IGNITE ACTIVITY

SOLID WATER

STEM²D Topic:
SCIENCE

Target Population:
Students, ages 11-14

Solid Water is part of the STEM²D **Student Activities Series** developed by FHI 360 as part of Johnson & Johnson's WiSTEM²D initiative (**W**inning in **S**cience, **T**echnology, **E**ngineering, **M**ath, **M**anufacturing, and **D**esign). The series features interactive and fun, hands-on activities for youth.

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ACTIVITY DESCRIPTION

Students will explore science and learn about the physical process involved when elements switch states, specifically, water at the freezing point.

ESTIMATED TIME

This activity is intended to be done at a career fair, science fair, exhibit, or other type of "booth" event. It typically takes **10 to 15 minutes** to complete.

STUDENT DISCOVERIES

Students will:

- Learn about the physical process involved in elements switching states, specifically, water at the freezing point.
- Build important STEM²D skills, such as thinking critically, drawing conclusions.
- Realize that STEM²D offers diverse and exciting career opportunities.
- Be inspired to participate in other types of STEM²D experiences.
- Have fun experiencing STEM²D.

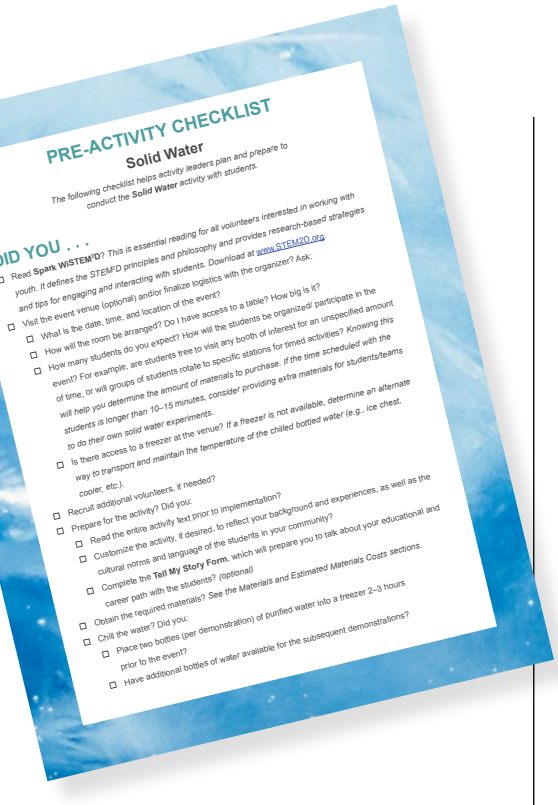
GETTING READY

Materials:

- Pre-Activity Checklist
- Tell My Story Form, *optional*
- Hand wipes or paper towels (for cleanup)
- Tablecloths (number required depends on tables being used)

STEM²D Skills

- Critical Thinking
- Drawing Conclusions


PRE-ACTIVITY CHECKLIST

Solid Water

The following checklist helps activity leaders plan and prepare to conduct the **Solid Water** activity with students.

- Solid Water materials, *1 set of the following items per demonstration:*
  - 2, 8 oz bottles of purified water, chilled in freezer for 2–3 hours
  - 1 bowl of ice
- Freezer or cooler filled with ice
- STEM²D brochures, flyers, or other informational materials, *optional*

Estimated Cost:

Activity leaders can expect to incur less than $15.00 in materials costs when conducting this activity multiple times with student groups.

Activity Leader Preparation

1. Read **Spark WiSTEM²D**. This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.
2. See the **STEM²D Student Activities Overview** for additional information.
3. Review the **Pre-Activity Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
4. Begin cooling the bottled water up to three hours before the demonstration; the site must have a freezer or cooler stocked with ice to keep the bottled water chilled.
5. Set up the display, lining the tables with tablecloths. See Materials section for a list of required materials and the **Pre-Activity Checklist** for additional instructions.

