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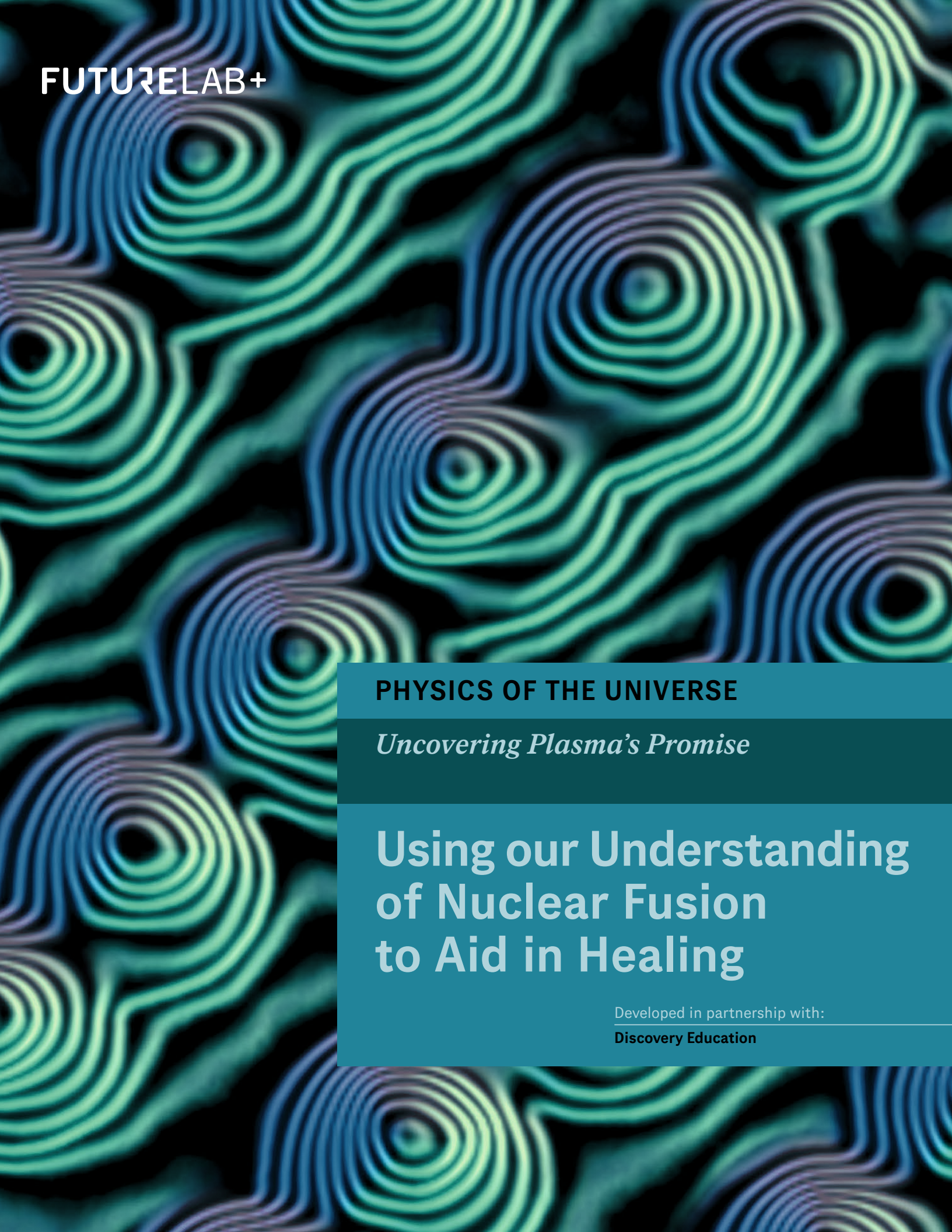


PHYSICS OF THE UNIVERSE

Uncovering Plasma's Promise

Using our Understanding of Nuclear Fusion to Aid in Healing

Developed in partnership with:

Discovery Education

In this Lesson Plan:

Print the **Teacher Section** →

Print the **Student Section** →

This document is separated into two sections, For Teachers [T] *and* Student Resources [S]*, which can be printed independently.*

Select the appropriate printer icon above to print either section in its entirety.

Follow the tips below in the Range field of your Print panel to print single pages or page ranges:

Single Pages (use a comma): T3, T6

Page Range (use a hyphen): T3–T6

Cover Image
Image of magnetic flux lines around nickel nanodots.

PHYSICS OF THE UNIVERSE / UNCOVERING PLASMA'S PROMISE

Using our Understanding of Nuclear Fusion to Aid in Healing

DRIVING QUESTION

How can we predict future solar storms to protect human society?

