Hypersonics STEM Curriculum

Humans at Hypersonic Speeds

Grade	Time	Subject Area	Key Concepts
High School	40 min	Life Science	Adaptations

Lesson Overview

In this lesson, students learn about the conditions presented in a hypersonic environment and explain ways in which humans could adapt and evolve to be able to thrive in a hypersonic environment.

NGSS Standards

HS-LS4-4 Construct an explanation based on evidence for how natural selection leads to adaptation of populations.

Learning Objectives

By the end of this lesson, students will be able to:

- Explain the conditions present in a hypersonic environment.
- List features of humans that might be considered strengths and weaknesses in a hypersonic environment.
- Explain possible ways humans could adapt and evolve to be able to survive in a hypersonic environment.

Essential/Overarching Question

Could humans survive in a hypersonic environment?

Key Vocabulary

Speed – the rate at which an object is moving. Speed is calculated by dividing the distance travelled by the time it took to travel that distance.

Speed of Sound – the rate at which sound moves through a medium. The speed of sound depends on both the density and the temperature of the medium. The speed of sound through air at 20° C (68° F) at sea level is 343 m/s (767 mph).

Mach – the ratio of the speed of an object to the speed of sound or how many times the speed of sound an object is moving. It is often followed by a number indicating the ratio; for example: Mach 1 is the speed of sound, Mach 2 is twice the speed of sound, Mach 5 is five times the speed of sound.

Sonic – speeds equal to the speed of sound (Mach 1).

Subsonic – speeds smaller than the speed of sound (less than Mach 1).

Transonic – speeds near (Mach 0.8-1.2) the speed of sound where drag is highest (e.g. sound barrier).

Supersonic – speeds greater than the speed of sound (Mach 1 and greater).

Hypersonic – speeds greater than five times the speed of sound (Mach 5 and greater).

Fluid – a substance with no fixed shape; a liquid, gas, or plasma. A substance that flows when an external force is applied to it.

Flow – the motion of a fluid (liquid, gas, or plasma) when it experiences unbalanced forces.

Adaptation – a change where an organism becomes better suited for its environment.

Evolve – to undergo a change or development.

Science Concepts Overview

Aircrafts fly at a variety of speeds. Some fly at subsonic (slower than the speed of sound: $v < 343$ m/s) speeds, some at supersonic (faster than the speed of sound: $v > 343$ m/s) speeds and some at hypersonic (faster than five times the speed of sound: $v > 1715$ m/s) speeds. As aircrafts fly at higher speeds, they experience a lot of heat (high temperatures) and friction (resistance) as well as other extreme conditions.

Humans have not evolved to thrive in the extreme conditions provided by hypersonic environments. In this lesson, students are posed with the question, how would humans need to adapt and evolve to survive in a hypersonic environment. All animals adapt and evolve to survive in their environment. These changes usually happen as a result of a change in environment, weather, food sources, shelter, and/or predators. In some cases, these adaptations lead to new species.

Materials List

- ☐ Devices with access to the internet (one per student)
- ☐ Humans at Hypersonic Speeds handout (one per student)

Lesson Preparation

Prior to the lesson, the instructor should make copies of the Humans at Hypersonic Speeds handout and ensure that the devices that the students will be using to do the activity are charged and connected to the internet.

If possible, the instructor should provide students with either an electronic copy of the Humans at Hypersonic Speeds handout and/or links to the websites through whatever

learning platform is used at their school. This will help students more easily and quickly get to the correct resources.

Safety

There are no additional safety concerns beyond normal classroom procedures for this lesson.

Procedure

Engage (10 minutes)

1. Ideally, students should work individually on this lesson. If there is not a one-to-one student to electronic device ratio, students can work in groups.
2. Individually or as a class, read the Introduction section of the Humans at Hypersonic Speeds handout and watch the video about the behind the scenes look at going hypersonic in Top Gun: Maverick. https://www.youtube.com/watch?v=j4qwMGd2wmQ
3. Have students answer questions 1-2 in the Introduction section of the Humans at Hypersonic Speeds handout:
    - Do you think a human could survive ejecting safely while moving at a hypersonic speed? Could a human survive a hypersonic environment? Explain your reasoning.
    - What tools were given to Maverick to help him survive while flying at hypersonic speeds? (Think about both his suit and within the aircraft.)
4. Have students discuss their answer to the questions. This can be done in small groups as a think, pair, share or as a whole class discussion.

Explore (10 minutes)

5. Students will use the resources provided in the Brainstorming section of the Humans at Hypersonic Speeds handout to learn about hypersonic environments.