KEY WORDS

- Chemistry
- Nucleation
- Nucleus
- STEM²D

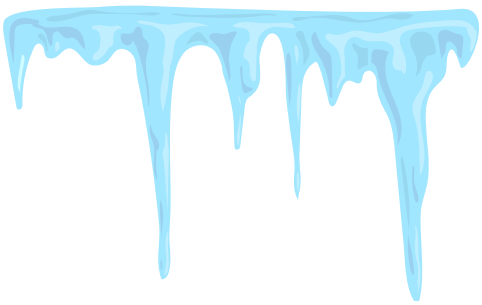
STEP-BY-STEP INSTRUCTIONS: SOLID WATER

1. **Welcome & Introductions (1–2 minutes)**
    - Welcome the students as they arrive at the table/booth.
    - Introduce yourself by saying your name, title, and your organization/company.
    - Explain that your career is one of many STEM²D careers. Indicate:
        - **STEM²D** refers to Science, Technology, Engineering, Math, Manufacturing, and Design.
        - Individuals with an interest or degree in these areas are in demand.
    - Ask the other volunteers and students to introduce themselves.
2. **Learning Activity (5–7 minutes)**
    - Introduce the activity. Ask:
        - Do you know at what temperature water freezes?
    - Explain:
        - Contrary to popular conception, not all water freezes at exactly 0º Celsius (32º Fahrenheit).
        - To freeze, water requires **nucleation**: a physical process in which a change of state—for example, water changing from a liquid to a solid—occurs around a certain focal point, known as a nucleus.
        - The **nucleus** is the central part of a cell and forms the basis for its activity and growth. It is the main control center for the cell.
        - When water changes states, this nucleus is usually a speck of dust, dirt, or other particle in the water.
    - Start the demonstration. Carefully remove one bottle of water from the freezer or cooler. Jostling, dropping, or otherwise abruptly moving the water will start the freezing process too early.
    - Tell the students that the water has been in the freezer for 2–3 hours.
    - Show the students that the bottled water is not frozen.

TIPS FOR ENGAGING STUDENTS

Involve students in the demonstration:

- Check frequently for understanding by asking open-ended, topic-specific, or process questions.
- Ask students to talk about what they already know.
- Encourage students to ask questions to gain deeper understanding.
- Encourage students at every opportunity to predict what will happen.



- Tap the bottle hard on its side with your finger or knock the bottle against the table—ice should begin to form at the point of impact and continue forming until the entire bottle is frozen.
- Invite students to share their observations and reflections. Ask:
  - Why did the water suddenly change state?
  - What happened?
- Explain the reaction.
  - We used purified water. Purified water contains very few particles that can act as the nuclei. This is the reason purified water can be colder than 0º Celsius (32º Fahrenheit) and not freeze.
  - The impact forced the chilled water molecules at the point of impact into a crystal. The crystal served as the nucleus, which was needed for nucleation, and resulted in a chain reaction that quickly froze the entire bottle!
- Start the second demonstration:
  - Take your second bottle of water carefully out of the freezer or cooler. Again, do not make any sudden movements.
  - Open the bottle and slowly pour the water on the bowl of ice; the water should freeze as it hits the ice, creating a tower roughly the consistency of a snow cone.
- Initiate a discussion by asking one or more of the following questions:
  - Why did the water suddenly change state?
  - What happened?
- Explain:
  - In this second demonstration, the ice below acted as the nucleus in nucleation. The water, which was already cold enough to freeze, froze from the point of contact with the ice.

3. **Student Reflection (2 minutes)**
    - Wrap up the activity by asking any of the following reflection questions:
        - What did you learn about how water freezes?
        - What surprised you?
        - How can the process of nucleation be readily observed every day?
        - What types of careers might someone consider if they are excited or intrigued by these experiments?
    - If time permits, describe the STEM²D disciplines this activity touches on:
        - Clouds are an everyday example of nucleation; they consist of water vapor that clusters around pollutants or other particles floating in the atmosphere.
        - Rock candy is an everyday product that depends on nucleation; it is a sugar crystal (solid) created when a sugar solution (liquid) undergoes nucleation.
        - Today we observed, studied, and experimented to better understand the natural world and how it works. This is **science**; two branches of science—**chemistry** and **physics**—were the focus of this activity.

EXTENDED LEARNING

You can extend student learning or expand this activity to a one-hour activity by:

- **Allowing Students to Experiment.** Provide students their own supercooled water bottles to flash freeze.
- **Incorporating other Examples.** The ever-popular demonstration of dropping mints into a bottle of soda provides another example of nucleation. In this case, the sugar crystals atop the mints act as nuclei; carbon from the soda coalesces around these nuclei, creating large pockets of gas. This in turn creates an explosive effect and sends soda gushing into the air. You can use this experiment to show students that nucleation looks very different when occurring in liquids and gases, but that the underlying phenomenon—molecules coalescing around a nucleus to create a quick change in state—is the same.

TIPS ABOUT STEM²D CAREERS

Share with students that there are many different kinds of careers related to STEM²D. Some STEM²D careers related to this activity are:

- Chemical manufacturing
- Food preparation
- Engineering
- Experimental science

Key Words

Chemistry: The branch of science that deals with the identification of the substances of which matter is composed; the investigation of their properties and the ways in which they interact, combine, and change; and the use of these processes to form new substances.

Nucleus: The central and most important part of an object, movement, or group, forming the basis for its activity and growth (plural: **nuclei**).

