TEACHER GUIDE

A Look inside the Lab: Liquid Nitrogen Freezer

OVERVIEW

The VMP Next Step Science resources provide mini lessons, videos, and other materials related to the practice of science. These resources are meant to enhance the exploration of a particular topic or offer insights into the profession of scientific research.

The Next Step Science "A Look inside the Lab" series is comprised of reading passages and videos designed to introduce students to pieces of laboratory equipment and the scientists who use them. The series can be used to enhance an existing lesson or as a starting point for introducing a concept.

Each mini lesson will include:

- Short video featuring scientists from the Children's Hospital of Philadelphia Research Institute discussing their work and how they utilize the lab equipment on a day-to-day basis
- Related reading passage
- Teacher guide
- Student worksheet

Additional VMP "A Look inside the Lab" videos and materials can be found at vaccinemakers.org/next-step-science.

OBJECTIVES

"A Look inside the Lab" series activities are designed to:

- Introduce students to equipment commonly used in medical research laboratory settings and explore how the technology impacts and serves society
- Introduce students to scientists, science careers, and the types of investigations that scientists conduct on a day-to-day basis
- Provide an opportunity for students to read informational text about scientific topics enhance their understanding of how science is done, and consider how scientists develop possible solutions to problems

LESSON RESOURCES

- Lesson video, *A Look inside the Lab: Liquid Nitrogen Freezer,* https://vimeo.com/522825384
- Video transcript PDF: https://vaccinemakers.org/sites/default/files/resources/Look%20in%20Lab_LiqNitroFrz_video%20transcript_FINAL.pdf
- Reading passage, *COVID-19 mRNA vaccines and the role of temperature,* https://vaccinemakers.org/sites/default/files/resources/Look_Lab_LIqNitroFrz_reading%20passage_FINAL.pdf
- Student worksheet: https://vaccinemakers.org/sites/default/files/resources/Look%20in%20Lab_LiqNitroFrz_worksheet_FINAL.pdf
- Temperature conversion tool and calculation information, Math is Fun, https://www.mathsisfun.com/temperature-conversion.html#explanation
- Vaccine storage and handling summaries, CDC,
    - "Pfizer-BioNTech COVID-19 Vaccine" https://www.cdc.gov/vaccines/covid-19/info-by-product/pfizer/downloads/storage-summary.pdf
    - "Moderna COVID-19 Vaccine" https://www.cdc.gov/vaccines/covid-19/info-by-product/moderna/downloads/storage-summary.pdf#:~:text=Vaccine%20vials%20may%20be%20stored,vaccine%20cannot%20be%20refrozen
- Press release, *Pfizer and BioNTech Submit COVID-19 Vaccine Stability Data at Standard Freezer Temperature to the U.S. FDA,* Pfizer, https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-submit-covid-19-vaccine-stability-data
- Article, *"Vaccine cold chain Q&A,"* PATH, https://www.path.org/articles/vaccine-cold-chain-q/

LESSON

The lesson progression outlined below can be completed in one 90-minute class or be split over two class periods.

Engage
Time: 10-15 minutes
Have students:

- Brainstorm ways that temperature is used in daily life. This can be done as a class, individually, or in small groups.
- Think of situations where extremely cold temperatures serve a purpose or solve a problem.

Explore
Time: 10-15 minutes
Have students:

- Watch the short video, *A Look inside the Lab: Liquid Nitrogen Freezer,* https://vimeo.com/522825384.
- Read the passage, "*COVID-19 mRNA vaccines and the role of temperature,*" https://vaccinemakers.org/sites/default/files/resources/Look_Lab_LIqNitroFrz_reading%20passage_FINAL.pdf. Have students note the temperature measurements of Celsius and Fahrenheit.

Explain
Time: 20-30 minutes
Have students:

- Complete the student worksheet, which includes temperature conversions and "think about it" questions: https://vaccinemakers.org/sites/default/files/resources/Look%20in%20Lab_LiqNitroFrz_worksheet_FINAL.pdf.
- Compare temperature conversions/scales as a class and engage in group discussion of the questions.

Elaborate
Time: 15-20 minutes
Have students:

- Review the CDC vaccine storage and handling guidelines for the COVID-19 mRNA vaccines and locate a news report about the role of temperature during distribution of the COVID-19 mRNA vaccines (or review a pre-selected news report, such as this one: *"Vaccine cold chain Q&A,"* https://www.path.org/articles/vaccine-cold-chain-q/). If time allows, you may also wish to introduce the Pfizer press release regarding the updated temperature stability data to reinforce the concept of thermal stabilization studies: https://www.pfizer.com/news/press-release/press-release-detail/pfizer-and-biontech-submit-covid-19-vaccine-stability-data.
- Draft a short paragraph that discusses how the need for cold temperatures might affect COVID-19 vaccine distribution and use.