ACTIVITY DURATION

Three Days (45-minute sessions)

ESSENTIAL QUESTIONS

How does the Sun generate energy?

How can we predict future solar flare events?

How does the solar cycle impact solar activity?

OVERVIEW

The Sun is essentially a giant ball of hot gas known as plasma. A plasma is an ionized gas consisting of positive ions and free electrons in equal amounts. The gas is so hot, the electrons do not stay attached to the nucleus of their atoms. Plasma isn't just a substance that is commonly found throughout the universe—it also has lots of applications in biomedicine. For example, platelet-rich plasma has been shown to heal wounds and regenerate damaged tissue in patients.

During the opening activity, students learn about the hazards posed by solar flares, learn about past solar flare events that impacted our society, and are given the design challenge to create a 3D sun model that predicts solar flare activity at a specific year in the future. First, students learn about nebular theory's explanation for how the sun was formed and compare and contrast nuclear fusion and fission by creating a Venn Diagram. Students use this information to then write a summary that explains the formation of the sun. Then, students research different inner and outer layers of the sun as well as its most important features—sunspots and solar flares. Next, students learn about the 11-year solar cycle and

Continues next page >

OBJECTIVES

Students will be able to:

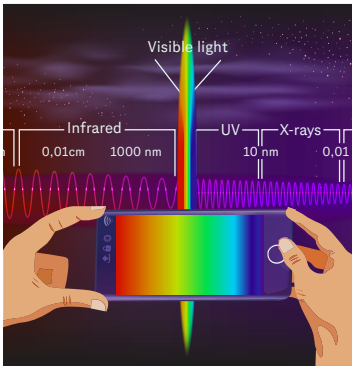
Explain the formation of the Sun and how it generates energy.

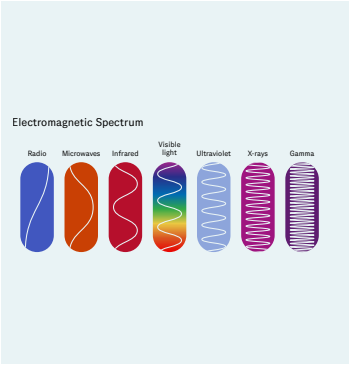
Predict the appearance of the Sun during a given year in the future using knowledge of the parts of the Sun, the features of the Sun, and the 11-year solar cycle.

Analyze 3D Sun models to predict future solar storm events.

OVERVIEW (CONTINUED)

its impact on the number of sunspots and solar flares. Using this information, student groups begin to make their 3D sun models in order to predict future solar storms. First, student groups are given a specific year in the future they will use to predict the appearance of their 3D sun model. Then, students will individually sketch their 3D sun model, making sure to include the parts of the sun and the number of sunspots predicted on the surface based on the year their group was given using the 11-year solar cycle. Students then share their sketches with their group members, and using these sketches, develop a 3D model of the sun that predicts the appearance of the sun for the year in the "future" the group was given using craft materials such as felt, fabric, clay, construction paper, and LED lights. Finally, students participate in a Gallery Walk where they view the other group's 3D models in order to make predictions about uture solar flare events using their understanding of the 11-year solar cycle and the influence the number of sunspots have on solar flare activity. As an extension, students will explore novel biomedical applications of plasmas including disinfecting wounds and accelerating healing.





STUDENT TASKS

Day 1	*Day 2*	*Day 3*
Nebular theory research. Nuclear Fusion and fission Venn diagram. Sun formation summary. Students research the different parts and features of the Sun.	Students research the 11-year solar cycle of the Sun. Students create a sketch of the Sun that predicts the Sun's appearance during a specific year in the future. Student teams build a 3D model of the Sun that predicts the Sun's appearance during a specific year in the future.	Students participate in a gallery walk review of the class 3D Sun models to analyze the models and make predictions of future solar flare events.

MAKE CONNECTIONS!

How does this connect to careers?

Biotech research and development engineers are responsible for developing and implementing new products using established biotech design control processes and good engineering practices. They use specialized knowledge of product design and development and the design control process to test, analyze, and solve biotechnical problems and design cutting-edge biotech products.

Plasma physicists study plasmas—a distinct state of matter that occur naturally in stars and interplanetary space and artificially in products such as neon signs and fluorescent lights. These physicists may study ways to create fusion reactors as a potential energy source.

Space weather forecasters analyze conditions in space to predict things like solar flares and meteor showers.

