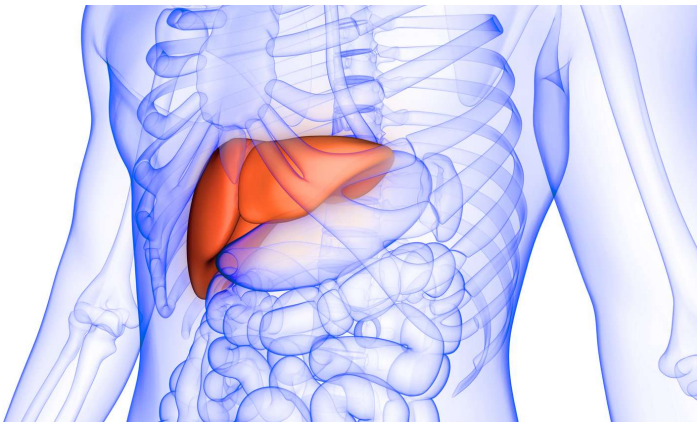
# The Effect of Microgravity on Catalase Enzyme Activity in Liver

## Introduction

Microgravity has been determined to have a significant impact on liver function in mice after two weeks in space. This experiment will investigate whether microgravity has an immediate impact on the function of catalase enzyme in liver, which is responsible for the degradation of hydrogen peroxide toxin in our bloodstream.



Reactants for this experiment will be food-grade, pureed calf liver and 3% hydrogen peroxide.

Students gain valuable experience in chemistry, anatomy, current space research topics, microgravity, engineering, experimental design, and critical thinking, even before the actual flight.

**Target Grade Level**: 6th-12th
**Suggested Time Frame**: 4 days (50 minute class periods)

## US Next Generation Science Standards (NGSS)

Properties of Matter PS1.A: Understanding the properties of matter and their relationship to molecular structure.

Force and Motion PS2.A, PS2.B: Understanding the principles of force, motion, and energy.

Space Systems ESS1.A, ESS1.B: Understanding the properties of celestial bodies and the history and future of space exploration.

Matter and its interactions PS1.1, PS1.2, PS1.4, PS1.5, PS1.6: Understanding the interactions between matter and energy.

Energy PS3.2, PS3.4: Understanding the different forms of energy and how they can be transferred and transformed.

From Molecules to Organisms: Structures and Processes LS1.1, LS1.2, LS1.3: Understanding life at the cellular and molecular level.

Ecosystems, Energy, and Dynamics LS2.4, LS2.5: Understanding the relationships between organisms and their environment and the cycling of matter and energy through ecosystems.

Engineering Design ETS1.A, ETS1.B, ETS1.C: Understanding the engineering design process and designing solutions to real-world problems.

**Objectives**

- To experience the scientific research process in a meaningful, relevant way.
- To investigate whether microgravity inhibits catalase enzyme activity in liver.
- To use the engineering process to develop an apparatus which can be used to conduct and contain a chemical reaction on board G-Force One.
- To understand that chemical reactions occur in the cells of every living organism
- To investigate human anatomy and the effect of space flight on human health.
- To strengthen critical thinking skills.

**Background**

This is a student driven, authentic research experience in which students determine whether microgravity will suppress catalase enzyme activity in calf liver.

Students are introduced to exothermic chemical changes requiring a catalyst with the classic elephant toothpaste reaction (*link provided*). Students then learn about a similar reaction that occurs in our body- the breakdown of hydrogen peroxide by our liver. Students conduct an experiment to investigate how liver damage results in less catalase enzyme activity in our liver, resulting in little to no breakdown of hydrogen peroxide (*link provided*).

After understanding the role that catalase enzyme and environmental stress play in the breakdown of toxins passing through the liver, students brainstorm and engineer an apparatus to test catalase enzyme in a weightless environment within 20 second time frame.

The apparatus is used to gather data at 1-g (control) in the classroom. The experiment is subsequently conducted on board G-Force One and recorded for classroom use.

Students need to work under the weight, size, and safety constraints required by Zero-G for parabolic flight.

S*pecial care should be taken to design an apparatus that will contain blood and withstand pressure buildup inside the reaction tube*.

