Science and Innovation

A Boeing/Teaching Channel Partnership

EXTREME BIOSUITS

Teacher Handbook

Teaching Channel

Extreme Biosuits

Day 1: What Is a Biosuit?

Grade Level	Middle School
Lesson Length	One 50-minute session (if possible, consider adding another day)

Lesson Overview

In this lesson, students are introduced to the design problem. They learn that Boeing would like to develop biosuits capable of protecting scientists and engineers in extreme environments while allowing them to do their work comfortably. Before brainstorming the design of their own biosuits, students examine three existing biosuits to use as models—space suits, wet suits, and hazardous materials (hazmat) suits. At the end of the lesson, students brainstorm possible criteria and constraints for their biosuits.

Connecting to the Next Generation Science Standards

On Day 1, students make progress toward developing understanding across the following three dimensions:

- Science and Engineering Practices: Asking Questions and Defining Problems
- Disciplinary Core Ideas: ETS1.A Defining and Delimiting Engineering Problems
- Crosscutting Concepts: Influence of Science, Engineering, and Technology on Society and the Natural World, Structure and Function

In the following table, the specific components addressed in this lesson are underlined and italicized. The specific connections to classroom activity are stated.

Performance Expectations
This lesson contributes toward building understanding of the following *engineering* performance expectations: MS-ETS1-1. *Define the criteria and constraints of a design problem* with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
Specific Connections to Classroom Activity On Day 1, students are introduced to the design problem. Students are challenged to design a biosuit that can be worn in an extreme environment, and allows scientists and engineers to do their work comfortably and safely. By examining three example biosuits, students figure out that biosuits are built for particular environments and particular tasks. Using knowledge of the specific environment and task included in the design problem, students begin to identify some of the design criteria and constraints for their biosuits. Students also consider the societal pressures driving the need for their assigned biosuits. Later in the module, students further define criteria and constraints by taking into account relevant scientific principles.

Dimension	NGSS Element	Connections to Classroom Activity
Science and Engineering Practices	**Asking Questions and Defining Problems** • *Define a design problem that can be solved through the development of an object, tool,* process, or system and *includes multiple criteria and constraints,* including scientific knowledge that may limit possible solutions.	Students are challenged to design a biosuit that can be worn in an extreme environment and that allows scientists and engineers to do their work comfortably and safely. This design problem can be solved through the development of a biosuit and associated tools. Students figure out that biosuits must be designed for a particular environment and a particular task, which contributes to the design criteria and constraints.
Disciplinary Core Ideas	**ETS1.A Defining and Delimiting Engineering Problems** • *The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of* scientific principles and other *relevant knowledge likely to limit possible solutions.*	Students begin to identify criteria and constraints related to the design problem. As students brainstorm criteria and constraints, they draw on relevant knowledge about the environment and task for which the biosuit is intended.
Crosscutting Concepts	**Influence of Science, Engineering, and Technology on Society and the Natural World** • *The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values*; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. **Structure and Function** • *Structures can be designed to serve particular functions* by taking into account properties of different materials and how materials can be shaped and used.	Students read about three different biosuits that are used by scientists to do scientific research and to help solve societal issues (for example, the plague). Students are presented with a design problem (keep an engineer safe and comfortable while working in extreme environments) for which they must design a technology (build a biosuit). Students comment on the societal pressures driving the need for their assigned biosuit. Students consider structures on the biosuit that may serve particular functions when completing a task.

Basic Teacher Preparation

Organize the class into groups of 3 or 4 students. Students work in these groups throughout the module. Establish these working groups before beginning Day 1. An optional Day 1 activity can be used to build team cohesion.

Refer to the Extreme Biosuits Student Handbook ahead of time, so you can address any questions students might have. All Day 1 documents can be found on pages 1–14 in the Extreme Biosuits Student Handbook. The documents used in this lesson are:

- The Engineering Design Process (page 1)
- Welcome Letter (page 2)
- Building Our Driving Question Board (page 3)
- Examining Biosuit Models (pages 4–10)

- Biosuit Environments and Tasks (pages 11 and 12)
- Defining the Problem and Identifying Solutions (Round 1) (page 13)
- Team Roles (page 14)

To prepare for the whole group discussions, review the Talk Science Primer (refer to the Suggested Teacher Resources at the end of this lesson).

Required Preparation	Links/Additional Information
❑ Gather or purchase the required materials for the lesson	Refer to the Materials List below
❑ Download, print, and prepare the Extreme Biosuits Student Handbook packets for students	Refer to the Materials List below
❑ Review suggested teacher preparation resources and recommended websites	Refer to the Suggested Teacher Resources at the end of this lesson

Materials List

Item	Description/Additional Information	Quantity	Where to Locate/Buy
Extreme Biosuits Student Handbook	Print the handbooks and collate them to remain sturdy for 7–10 days	1 per student	[Resource Link]

Day 1: What Is a Biosuit?