Evaluate
Time: 20-30 minutes
Have students:

- Work in small groups to discuss what they discovered in their news report research. Ask them to focus on the challenges of temperature requirements on vaccine distribution and create a proposal for dealing with such challenges.
- If time allows, have each group present their proposal to the class.

RUBRIC: STUDENT WORKSHEET

°C to °F: Divide by 5, multiply by 9, then add 32

°F to °C: Subtract 32, multiply by 5, then divide by 9

Item	°F	°C	Calculation
Household refrigerator	**39.2°F**	4° C	4/5 = .8 .8 x 9 = 7.2 7.2 + 32 = **39.2**
Household freezer	**-0.4°F**	-18° C	-18/5 = -3.6 x 9 = 32.4 + 32 = **0.4**
Boiling point of water	212°F	**100°C**	212 - 32 = 180 x 5 = 900 /9 = **100**
Room temperature	**75.2°F**	24° C	24/5 = 4.8 x 9 = 43.2 + 32 = **75.2**
Moderate oven	350°F	**176.67°C**	350 - 32 = 318 x 5 = 1,590 /9 = **176.67**
Typical body temperature	98.6°F	**37°C**	98.6 - 32 = 66.6 x 5 = 333 /9 = **37**
High fever	103°F	**39.44°C**	103 -32 = 71 x 5 = 355 /9 = **39.44**
Liquid nitrogen freezer	**-310°F**	-190°C	-190/5 = -38 x 9 = -342 + 32 = **-310**
Pfizer-BioNTech COVID-19 vaccine	**-94°F**	-70°C	-70/5 = -14 x 9 = -126 + 32 = **-94**
Moderna COVID-19 vaccine	-4°F	**-20°C**	-4 - 32 = -36 x 5 = -180 /9 = **-20**
Antarctica – Coldest recorded temperature	**-129.28°F**	-89.6°C	-89.6/5 = -17.92 x 9 = -161.28 + 32 = **-129.28**
Sahara Desert– Hottest recorded temperature	136°F	**57.78°C**	136 - 32 = 104 x 5 = 520 /9 = **57.78**

Students may have different approaches to drawing the thermometer scale, but the scale should indicate the progression of temperatures from hottest to coldest or vice versa.

Moderate oven	350°F	176.67°C	Hottest
Boiling point of water	212°F	100°C	
Sahara Desert	136°F	57.78°C	
High fever	103°F	39.44°C	
Body temperature	98.6°F	37°C	
Room temperature	75.2°F	24°C	
Household refrigerator	39.2°F	4°C	
Household freezer	-0.4°F	-18°C	
Moderna vaccine	-4°F	-20°C	
Pfizer-BioNTech vaccine	-94°F	-70°C	
Antarctica	-129.28°F	-89.6°C	
Liquid nitrogen freezer	-310°F	-190°C	Coldest

Lesson questions:

- What do you think are the pros and cons of having two temperature systems?

  Answers may vary. Sample responses may include things like:
  Pro-
  - Most people are used to using one system, so removing one of the systems could cause confusion for the group that had to abandon the system they normally use and learn a new one.
  - Measuring tools like thermometers or sensors would need to be replaced, which could be inconvenient and expensive for some people/businesses.

  Con-
  - If people who use one system are interacting or sharing data with people who use another system, it could cause confusion since they are working with different numbers
  - Having two systems increases the need for converting temperatures and, therefore, increases the chance for errors.

- What do you think are the most important considerations for people working with liquid nitrogen freezers?

  Answers may vary. Sample responses may include:
  - Using proper personal protective equipment to ensure tech safety
  - Making sure the temperature is accurate and stable to avoid degradation of any stored items such as cells or vaccines
  - Knowing the proper techniques to put items into or bring items out of extremely low temperatures.
  - Making sure the environment is suitable for the equipment, e.g. restricted access, proper power supply, regular maintenance protocols

- Why are thermal stabilization experiments important in vaccine development?

  Thermal stabilization experiments are important to determine the stability of a vaccine at different temperatures. The experiments help scientists learn how a product reacts to different temperatures. This information informs storage guidelines to ensure the vaccine does not degrade and will remain effective.

  These experiments can also be used to help figure out more convenient storage temperatures since vaccines that do not need special cold storage equipment could be made more widely available.