Explain & Elaborate (10 minutes)

6. Students will explain their understanding of hypersonic environments and elaborate on how humans would interact with that environment by answering questions 1-4 in the Brainstorming section of the Humans at Hypersonic Speeds handout:
    - Describe what extreme conditions a hypersonic environment might entail.
    - What are current features of humans that would help them survive in a hypersonic environment?
    - What are current features of humans that would make them vulnerable in a hypersonic environment?
    - If humans had to evolve to be able to thrive in a hypersonic environment (without the protection of a suit or aircraft), what adaptations would they need to make? Be as creative as you like and use a combination of diagrams and verbiage to explain your ideas.

Evaluate (10 minutes)

7. Have students present their ideas to the class. This could be done as a think, pair, share or as a full class discussion.

STEM Career Connections

- Bioastronautics
- Aircraft design
- Aerospace engineering
- Pilots
- Materials scientist

Extensions

Students could further *explain* their understanding by finding an example from a different movie or television show (that is school and age appropriate) where humans survival in an environment was implausible. Students can share why humans could not survive in that environment and how humans would need to adapt or evolve to survive in that environment.

References & Resources

Benson, T. (2021, May 7). Welcome to the NASA's Guide to Hypersonics. NASA. https://www.grc.nasa.gov/www/BGH/index.html

Lockheed Martin (n.d.). *Top Gun – The need for speed*. Lockheed Martin. https://lockheedmartin.com/topgun

SciShow. (2019, July 8). *A surprisingly simple secret to supersonic flight* [Video]. YouTube. https://www.youtube.com/watch?v=kGefMLHJBKA

Talented Tuber. (2017, April 11). *Difference between subsonic, supersonic and hypersonic speed* [Video]. YouTube. https://www.youtube.com/watch?v=LBJ3tXCjzN0

TestTube 101. (2015, November 11). *Flying at hypersonic speeds* [Video]. YouTube https://www.youtube.com/watch?v=vL1qAfS0gic

The New York Times. (2022, June 3). *Watch Tom Cruise go hypersonic in 'Top Gun: Maverick' | Anatomy of a Scene* [Video]. YouTube. https://www.youtube.com/watch?v=j4qwMGd2wmQ

UVA Engineering. (2021, September 27). *"Need for speed: A hypersonics lecture"- Need for speed video contest* [Video]. YouTube. https://www.youtube.com/watch?v=at2v5LJ0SUU

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Humans at Hypersonic Speeds

✈ Introduction

In the movie *Top Gun: Maverick*, Captain Pete "Maverick" Mitchell flies the Dark Star at high hypersonics speeds. ***Supersonic*** means faster than the speed of sound while ***hypersonic*** means faster than five times the speed of sound. In the movie, Maverick pushes the Dark Star to fly faster than Mach 10, or at a hypersonic speed that is over 10 times the speed of sound. Watch the video linked below to learn more about that scene in the movie.

The New York Times. (2022, June 3). *Watch Tom Cruise go hypersonic in 'Top Gun: Maverick' | Anatomy of a Scene* [Video]. YouTube. https://www.youtube.com/watch?v=j4qwMGd2wmQ

In the movie, the Dark Star crashes and Maverick survives the crash. Although the movie does not show how he survived the crash, for the sake of this lesson, we are going to assume that he ejected safely from the aircraft.

1. Do you think a human could survive ejecting safely while moving at a hypersonic speed? Could a human survive a hypersonic environment? Explain your reasoning.

2. What tools were given to Maverick to help him survive while flying at hypersonic speeds? (Think about both his suit and within the aircraft.)

✈ Brainstorming

Explore the following hypersonics resources:

Benson, T. (2021, May 7). Welcome to the NASA's Guide to Hypersonics. NASA. https://www.grc.nasa.gov/www/BGH/index.html

SciShow. (2019, July 8). *A surprisingly simple secret to supersonic flight* [Video]. YouTube. https://www.youtube.com/watch?v=kGefMLHJBKA

TestTube 101. (2015, November 11). *Flying at hypersonic speeds* [Video]. YouTube https://www.youtube.com/watch?v=vL1qAfS0gic

1. Describe what extreme conditions a hypersonic environment might entail.

2. What are current features of humans that would help them survive in a hypersonic environment?

3. What are current features of humans that would make them vulnerable in a hypersonic environment?

4. If humans had to evolve to be able to thrive in a hypersonic environment (without the protection of a suit or aircraft), what adaptations would they need to make? Be as creative as you like and use a combination of diagrams and verbiage to explain your ideas.