hand margin. For example, they could underline key passages, paraphrase important information, or write down questions that they have. They may also use this space for drawings or diagrams of relevant processes.

In pairs, small groups, or as a class, have students create a graphic organizer to compare and contrast the life cycles of different types of stars from the reading; refer to the included flow chart as an example of how students might organize this information. Ask them: "How does the mass of a star at its formation affect its life cycle?" During discussion, remind students to use textual evidence to explain their thinking and to use precise language, including vocabulary such as *fusion, gravity, energy, mass*, and *rate*. Have students use context clues to define any unfamiliar vocabulary in the text.

After they have created their graphic organizers, have students discuss the role that gravity plays in every step of the processes they described in stars' formation and evolution, inserting that information in their organizers as appropriate.

SUPPORTS FOR DIVERSE LEARNERS: Student Reading

- "Chunking" the reading can help keep them from becoming overwhelmed by the length of the text. Present them with only a few sentences or a single paragraph to read and discuss before moving on to the next "chunk."
- Provide "wait-time" for students after you ask a question. This will allow time for students to search for textual evidence or to more clearly formulate their thinking before they speak.
- Review a partially-developed graphic organizer to show students as a model of how to organize their independent work.

2. DURING YOUR VISIT

This part of the activity engages students in exploring the hall.

Museum Visit & Student Worksheet

Explain to students that they will using worksheets to gather all the necessary information about gravity's role in the formation and evolution of celestial objects. Tell students that back in the classroom they will refer to these notes when completing the writing assignment.

SUPPORTS FOR DIVERSE LEARNERS: Museum Visit

- Review the Student Worksheet with students, clarifying what information they should collect during the visit.
- Have students explore the hall in pairs, with each student completing their own Student Worksheet.
- Encourage student pairs to ask you or their peers for help locating sources of information. Tell students they may not share answers with other pairs, but they may point each other to places in the hall where answers may be found.

3. BACK IN THE CLASSROOM

This part of the activity is to engage students in an informational writing task that draws on the pre-visit reading and on observations made at the Museum.

Writing Task

Distribute the Student Writing Guidelines handout, which includes the following prompt for the writing task:

> Based on the article "The Life Cycle of Stars," your visit to the Cullman Hall of the Universe, and your post-visit discussion, write an essay in which you describe the role of gravity in the evolution of stars and other objects in the universe.
>
> Be sure to:
> - compare and contrast the life cycles of at least two types of stars
> - describe the formation and evolution of an astronomical object or structure other than a star
> - describe an interaction among two astronomical objects
>
> Support your discussion with evidence from the reading "The Life Cycle of Stars" and the Cullman Hall of the Universe.

Go over the handout with students. Tell them that they will use it while writing, and afterwards, to evaluate and revise their essays.

Before they begin to write, have students use the prompt and guidelines to frame a discussion around the information that they gathered in the Cullman Hall of the Universe, and compare their findings. They can work in pairs, small groups, or as a class. Referring to the writing prompt, have students underline or highlight all relevant passages and information from the reading, the charts they created, and their notes from the hall that can be used in their response to the prompt. Instruct each student to take notes on useful information that their peers gathered as they compare findings. Students should write their essays individually.

SUPPORTS FOR DIVERSE LEARNERS: Writing Task

- Re-read the "Before Your Visit" assignment with students. Ask what they saw in the hall that helps them understand star formation and evolution.
- Allow time for students to read their essay drafts to a peer and receive feedback based on the Student Writing Guidelines.