Healthcare/Biotech/Pharma consultants offer specialized services in innovative sectors, such as the life sciences (food, biotech, healthcare), energy, aeronautics, chemistry, cosmetics, materials, space, and defense. They study and share information about new technologies, innovative products and services, new usages and business models, and innovation management. These professionals create strategic recommendations by conducting investigations, analyzing literature, advising key opinion leaders, and facilitating workshops.

Plasma technicians collect plasma samples and perform tests on patients. Many plasma technicians work in donor labs, where patients give blood and plasma to support medical research and healthcare.

How does this connect to our world?

Students learn that plasma is an ionized gas consisting of positive ions and free electrons in equal amounts. The Sun is composed of plasma. They learn about the hazards posed by solar flares, and how past solar flare events have impacted our society. Students will make predictions about future solar flare events using their understanding of the 11-year solar cycle and the influence that the number of sunspots have on solar flare activity.They also learn how plasma is being used today in biotechnology to treat various medical conditions.

Pedagogical Framing

Instructional materials are designed to meet national education and industry standards to focus on in-demand skills needed across the full product development life cycle—from molecule to medicine—which will also expose students and educators to the breadth of education and career pathways across biotechnology.

Through this collection, educators are equipped with strategies to engage students from diverse racial, ethnic, and cultural groups, providing them with quality, equitable, and liberating educational experiences that validate and affirm student identity.

Units are designed to be problem-based and focus on workforce skill development to empower students with the knowledge and tools to be the change in reducing health disparities in communities.

SOCIAL-EMOTIONAL LEARNING

In this lesson, students will have multiple opportunities to present their learning to their peers, as well as critically, yet respectfully, engage with their peers' presentations and participate in the creation of a group 3D model. Students will exhibit communication and cooperative skills as they work in their student groups. They will practice social awareness and self-management skills by resisting inappropriate social pressure, negotiating solutions to conflict, and seeking help when needed.

CULTURALLY AND LINGUISTICALLY RESPONSIVE INSTRUCTION

This lesson applies culturally and linguistically responsive instruction to student research into the Sun's solar cycle and how solar flares can impact Earth and the humans and technology on it. Strategies include those that allow culturally diverse students to voice their ideas in a non-threatening space within small groups. This lesson also uses the responsive strategies of allowing students to use word banks and drawings to make sure concepts are understood and learning can be demonstrated.

COMPUTATIONAL THINKING PRACTICES

In this lesson, students use the computational thinking strategies of finding patterns and abstraction to understand how scientists predict solar flares and to identify commonalities between nuclear fission and nuclear fusion.

ADVANCING INCLUSIVE RESEARCH

The field of astrophysics has been dominated by predominantly white male scientists. To develop a richer understanding of our universe, it is essential that fields like astrophysics recruit scientists from underrepresented backgrounds. To accomplish amazing feats like predicting solar flares, it is important to acknowledge a variety of perspectives.

CONNECTION TO THE PRODUCT LIFE CYCLE

The process of understanding and predicting solar flares is in the **discover** phase of the product life cycle, as scientists are just beginning to understand solar behavior, as unearthed in their research.

Day 1

Slides 1–14

INDUSTRY AND CAREER CONNECTION

Plasma physicists are beginning to predict when solar flares will erupt. They do this by observing the magnetic field on the surface of the sun.

Slides 1–10

As a class, generate a list of student questions about solar flares. (5 minutes)

1	Show students the *NASA 5 Years of Sun video*. While students watch the video, use *Pause and Play* to allow them time to write down their observations in the *Sun Observation and Questions* capture sheet.
2	Have students volunteer to share their observations, or use a random picking strategy like *Pick a Stick*.
3	Ask students to name the flame rings shooting out of the Sun. Introduce the term solar flare to students.
4	Now have students write down their questions about Solar Flares.
5	Have students share aloud their questions in a *Round Robin* and add them to a large poster paper titled Solar Flare Need to Know Questions.

COMPUTATIONAL THINKING IN ACTION

By observing the way past solar flares have allowed us to predict future events, students see how the computational thinking strategy of finding patterns contributes to the advancement of science.

Slides 11–14

Students consider the potential threat of Solar Flares to people and technology and introduce the lesson's Driving Question. (8 minutes)

1	Review the March 10th, 1989 and the July 23, 2012 solar events with students from the article *5 times Solar Activity Affected Earth*. Ask students to do a *Quick Write* on how these past events highlight the importance of predicting solar storms.
2	Now, introduce the Driving Question to students to establish the challenge for this lesson: *How can we predict future solar storms to protect human society?*
3	Ask students to write down any new questions they have about solar flares and the challenge of the lesson they will help solve. Have students share their questions using a simple *Turn and Talk* with an elbow partner. Afterward, add the questions to the Solar Flare Need to Know Questions poster.