Introduction (5 minutes)

Begin the lesson by explaining to students that they are going to assume the roles of engineers who have been hired by Boeing. Boeing wants to design biosuits that can be worn in many different extreme environments, and will allow scientists and engineers to do their work comfortably and safely. Some biosuits, such as the spacesuit, have already been created. Boeing wants to take biosuit technology a step further by designing biosuits for a wide variety of extreme environments.

As Boeing employees, the students develop and test new biosuits for extreme conditions. Introduce students to the Driving Question for this module, *How can we design a biosuit that can be worn in an extreme environment, and allows scientists and engineers to do their work comfortably?* Post the Driving Question on the Driving Question Board (DQB).

Important Note

The Driving Question Board (DQB) is used throughout the module to guide student learning. Make sure the Driving Question Board is placed in a prominent location and can be easily accessed by students.

Provide students with the Extreme Biosuits Student Handbook, which contains all the information they need for this module. Point out that the handbook provides an overview and detailed descriptions of everything students need to know while they design their biosuit models.

Read the Welcome Letter on page 2 of the Extreme Biosuits Student Handbook out loud. Tell students they are going to work through the engineering design process as they design biosuits for Boeing. Reveiw The Engineering Design Process on page 1 of the Extreme Biosuits Student Handbook (The Engineering Design Process can also be found in Appendix A).

Tell students that they need to know more about the engineering design problem before beginning design work. Have students develop a list of questions about the design problem. Start by developing one question as a class, and then have students work in small groups to develop the remaining questions. Students should record their questions on Building Our Driving Question Board on page 4 in the Extreme Biosuits Student Handbook. Questions may include:

- What are biosuits?
- Why do we need biosuits?
- What are biosuits made out of?
- What kinds of extreme environments will the biosuits be used for?
- Why is it important to protect the body in extreme environments?

NGSS Key Moment

Engineers often refer to the *engineering design process* when they discuss their work. In NGSS, the Science and Engineering Practices are used in place of the engineering design process. Students should understand that the engineering design process is not necessarily linear. Rather, engineers engage in all the steps, often jumping between steps. Students might think of the engineering design process as a web of practices.

Extension

Consider showing LaunchPad: The Making of the Biosuit to provide students with additional background on Biosuits.

Whole Group Discussion: Our Questions (10 minutes)

Engage the class in a large group discussion. The goal of this discussion is to categorize student questions into a few main categories. Start by having students share the questions they developed. Then, guide students to categorize the questions. Students should search for patterns in the questions developed by students in the class. Try to come to class consensus about the categories.

At a minimum, guide the class toward developing the following three categories, although additional categories may emerge.

- What is a biosuit?
- Why are biosuits needed in certain environments?
- How can we design a model to test our biosuit?

NGSS Key Moment

Whole group discussions, particularly consensus discussions, can be an effective way to engage students in the science practices of argumentation and explanation. Leading whole group discussions requires proper preparation. Refer to the Talk Science Primer for useful strategies.

Tell students that these three questions will drive their work over the next several days. In addition, these questions will help them answer the overarching Driving Question, *How can we design a biosuit that can be worn in an extreme environment, and allows scientists and engineers to do their work comfortably?* Post the questions on the DQB so students can clearly see them. Leave space under the questions to add sticky notes.

DRIVING QUESTION BOARD

How can we design a biosuit that can be worn in an extreme environment, and allows scientists and engineers to do their work comfortably?

What is a biosuit?

Why are biosuits needed in certain environments?

How can we design a model to test our biosuit?

Mini-Lesson: What Is a Biosuit? (15 minutes)

Tell students they are going to start with the first question, *What is a biosuit?* To answer this question, students examine features of three biosuits that already exist—spacesuit, diving suit, and hazmat suit. The existing biosuits serve as a model for the design of new biosuits for different environments.

Students individually read three short articles to gather information about the existing biosuits. The articles discuss spacesuits, diving suits, and hazmat suits. The articles can be found on pages 4–10 of the Extreme Biosuits Student Handbook.

As students read, they should record notes on Examining Biosuit Models on page 4 in the Extreme Biosuits Student Handbook. Refer students to the concepts that must be summarized for each article:

- Protects against
- Key features
- Environments used In
- History

As students read and complete the graphic organizer, prompt students to think about the relationship between biosuit development and changing societal needs and desires.

NGSS Key Moment

By thinking about the relationship between biosuit development and changing societal needs driving the development of biosuits, students make progress on the crosscutting concept: Influence of Science, Engineering, and Technology on Society and the Natural World.

Extension

NASA published an article about innovations in spacesuit design. *Building the Future Spacesuit* can be found here. This article could be used to differentiate for more advanced readers or could be used as an extension.

For students who may need additional reading support, assign only one or two of the articles and have groups share their findings.

Whole Group Discussion: Defining the Problem (5 minutes)

Reference the question on the DQB, *What is a biosuit?* Have students share their findings from the readings to try to answer this question. Remind students to think about the biosuits in the articles as models for their own biosuits.

During the discussion, draw out the idea that biosuits are designed for a specific purpose, to be used in a specific environment, and as a result of a specific societal need. While all biosuits have many similarities, the differences among biosuits make them better suited for their particular environment and task. Be sure to record student ideas on the DQB.