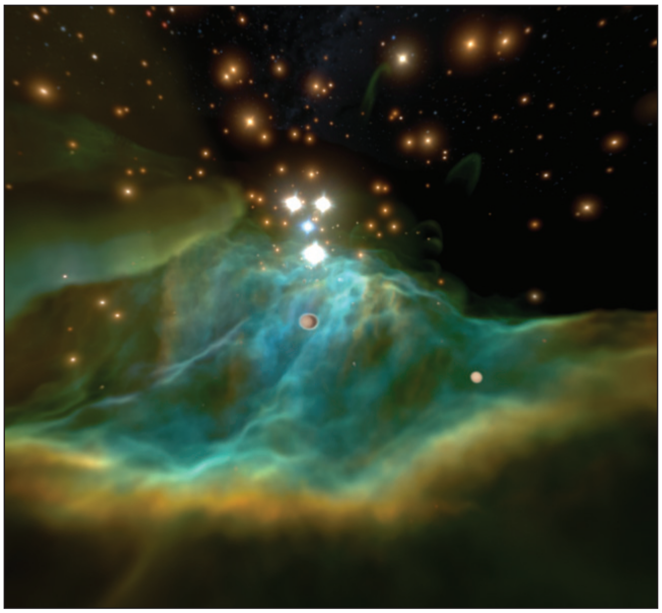
Student Reading

The Life Cycle of Stars

Text adapted from *One Universe: At Home in the Cosmos* by Neil de Grasse Tyson, Charles Tsun-Chu Liu, and Robert Irion. Joseph Henry Press, 1999.

Stars Are Born

At the beginning of our universe was the Big Bang. After that event, light elements made up most of the matter in the young universe. About 75% of the matter was hydrogen. Helium made up roughly the other 25%. Pockets of matter began to attract to each other because of their gravity. This slow process probably took several million years. But in time, these pockets of matter became very large and very hot. They got dense enough at their cores to begin the process of fusion, eventually becoming stars like our Sun.



Scientists find huge stellar nurseries like the Orion Nebula throughout the Milky Way Galaxy and the universe today.

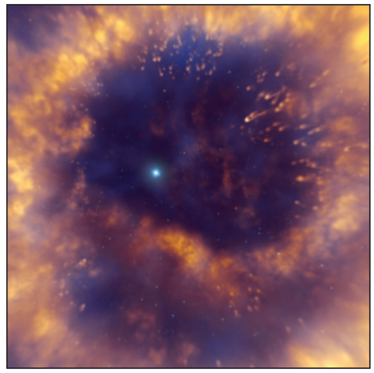
So how did this happen? Fusion occurs when light elements such as hydrogen combine to form heavier elements. In the early universe, this was possible because light elements were everywhere. Hydrogen atoms in the cores of developing stars collided with each other. They fused together into new atoms of helium. When elements fuse, they lose a small amount of matter. But this small amount of matter equals a large amount of energy.

That energy flowed out from the cores of the newborn stars. It provided the heat and pressure needed to counter-balance the inward force of gravity. This constant balancing act between gravity and nuclear fusion is how adult stars live their lives.

Types of Stars

All stars are born, mature, and eventually die. A star's mass is the main factor that determines how it will live and die. There are three main types of stars: low mass, intermediate mass, and high mass.

Low-Mass Stars
Low mass stars are less massive than our Sun. Because they are smaller, less energy is required to maintain the balance between gravity and fusion. Therefore these stars have a slow fusion rate. They are able to ration their energy supply for hundreds of billions of years before losing their outer layers and dying as white dwarfs. White dwarfs are very dense, and about the size of Earth. 99% of all stars in existence end their lives as a white dwarf.



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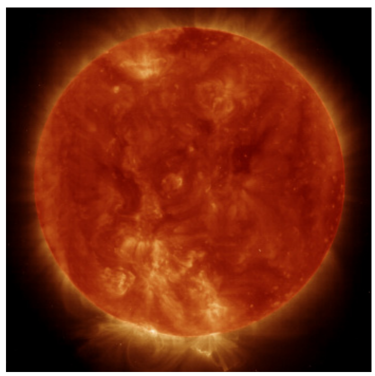
Scientists observe the remains of stars, like the Helix Nebula, within which the star's core has already contracted into an extremely dense white dwarf.

Intermediate-Mass Stars
Intermediate mass stars range in size from our Sun up to 10 times our Sun's mass. Their fusion rate is only slightly higher than low mass stars. This means that intermediate mass stars fuse hydrogen in their cores for billions of years. Eventually, their outer layers swell until the stars become red giants. At that point, the stars eject their outer layers and their interiors collapse into white dwarfs. The white dwarf cores cool down over billions more years.



© NASA

Our star, the Sun, is a middle-aged yellow star that is more massive than the average star.