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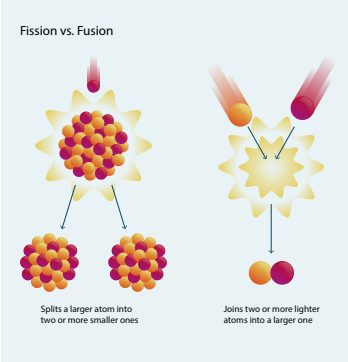
Day 1

Continued

Slides 15–21



COMPUTATIONAL THINKING IN ACTION

By utilizing a Venn diagram, students are putting the computational thinking strategy of abstraction into practice. Abstraction involves looking at the commonalities, or shared characteristics, within a dataset.

Slides 15–18

Students explore the Nebular Theory of Solar System Formation (12 minutes)

1 Tell students in order to begin to answer the driving question, we need to first learn how the sun formed and how it continues to burn.

2 Have students complete the *Note-Catcher Capture Sheet* individually first by viewing the resources below.

- *NASA Nebular Theory of Solar System Formation Video*
- *Nuclear fusion vs. fission Article*
- *Nuclear fusion vs. fission Video*

3 Then have students pair up and complete the *Fusion vs. Fission Venn Diagram* capture sheet.

4 Finally, have students define and use the key vocabulary listed in the wordbank to summarize the formation of the sun.

Slides 19–21

Students learn about the layers and features of the Sun. (20 minutes)

1 Tell students that to understand how the Sun is able to produce harmful radiation that can impact life and technology on Earth, we need to first learn how the Sun formed and how it continues to burn.

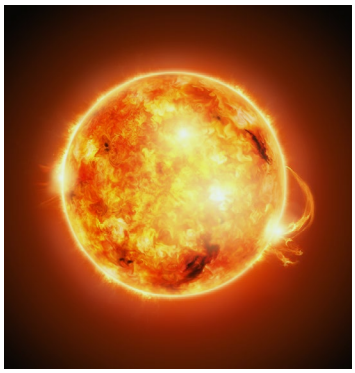
2 Have students, as individuals, complete Part 1 of the *Features of the Sun* capture sheet using the following resources:

- NASA article: *Layers of the Sun*
- *Parts of the Sun*
- Dartmouth Article: *Inner Layers of the Sun Article* (advanced reading)
- NASA Video: *How the Sun creates energy*
- *Sunspots and Solar Flares article*
- NASA Video: *A Guide to Solar Flares*
- NASA Video: *The truth about Solar Flares*

3 Then have students complete Part 2 of the *Features of the Sun* capture sheet using the word bank. *Source Material*

Day 2

Slides 22–31



Slides 22–24

As a class, review the Solar Flare Need to Know Questions with students. (5 minutes)

Review the Solar Flare Need to Know Questions with students.

1 In small groups, have students review the questions from the list and identify questions they can answer based on the content and work from the previous day.

2 Ask students to identify what new questions they have and add them to the list.

3 Remind students of the Driving Question for the lesson. Now, ask students to identify the questions from the list they need to answer next to get close to solving this challenge. Use this discussion to transition to the next section of the class.

Slides 25–31

Students are introduced to the Solar Cycle. (10 minutes)

1 Have students use the *See, Think, Wonder* thinking routine *using this graph* and this *NASA video* depicting the number of sunspots counted on the Sun over seven decades.

2 Ask students what patterns they see. From this conversation, introduce the 11-year solar cycle to students. Have students review the solar cycle using *this article from NASA* and *this NASA video*.

3 Divide the class into 5 groups, each of which will create a 3D model of the Sun in a given year in the future, based on where they expect it to be in the solar cycle. Tell students they will indicate the Sun's appearance using the number of sunspots they expect to see on the surface of the Sun.

- **Group A**—Create a Diagram of the Sun with the amount of sunsports you'd expect to see on the surface in 2025.
- **Group B**—Create a Diagram of the Sun with the amount of sunsports you'd expect to see on the surface in 2028.
- **Group C**—Create a Diagram of the Sun with the amount of sunsports you'd expect to see on the surface in 2033.

COMPUTATIONAL THINKING IN ACTION

As students create their 3D models of the sun, they are using the computational thinking strategy of building models to test and refine a hypothesis.