Design Work: Defining the Problem (10 minutes)

After establishing the idea that biosuits must be designed for a specific purpose and environment, tell students that Boeing has already identified target environments for their biosuits. Each design team will be assigned to one environment and purpose.

Here are the key assignments:

- Alaska: Oil Pipeline Engineer
- Antarctica: Glaciologist
- Pacific Ocean: Deep Sea Biologists
- Gulf of Mexico: Hazardous Material Technician

Assign each group to an Environment/Task listed on pages 11 and 12 in the Extreme Biosuits Student Handbook. Allow time for students to read the description of their assignment.

NGSS Key Moment

At this point in the lesson, students make progress on MS-ETS1-1. Students have already started to define the design problem. They are now working to identify possible criteria and constraints. Throughout the rest of the module, students will continue to build on this initial list of criteria and constraints.

Emphasize the importance of considering a design task's criteria and constraints. *Criteria* typically address details such as the job a product will perform and its durability. The particular environment and task for which the biosuit is intended will likely contribute to the criteria for the design problem. *Constraints* include the limitations of creating a product, such as time or cost.

Have students begin to define the design problem and describe successful solutions. Students should record their ideas on the Defining the Problem and Identifying Solutions (Round 1) chart on page 13 in the Extreme Biosuits Student Handbook. Review the chart with students prior to having students work in groups to complete the chart.

At this point, students do not yet have information to complete the last column (*Challenges*). Students revisit this column later. In addition, students only partially fill out the first three columns (*Environment*, *Task*, and *Reason*). In later lessons, students add to these columns.

Extension

The Biosuit Environments/Tasks can be differentiated based on the needs of the group. The most straightforward Environment/Task is Alaska: Oil Pipeline Engineer. The most complicated Environment/Task is Gulf of Mexico: Hazardous Material Technician.

Returning to the Driving Question Board (5 minutes)

Reference the lesson question on the DQB, *What is a biosuit?* Ask students if they think that they made progress in answering the question. Also ask students if they think they made progress in answering any of the other questions on the board. Tell students to record their progress on a post-it note. When students are done, they should read their post-it notes out loud to the class and post them to the DQB. If students have additional questions, they should add them to the DQB.

Helpful Tip

To organize the DQB, color-code your use of sticky notes. Use one color for questions and a different color for "what we figured out" or other findings.

Design Work: Establishing Group Work Expectations (Optional) (10 minutes)

To support team development, you might choose to engage students in a team development activity with their design groups prior to completing design work.

You might also want to assign, or have team's assign, specific roles to each team member. Possible team roles and descriptions can be found on page 14 in the Extreme Biosuits Student Handbook**.** If possible, have students work as a group to determine each person's role on their team, based on their strengths and personal interests**.**

Remind students that all team members must contribute to all portions of the design problem. Team roles designate a leader in a particular area. They do not exempt students from certain tasks in the design problem.

Assessment

Several opportunities for formative assessment exist in this lesson:

- Extreme Biosuit Student Handbook entries can be used to monitor student progress during the module. Focus specifically on the Examining Biosuit Models chart on page 4.
- The Defining the Problem and Identifying Solutions (Round 1) chart on page 13 is used in multiple lessons during this module. Use this chart to monitor student progress on key ideas.
- Consider gathering evidence of student progress through small group and whole group discussions.
- Student contributions to the Driving Question Board can also be monitored.

Use the identified assessment opportunities to monitor student progress on disciplinary core ideas, science and engineering practices, and crosscutting concepts. Provide appropriate supports or extensions when necessary.

Reference Appendix B for suggestions for meeting the needs of all learners.

Community Connections

Many communities have companies and organizations whose employees must use protective clothing for technical or production work. Often, these companies and organizations are willing to suggest a guest speaker to talk with students.

The teacher can also have students ask parents, guardians, or family members to share information about any protective gear they use at work or home. Students can share this information and create a class Protective Clothing Chart that can be posted for students to gain a better understanding of how often protective clothing is used in various professions.

Suggested Teacher Resources

Engineering Design Process	Extreme Biosuits Teacher Handbook, Appendix A
Meeting the Needs of All Learners	Extreme Biosuits Teacher Handbook, Appendix B
Extreme Biosuits Student Handbook	[Resource Link]
Talk Science Primer	[Web Link]
Smithsonian Magazine article on Neil Armstrong's spacesuit	[Web Link]
Divers Institute of Technology article, *The History of the Wetsuit*	[Web Link]
Io9 article about the history of wetsuits	[Web Link]
How Products Are Made article about wetsuits	[Web Link]
Naval Undersea Museum article about wetsuits	[Web Link]
The North East Diving Equipment Group page	[Web Link]
wiseGEEK article about hazmat suits	[Web Link]
WCTi12.com article about hazmat oil spill cleanup	[Web Link]
The Independent article about hazmat suits and Ebola	[Web Link]
Designing the Future Spacesuit	[Web Link]
Launchpad: The Making of a Biosuit (video)	[YouTube Link]