High-Mass Stars
There are two kinds of high-mass stars. Both kinds burn their fuel at a furious rate. Their lives are over in less than 100 million years. At the end of that lifetime, high mass stars that range from 10-20 times the mass of the Sun swell to become red supergiants. Soon after, they begin to shed their stellar matter. These stars collapse in on themselves, causing them to blow apart in explosions called supernovas. Their cores become neutron stars. Neutron stars are extremely dense remnants of the massive stars that are now about the size of a city. They take millions of years to cool down.

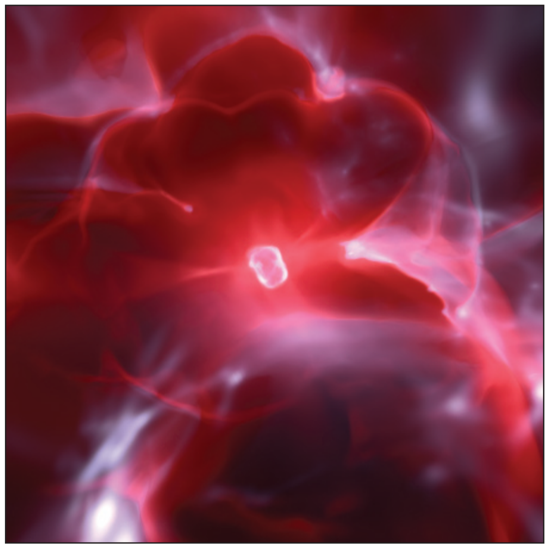
The most massive stars range from 20-100 times the Sun's mass. These red or yellow supergiants also undergo a catastrophic gravitational collapse. But when they explode as supernovas, they leave behind black holes instead of neutron stars. Black holes are objects so dense that not even light can escape their gravity!

Not Quite Stars

Some objects in the universe never quite become stars. These objects, about 10% the size of our Sun, are known as brown dwarfs. Brown dwarfs can achieve only a limited nuclear fusion. They fuse just the heavy hydrogen called deuterium, and only for a brief period of millions of years. After this fuel runs out, the brown dwarf simply cools down over billions of years.

Supernovas

As we have seen, most stars use their energy supply for billions of years before they run out of fuel. For instance, our own Sun should burn for another 10 billion years. Massive stars, however, live fast and die young. Their inward gravitational forces are so strong that they need to burn fuel at a breakneck pace just to support their weight. Their stores of hydrogen dwindle in just a few tens of millions of years, a cosmic blink of an eye.



Massive stars live fast and die young in supernova explosions (white region in center).

In these massive stars, the lighter elements fuse into heavier elements more quickly. Helium fuses to create carbon, carbon changes to oxygen and neon, oxygen becomes silicon, and silicon creates iron. Iron is the end of the line. Its fusion absorbs energy rather than releasing it. At that point the energy output from the star's core drops quickly, and gravity takes over. The star's outer layers rush inward. Within seconds the core collapses and unleashes a tremendous shock wave that destroys the rest of the star.

These events, called supernovas, happen about once a century in our Milky Way Galaxy. They occur about once a second in the whole universe. When a supernova explodes, it blasts 100 times more energy into the universe within ten seconds than its star released over an entire lifetime! This giant burst of energy triggers amazing changes. The star's elements instantly combine with free protons and neutrons. When they do, heavy elements such as cobalt, copper, gold, and uranium are created. The next time you see someone wearing gold jewelry, you will know that it came from a star that exploded in our galactic neighborhood long ago.

When massive stars blow up, they scatter their atoms into space. When that happens, the amount of heavy elements in their galaxy increases. So stars continue to convert the universe's original supply of hydrogen and helium into the many other elements that fill out the periodic table.

