

Sun Life Cycle

Build evidence-based models of a star's lifetime and energy.

HIGH SCHOOL • HS-ESS1-1

HS-ESS1-1 "Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation..."

NAME _____

DATE _____

FUEL, TIME, AND ENERGY

The Sun formed about 4.6 billion years ago and has roughly 5 billion more years of core hydrogen fusion. Hydrogen becomes helium, releasing energy. Fusion releases far more energy per mass than chemical burning; chemical fuel cannot explain billions of years of sunlight. Energy moves outward by radiation and convection, then crosses space as electromagnetic radiation.

WORKED EXAMPLE

Does more mass always mean a longer stellar lifetime?

STAR LIFETIMES

Mass	Years
Very high	Millions
Much lower	Up to trillions

1. Very massive stars use fuel much faster.
2. Compare fuel supply AND use rate.

Answer: No. Faster fuel use can mean a shorter life.

PRACTICE 4 problems

- 1** Use the Sun estimates. About how many billion years separate formation from the end of core hydrogen fusion? Explain why this is approximate.

SUN ESTIMATES

Quantity	Billion years
Age now	4.6
Core-fusion time left	about 5

ANSWER _____

- 2** As core hydrogen fusion continues, predict how the amounts of hydrogen and helium in the core change. Explain the cause.

ANSWER _____

- 3** A student says ordinary chemical burning powers the Sun. Use the concept box and the Sun's estimated age to explain why this model fails.

ANSWER _____

- 4** Read the observation summary. Does a flare mean the Sun is becoming a red giant that day? Explain using the different time scales.

TWO TIME SCALES

Observation or estimate	Scale
Flare brightening	Sudden, short-lived
Core-fusion time left	Billions of years

ANSWER _____

APPLY IT Show your work

- 1** Build a time-ordered model of the Sun. Draw and connect: collapsing gas/protostar, main-sequence Sun, red giant, and white dwarf with shed outer gas. Mark 'now: 4.6 billion years' within the main-sequence stage and 'about 5 billion years left' before leaving it. Label the fuel change that ends core hydrogen fusion. Explain one way observations of other stars support your model.

ANSWER _____

2

Develop an energy-transfer model using these facts: core fusion changes hydrogen into helium and releases energy; radiation carries energy through the radiative zone; moving hot plasma carries energy through the convection zone; the surface emits radiation into space. Draw and label these Sun regions and Earth. Connect them with arrows showing each transfer. Predict the core's changing fuel composition. Show how energy crosses empty space.

ANSWER _____

CHALLENGE

One step up

Revise your energy model to show a solar flare as a short-lived release of magnetic energy in the Sun's atmosphere. Explain why it changes the radiation reaching Earth without turning the Sun into a new life stage. Then state one limitation of your lifetime model.

WORK SPACE AND ANSWER

PART 1 · PRACTICE

#	PROBLEM	ANSWER
1	Use the Sun estimates. About how many billion years separate formation from the end of core hydrogen fusion? Explain why this is approximate.	About 9.6 billion years, commonly rounded to 10 billion. Both the current age and remaining time are estimates; the remnant will persist after core hydrogen fusion ends.
2	As core hydrogen fusion continues, predict how the amounts of hydrogen and helium in the core change. Explain the cause.	Core hydrogen decreases and helium increases because fusion converts hydrogen into helium while releasing energy.
3	A student says ordinary chemical burning powers the Sun. Use the concept box and the Sun's estimated age to explain why this model fails.	Chemical reactions release far less energy per mass than fusion, so chemical fuel could not sustain the Sun's enormous output for billions of years. Core nuclear fusion supplies the required energy.
4	Read the observation summary. Does a flare mean the Sun is becoming a red giant that day? Explain using the different time scales.	No. A flare is a short-lived release of magnetic energy in the Sun's atmosphere; evolution toward a red giant occurs over much longer time scales.

PART 2 · APPLY IT

- Model follows protostar to main sequence to red giant to white dwarf; outer gas branches away from the remnant. Now is within main sequence, with about 5 billion years remaining before core hydrogen is depleted.** Astronomers observe stars at different stages and compare their masses and properties with stellar models. The Sun does not loop back into a protostar. The diagram need not be to scale; white-dwarf cooling lasts beyond the approximate 10-billion-year core-fusion lifetime.
- Connected model: core fusion produces helium and energy; radiation through radiative zone; convection through convection zone; surface emits electromagnetic radiation across space to Earth. Core hydrogen decreases as helium increases.** Accept nested regions or linked boxes with correct order, arrows and labels. Radiation can travel through empty space; convection requires moving matter. Do not draw convection carrying energy across space to Earth.

CHALLENGE

Add a separate flare in the atmosphere with an outward radiation arrow. It can briefly change radiation received at Earth while the Sun remains on the main sequence. Limits may include approximate timing, omitted intermediate stages, or sizes and durations not drawn to scale.

Use the models and explanations together for assessment, not just stage names. No atomic reaction details are required. Evidence summary sources: NASA, Sun: Facts (science.nasa.gov/sun/facts/); NASA, Stars (science.nasa.gov/universe/stars/); NGSS HS-ESS1-1 Evidence Statements (January 2015). The roughly 10-billion-year figure describes the Sun's main energy-producing lifetime, not the disappearance of its white-dwarf remnant. The stellar mass comparison is a general pattern, not two measured individual stars.