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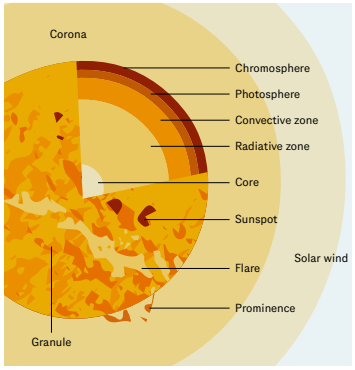
Day 2

Continued

Slides 25–33



- **Group D**—Create a Diagram of the Sun with the amount of sunsports you'd expect to see on the surface in 2037.
- **Group E**—Create a Diagram of the Sun with the amount of sunsports you'd expect to see on the surface in 2045.

Slide 32

Students individually develop a design for their 3D Sun model. (15 minutes)

1	Have students individually complete Part 1 of the *Create a Model of the Sun* capture sheet.
2	Tell students they will need to create a prototype drawing of their model before they build their model.

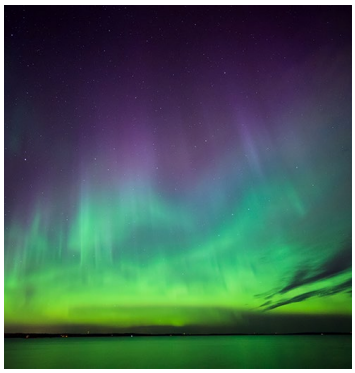
Slide 33

Student groups build a model of the Sun using various construction materials. (10 minutes)

1	Review Part 2 of the *Create a Model of the Sun* capture sheet with students. Show the groups the materials they will have to make their Sun.
2	Next, students will share their individual drawings from Part 1 of the Create a Model of the Sun Capture Sheet with their groups: • Each member shares their individual prototype. (2 minutes each) • The group listens and assesses using the checklist. (1 minute) • The group gives feedback—at least 2 glows and 2 grows. (2 minutes)
3	Then, the group will develop a final group diagram.
4	Have students use the Checklists in Part 2 to make sure their final design includes the required information and parts of the Sun.
5	Groups use the materials to create their model of the Sun for the rest of the remaining time in class. Tell students they will finish the 3D models during the first half of the next class.

Day 3

Slides 34–41



Slides 34–36

As a class, review the Solar Flare Need to Know Questions with students. (5 minutes)

Review the Solar Flare Need to Know Questions with students.

1	In their groups, have students review the questions from the list and identify questions they can answer based on the content and work from the previous day.
2	Ask students to identify what new questions they have and add them to the list.
3	Remind students of the Driving Question for the lesson. Now, ask students to identify the questions from the list they need to answer next to get close to solving this challenge. Use this discussion to transition to the next section of the class.

Slide 37

Student teams use the checklist to self-assess their 3D Sun models. (15 minutes)

Have student groups review the checklist in Part 2 of the *Create a Model of the Sun capture sheet* to see what they still need to include in their models. Give students 20 minutes to complete their designs.

Slides 38–41

Students analyze the class 3D Sun models to predict future solar storm events.

1	Have groups place their 3D models around the room for other groups to view.
2	Have groups do a *Gallery Walk* of the 3D models. As they view each group's 3-D model Sun, have them complete prediction #1 from *Predicting Future Solar Flare Events Capture Sheet*.

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Day 3

Continued

Slides 38–41

INDUSTRY AND CAREER CONNECTIONS

Space weather forecasters gather data from space that allow them to predict solar flares and electromagnetic phenomena like the aurora borealis.

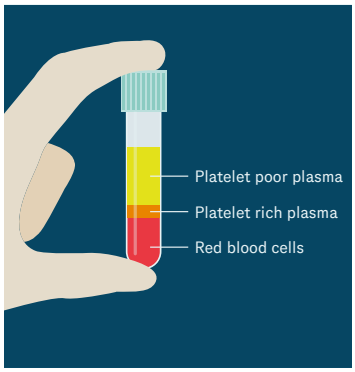
3 When done, have students individually complete prediction #2 from Part 3 of the *Predicting Future Solar Flare Events Capture Sheet*. Tell students to use the information they learned from the unit to answer the final questions:

- Which group's Sun poses the biggest threat of solar flare radiation damage to people on Earth?
- People make predictions for solar flares to prevent damage from the radiation. What do you think is difficult about making accurate predictions for solar flare radiation that can cause damage to people and technology?

Slides 42–45

INDUSTRY AND CAREER CONNECTIONS

Plasma physicists study the properties of plasma. They work with biomedical engineers to identify ways that plasma can serve as a treatment for things like cancer and wound healing.



Slides 42–45

As an extension or optional day, students discover the biomedical applications of plasmas. (45 minutes)

1. First, have students name the different states of matter. If students don't share first, reintroduce plasma as a fourth state of matter. Play the *Solid, Liquid, Gas, and... Plasma video*.