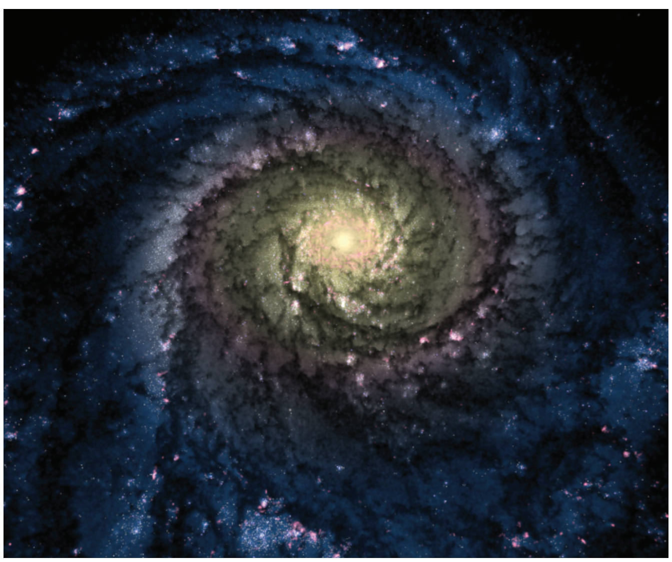
But don't worry; the cosmos won't run out of fuel any time soon. Even after 13 billion years, stars have burned much less than 1% of the available hydrogen and helium. New stars will continue to form for hundreds of billions of years. Eventually, however, the rate at which stars are created will decrease as the universe grows older and the matter within it spreads out.

Stellar Clues About Our Galaxy

Astronomers can chart small changes in solar ingredients to learn how our Milky Way galaxy has evolved. Newborn stars have the highest percentage of heavy elements. That is because they are created from matter already burned and ejected by many other stars. Old stars have only very light elements such as hydrogen and helium. We can determine what elements are present in given star by analyzing the light it gives off.

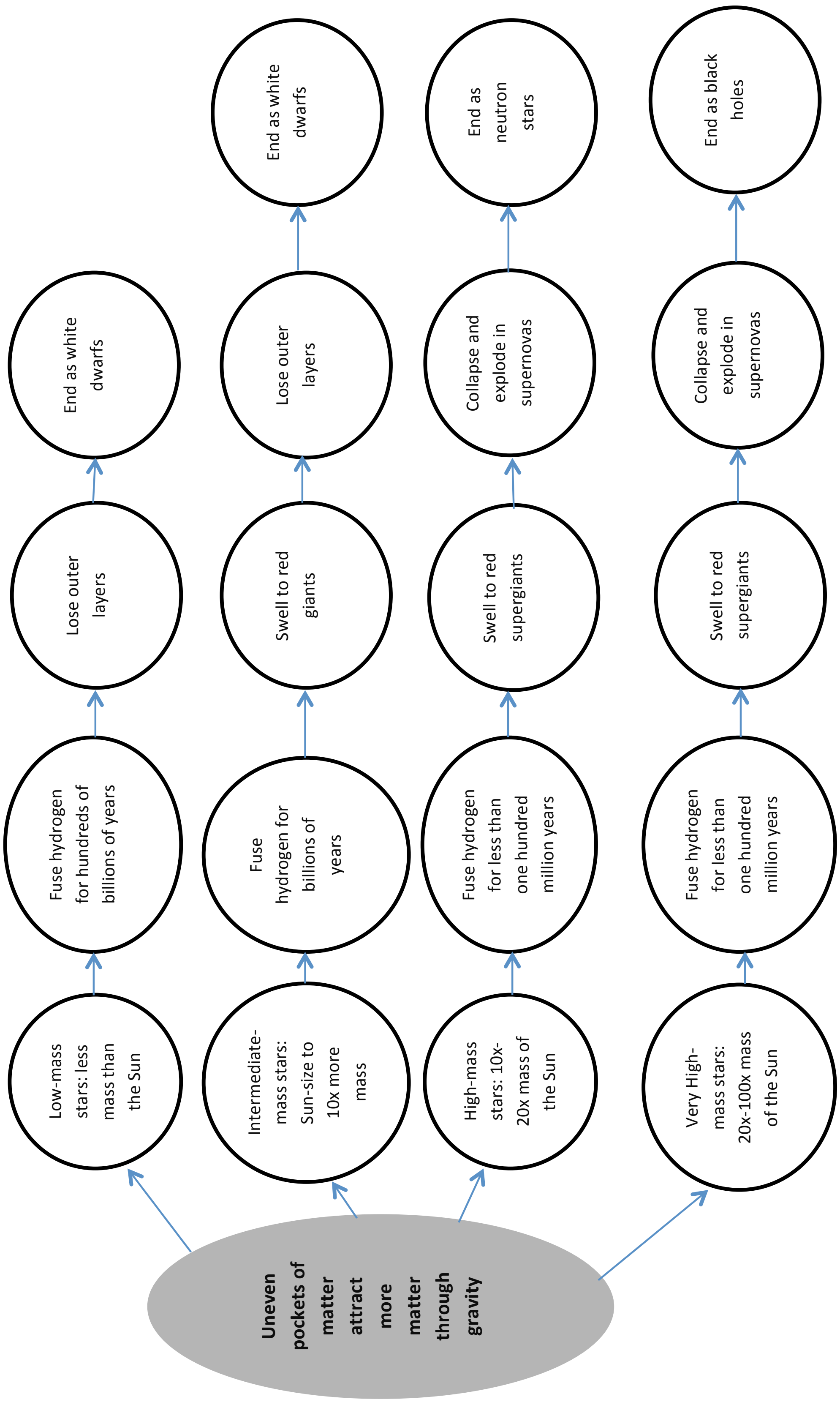
Surveys of the Milky Way show that the galaxy's youngest stars are located in its gas-rich spiral arms. The Orion Nebula (a huge cloud of gases) and its four enormous baby stars inhabit an arm of that Milky Way next to our own arm. Together, these stars are called the Trapezium.