**Purpose**
Does short term exposure to microgravity affect the function of catalase enzymes in liver?

**Hypothesis**

**Procedures: Construction of catalase enzyme assay apparatus**

1. Seal end with silicone plug
2. Inject 1 mL of hydrogen peroxide into tube
3. Clamp tube in middle with a quick-release IV clamp, so that the hydrogen peroxide is separated within the tube
4. Inject 1 mL of calf liver puree into the nylon tube, separate from the hydrogen peroxide
5. Stretch a small balloon across open end (closest to the liver), and secure with a zip tie

**The purpose of the balloon is to avoid pressure build-up within the tube due to oxygen gas production during the reaction.*

**The quick-release IV clamp should be tight enough to keep the reactants separate until it is time for reactants to come in contact with each other.*

**Procedures: In-flight experimental procedures**:

1. Begin video
2. Remove apparatus from secondary containment
3. Upon initiation of microgravity, release the clamp
4. Give the tube will be given a quick shake to mix the reactants in view of camera.
    - The presence of bubbles indicates the breakdown of hydrogen peroxide by catalase enzymes in the liver.
5. At end of parabola return apparatus to its containment bag for the duration of the flight

**In class:**
Watch video, record the results after 20 seconds

## Results

| | Foam? (Yes / No) | Amount of foam (0-5 scale) 0=no foam | Enzyme Active? (yes / no) | Other Observations |
|---|---|---|---|---|
| Rep 1 Classroom **(1-G)** | | | | |
| Rep 2 Classroom **(1-G)** | | | | |
| Rep 3 Classroom **(1-G)** | | | | |
| Rep 1 Flight **(0-G)** | | | | |
| Rep 2 Flight **(0-G)** | | | | |
| Rep 3 Flight **(0-G)** | | | | |

**Conclusion**

Does short term exposure to microgravity affect the function of catalase enzymes in liver? Use data or observations to support your statement.

.
Illustrate the apparatus used for the experiment. Include a description of parts and how it works.

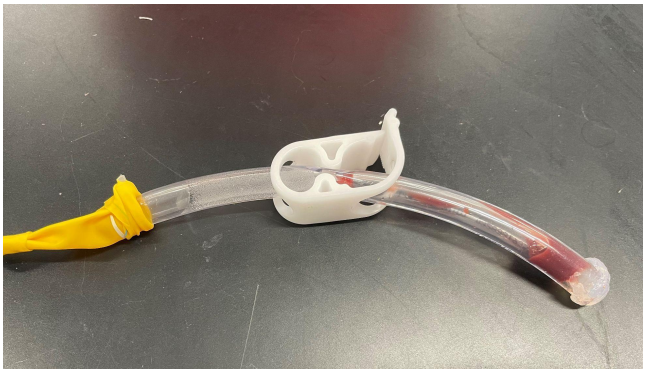
Does this design fully answer the original question? Why or Why not?

How could this experiment be improved?

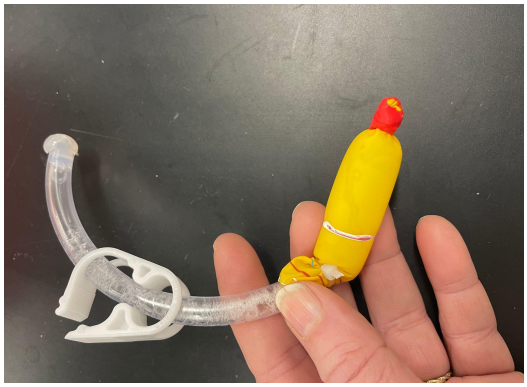
Why is this experiment important in space science? Earth science?

spaceforteachers.com

**Resources and photos**



Reactants separated by IV clamp



(Balloon after reaction)

Students investigating catalase enzyme activity in calf liver (traditional lab activity, see link below)



Testing catalase enzyme activity using microgravity apparatus (1-G, 0-G)

## Additional Resources

- Anatomy of the Liver

  https://www.stanfordchildrens.org/en/topic/default?id=anatomy-and-function-of-the-liver-90-P03069

- Elephant Toothpaste

  https://docs.google.com/document/d/1Q7n2lQAgReghbjc7z1GACfTl6gXYfQQ_xNB9VRmwkHk/edit

- Catalase Enzyme / Liver Lab

  https://docs.google.com/document/d/13fyN0FruCcfzuD9aZjAU-OQ5tds47U3DTKuNyq2tX7w/edit

- NASA Technical Archive (searchable)

  https://ntrs.nasa.gov/