2. Have students share places where plasma exists.
   - **a.** Stars
   - **b.** Lightning
   - **c.** Fluorescent lights and Neon signs
   - **d.** The Solar wind
   - **e.** Flames as Plasmas
   - **f.** Auroras (Northern & Southern lights)

3. Tell students that plasmas are used as medicine. To explore how plasmas are used in medicine, place students into groups of four.

4. Have students divide the resources below amongst themselves and complete the *Plasma as Medicine Note Catcher Capture Sheet*.
   - Article: *Cold Plasma—A new hope in the field of virus inactivation*
   - Article: *Hydrogen peroxide gas plasma*
   - Article: *Cold plasmas assist wound healing*
   - Video: *Using Cold Plasma to Kill Cancer Cells*

5. When done, have students share what they discovered with the other people in their group. As they listen, have students complete the other sections of the *Plasma as Medicine Note Catcher Capture Sheet*.

6. Now, have students complete the reflection question: *Which medical application of plasma do you think will have the greatest impact?* Then have students share their reflection at their table and discuss the question in their groups. After groups discuss, have each group share their thoughts.

National Standards

Next Generation Science Standards

Science Engineering Practices (SEP)

Asking Questions and Defining Problems

Ask questions to clarify and refine a model, an explanation, or an engineering problem.

Disciplinary Core Ideas (DCI)

PS1.C Nuclear Processes

Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process.

HS-ESS1 Earth's Place in the Universe

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.

Crosscutting Concepts (CC)

Patterns

Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

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Sun Observation and Questions Capture Sheet

Directions

Write down your observations from the video: NASA 5 Years of Sun. Based on the observations you made, what questions do you have?

	My Observations	My Questions
1		
2		
3		
4		
5		

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Note-Catcher Capture Sheet

Directions
Using the resources provided, summarize the big ideas of the concepts below.

	Concept	Notes
1	Nebular Theory	
2	Fission	
3	Fusion	

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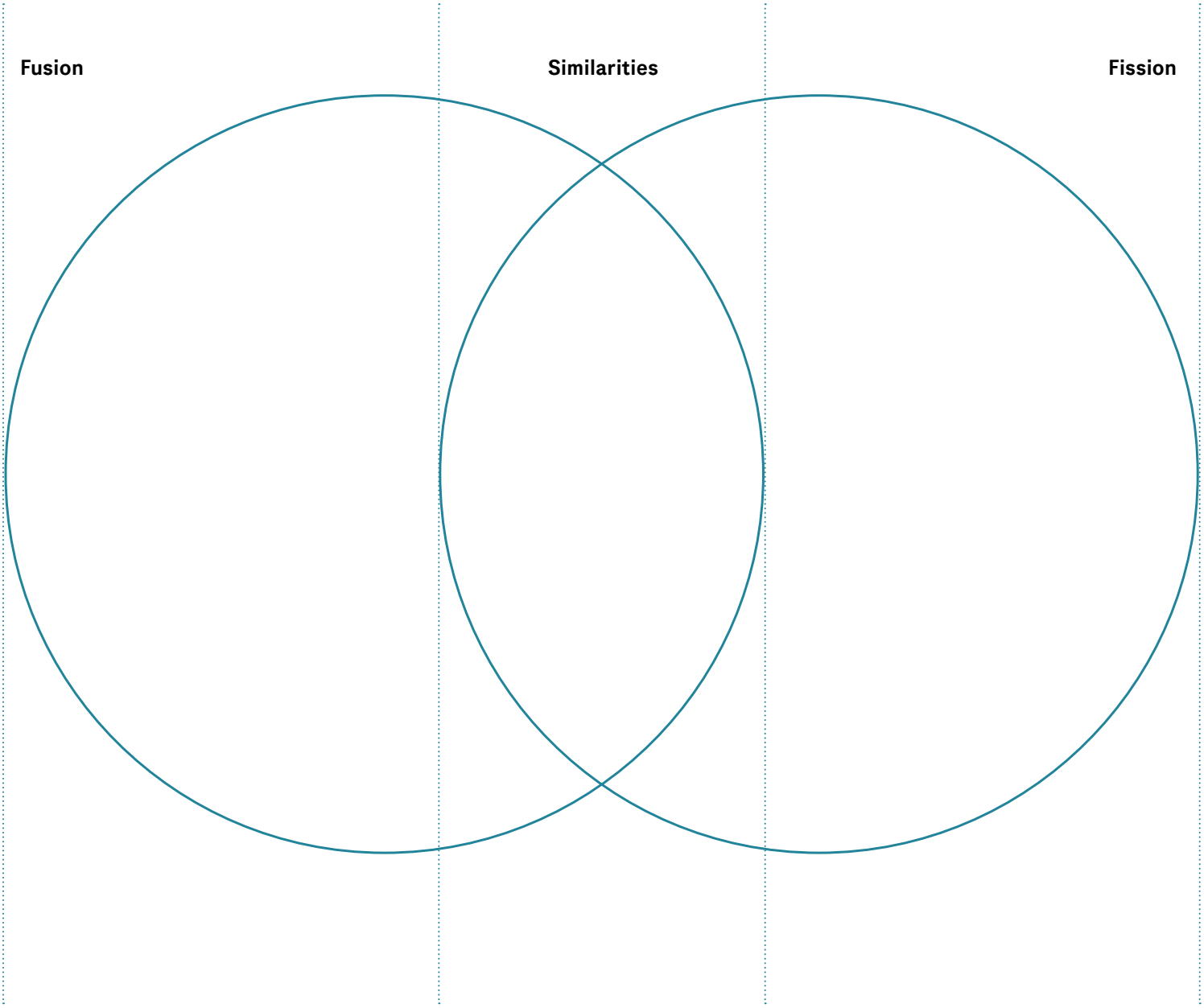
Fusion vs. Fission Venn Diagram Capture Sheet, Part 1