The oldest stars live in globular clusters, swarms of perhaps 100,000 suns that surround the center of the galaxy like moths around a street lamp. These stars are among the most ancient objects known. Their ages rival that of the universe. We have yet to spot any stars that contain no heavy elements at all. If we see such objects, we will have found survivors from the first generation of stars after the Big Bang itself.



Our Milky Way Galaxy is about 10 billion years old.

Sample Flow Chart of Star Life Cycles



Student Worksheet

Visit the following areas of the Cullman Hall of the Universe and answer the questions below.

Universe Wall: Active Galaxies and Black Holes

What evidence do we have that the force of gravity is universal?

What do Newton's and Einstein's descriptions of gravity have in common?

Galaxy Wall: Formation and Evolution of Galaxies and Interactive Galaxies

What is gravity's role in the structures of galaxies?

What is gravity's role in galaxies' interactions with one another?

Stars Wall: Formation and Evolution of Stars, Our Star: the Sun, and Supernovas

What is gravity's role in the formation of stars?

What is gravity's role in a star's life cycle?

Planets Wall: Formation of Our Solar System and Planetary Impacts

What is gravity's role in the formation of planets?

What is gravity's role in motions within our solar system?

ANSWER KEY

Student Worksheet

Visit the following areas of the Cullman Hall of the Universe and answer the questions below.

Universe Wall: Active Galaxies and Black Holes

What evidence do we have that the force of gravity is universal?
(Observations of objects in the universe, both close by and far away, move according to the same laws we observe on Earth.)

What do Newton's and Einstein's descriptions of gravity have in common?
(They both relate to the mass of objects and distances between them.)

Galaxy Wall: Formation and Evolution of Galaxies and Interactive Galaxies

What is gravity's role in the structures of galaxies?
(Galaxies are made up of millions to trillions of stars orbiting their common center of gravity. Gravity also holds galaxies in groups called "clusters". The gravitational influence of mysterious "dark matter" is necessary to hold galaxies and galaxy clusters together.)

What is gravity's role in galaxies' interactions with one another?
(Gravity causes galaxies to collide — either a larger galaxy "consumes" a smaller one, or two similar-sized galaxies combine to form a new galaxy of a different shape.)

Stars Wall: Formation and Evolution of Stars, Our Star: the Sun, and Supernovas

What is gravity's role in the formation of stars?
(Stars are formed in gas clouds called star forming regions, when dense pockets of material have enough gravity to cause the material to collapse.)

What is gravity's role in a star's life cycle?
(The gravitational collapse results in high temperature and pressure. A more massive star's higher gravity results in higher temperature and pressure, which causes the star to fuse its elements more quickly in a shorter life cycle.)