Directions

Using the information from your Note-Catcher Capture Sheet, compare and contrast fusion and fission using the Venn diagram below. Include at least four differences and three similarities between the two.



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Fusion vs. Fission Venn Diagram Capture Sheet, Part 2

Directions

In your own words, use what you learned about nuclear fusion and fission to summarize the formation of the sun. Define and use the key vocabulary listed in the word bank as you describe how the Sun was formed.

Word Bank

Atoms	Gravity
Energy	Helium
Fuse	Hydrogen
Fusion	Pressure

How was the Sun formed?

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Features of the Sun Capture Sheet, Part 1

Directions
Use the online resources to take notes about each part of the Sun in the table below.

Online Resources

	Parts of the Sun	Description
1		
2		
3		

Continues next page >

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Features of the Sun Capture Sheet, Part 1

Continued

	Parts of the Sun	Description
4		
5		
6		
7		
8		

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Features of the Sun Capture Sheet, Part 2

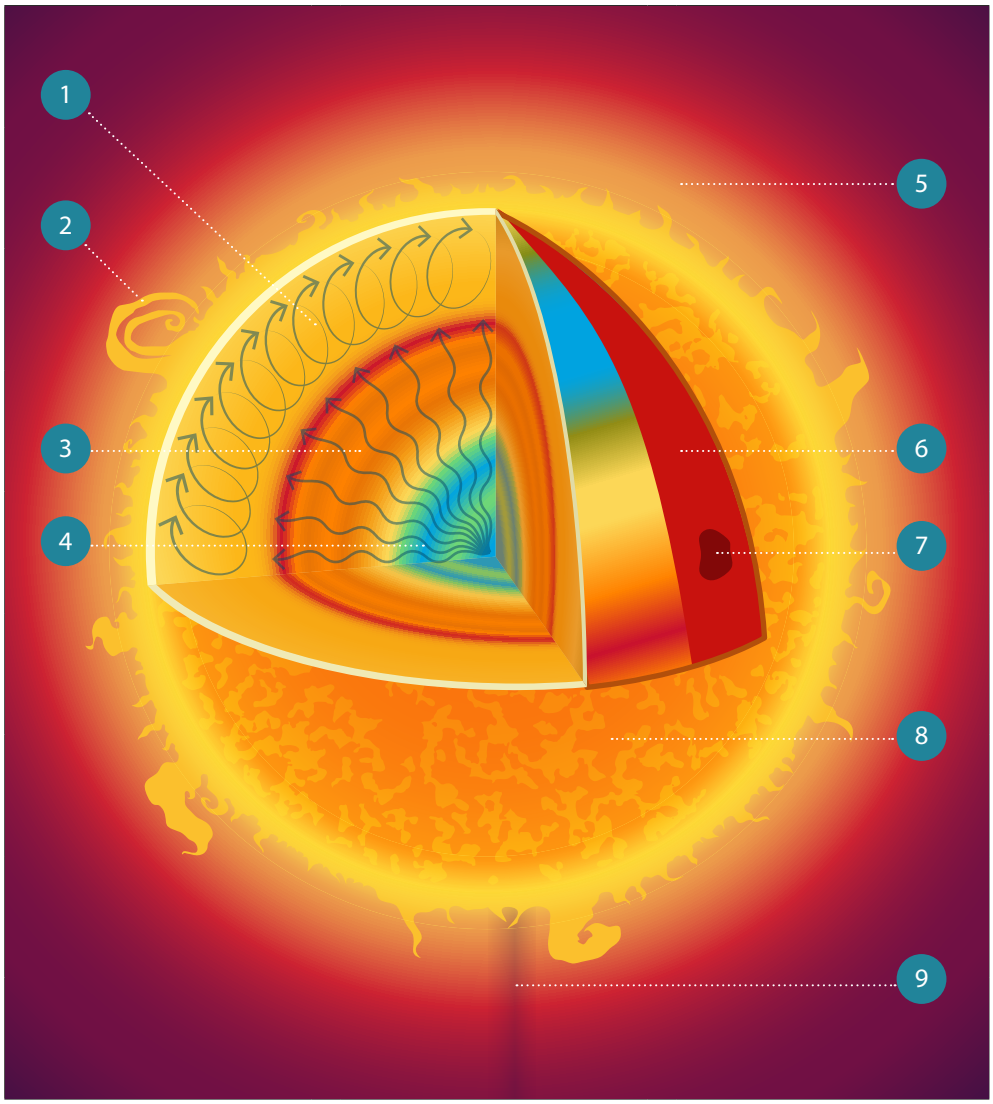
Directions
Label the parts of the Sun using the word bank below.

Word Bank

Corona	Core	Radiative zone
Chromosphere	Coronal hole	Solar flare
Convection zone	Photosphere	Sunspots

The Sun

Source: Vocabulary-List-7: ASTRON 001 : Elementary Astronomy, Khan M., Spring 2019



1
2
3
4
5
6
7
8
9

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Create a Model of the Sun Capture Sheet, Part 1

Directions

Create a prototype drawing of the 3D Sun model. In your drawing include all of the structures of the Sun, labels, color, and one interesting fact about each structure.

Parts of the Sun to Include

Chromosphere	Photosphere
Convection zone	Radiative zone
Core	Solar flare
Corona	Sunspots

Initial Sun Diagram Design

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Create a Model of the Sun Capture Sheet, Part 2

Directions
Use the checklist below to make sure to include all the necessary components of your 3D Sun model.

3D Sun Model Checklist

1	Information to Include in Your 3D Sun Model	Names of the layers of the Sun	
		Thickness of each layer	
		Interesting facts about each layer	
		Why solar flares pose a risk to people on Earth	
2	Parts of the Sun to Include in your Design	Chromosphere	Photosphere
		Convection zone	Radiative zone
		Core	Solar flare
		Corona	Sunspots
3	Materials to Build Your 3D Sun Model	Stick LED lights	Tape
		Poster board	Glue
		Five or more different colors of construction paper	Different colors of paint or markers

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Predicting Future Solar Flare Events Capture Sheet

Directions
Based on the other group's 3D Sun models, answer the questions below.

1. Predict whether each group's solar cycle is at solar minimum or solar maximum. Then justify your thinking.

Group	Solar Cycle Stage	How Do You Know?
A	☐ solar minimum ☐ solar maximum	
B	☐ solar minimum ☐ solar maximum	
C	☐ solar minimum ☐ solar maximum	
D	☐ solar minimum ☐ solar maximum	
E	☐ solar minimum ☐ solar maximum	

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Predicting Future Solar Flare Events Capture Sheet

Continued

2. Predict which group's Sun falls on the continuum below based on the number of solar flares you'd expect. Then justify your thinking.

Solar Flares

Fewer — More

Group	Symbol to Place on Continuum	Why Did You Place it There?
A	☆	
B	△	
C	○	
D	□	
E	⧖	

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Predicting Future Solar Flare Events Capture Sheet

Continued

3. Which group's Sun poses the biggest threat of solar flare radiation damage to people on Earth?

4. People make predictions for solar flares to prevent damage from the radiation. What do you think is difficult about making accurate predictions to solar flare radiation that can cause damage to people and technology?

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Plasma as Medicine Note Catcher Capture Sheet

Directions

Take notes on your assigned resource and respond to the questions in the corresponding space below. Share your notes with your group. As you listen to the other group members explain what they learned from their resource, complete the corresponding sections.

1. Fill out the table below.

			How is Plasma Used as Medicine?	What are the Benefits of Using Plasma for the Medical Application?
Articles	*Cold Plasma—A New Hope in the Field of Virus Inactivation*			
	Hydrogen Peroxide Gas Plasma			
	Cold Plasmas Assist Wound Healing			
Video	*Using Cold Plasma to Kill Cancer Cells*			

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Plasma as Medicine Note Catcher Capture Sheet

Continued

2. Reflection: Which medical application of plasma do you think will have the greatest impact for society?