Planets Wall: Formation of Our Solar System and Planetary Impacts

What is gravity's role in the formation of planets?
(Gravity is what causes accretion — objects attracting more material as they become more massive. Planets are objects that become massive enough for gravity make them spherical.)

What is gravity's role in motions within our solar system?
(Gravity governs all the orbital motions in our solar system — the orbits of planets around the Sun, and moons around planets. An orbit is a stable curved trajectory of an object around another more massive object. The initial gravitational collapse of the material in our solar system results in all of the objects rotating.)

Student Writing Guidelines

Based on the article "The Life Cycle of Stars," your visit to the Cullman Hall of the Universe, and your post-visit discussion, write an essay in which you describe the role of gravity in the evolution of stars and other objects in the universe.

Be sure to:
- compare and contrast the life cycles of at least two types of stars
- describe the formation and evolution of an astronomical object or structure other than a star
- describe an interaction among two astronomical objects

Support your discussion with evidence from the reading "The Life Cycle of Stars" and the Cullman Hall of the Universe.

Use this checklist to ensure that you have included all of the required elements in your essay.

- [ ] I introduced the topic of stellar life cycles.
- [ ] I clearly named gravity and described its role in the evolution of stars and other objects in the universe.
- [ ] I only included relevant information about the role of gravity in the evolution of stars and other objects in the universe.
- [ ] I used information from "The Life Cycle of Stars" to explain the role of gravity in the evolution of stars and other objects in the universe.
- [ ] I used information from the Cullman Hall of the Universe to explain the role of gravity in the evolution of stars and other objects in the universe.
- [ ] I used academic, non-conversational tone and language.
- [ ] I included a conclusion at the end.
- [ ] I proofread my essay for grammar and spelling errors.

Assessment Rubric

	Scoring Elements	1 Below Expectations	2 Approaches Expectations	3 Meets Expectations	4 Exceeds Expectations
RESEARCH	Reading	Attempts to present information in response to the prompt, but lacks connections to the texts or relevance to the purpose of the prompt.	Presents information from the text relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the text relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the text.
	AMNH Exhibit	Attempts to present information in response to the prompt, but lacks connections to the Museum exhibit content or relevance to the purpose of the prompt.	Presents information from the Museum exhibit relevant to the purpose of the prompt with minor lapses in accuracy or completeness.	Presents information from the Museum exhibit relevant to the prompt with accuracy and sufficient detail.	Accurately presents information relevant to all parts of the prompt with effective paraphrased details from the Museum exhibit.
WRITING	Focus	Attempts to address the prompt, but lacks focus or is off-task.	Addresses the prompt appropriately, but with a weak or uneven focus.	Addresses the prompt appropriately and maintains a clear, steady focus.	Addresses all aspects of the prompt appropriately and maintains a strongly developed focus.
	Development	Attempts to provide details in response to the prompt, including retelling, but lacks sufficient development or relevancy.	Presents appropriate details to support the focus and controlling idea.	Presents appropriate and sufficient details to support the focus and controlling idea.	Presents thorough and detailed information to strongly support the focus and controlling idea.
	Conventions	Attempts to demonstrate standard English conventions, but lacks cohesion and control of grammar, usage, and mechanics.	Demonstrates an uneven command of standard English conventions and cohesion. Uses language and tone with some inaccurate, inappropriate, or uneven features.	Demonstrates a command of standard English conventions and cohesion, with few errors. Response includes language and tone appropriate to the purpose and specific requirements of the prompt.	Demonstrates and maintains a well-developed command of standard English conventions and cohesion, with few errors. Response includes language and tone consistently appropriate to the purpose and specific requirements of the prompt.
SCIENCE	Content Understanding	Attempts to include science content in explanations, but understanding of the topic is weak; content is irrelevant, inappropriate, or inaccurate.	Briefly notes science content relevant to the prompt; shows basic or uneven understanding of the topic; minor errors in explanation.	Accurately presents science content relevant to the prompt with sufficient explanations that demonstrate understanding of the topic.	Integrates relevant and accurate science content with thorough explanations that demonstrate in-depth understanding of the topic.