Nucleation: A physical process in which a change of state—for example, liquid to solid—occurs in a substance around certain focal points, known as nuclei.

Physics: The branch of science concerned with the nature and properties of matter and energy. The subject matter of physics, distinguished from that of chemistry and biology, includes mechanics, heat, light and other radiation, sound, electricity, magnetism, and the structure of atoms.

Science: Observing, studying, and experimenting to better understand the natural world and how it works.

STEM²D: An acronym referring to the Science, Technology, Engineering, Math, Manufacturing, and Design disciplines.

Resources and References

Activity concepts and real-life connections adapted from:

- "Helmenstine, Dr. Anne Marie. "Nucleation Definition (Chemistry and Physics)." ThoughtCo., 11 September 2017. Accessed 15 November 2018. https://www.thoughtco.com/definition-of-nucleation-605425
- "Thompson, Grant. "Turn Water into Ice Instantly!" IFL Science! Accessed 15 November 2018. https://www.iflscience.com/chemistry/turn-water-ice-instantly/
- "What is Nucleation?" Wise Geek. 11 October 2018. Accessed 15 November 2018 https://www.wisegeek.com/what-is-nucleation.htm

PRE-ACTIVITY CHECKLIST

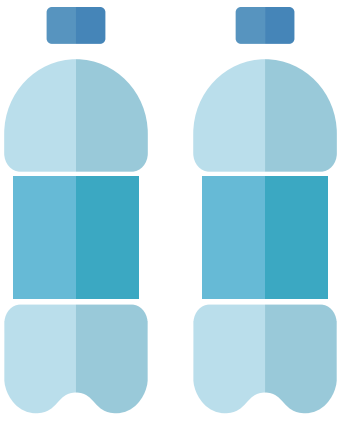
Solid Water

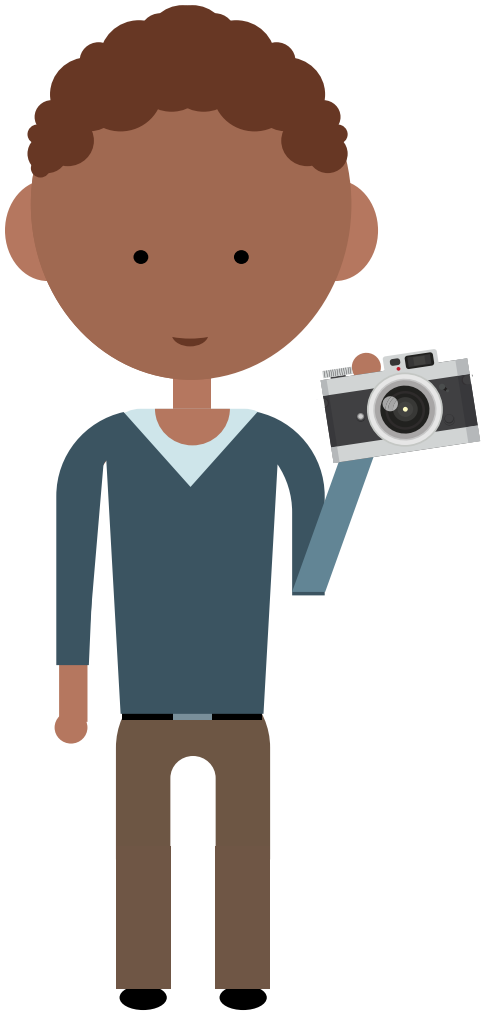
*The following checklist helps activity leaders plan and prepare to conduct the **Solid Water** activity with students.*

DID YOU . . .

- ☐ Read **Spark WiSTEM²D**? *This is essential reading for all volunteers interested in working with youth. It defines the STEM²D principles and philosophy and provides research-based strategies and tips for engaging and interacting with students. Download at www.STEM2D.org.*
- ☐ Visit the event venue (optional) and/or finalize logistics with the organizer? Ask:
  - ☐ What is the date, time, and location of the event?
  - ☐ How will the room be arranged? Do I have access to a table? How big is it?
  - ☐ How many students do you expect? How will the students be organized/participate in the event? For example, are students free to visit any booth of interest for an unspecified amount of time, or will groups of students rotate to specific stations for timed activities? *Knowing this will help you determine the amount of materials to purchase. If the time scheduled with the students is longer than 10–15 minutes, consider providing extra materials for students/teams to do their own solid water experiments.*
  - ☐ Is there access to a freezer at the venue? *If a freezer is not available, determine an alternate way to transport and maintain the temperature of the chilled bottled water (e.g., ice chest, cooler, etc.).*
- ☐ Recruit additional volunteers, if needed?
- ☐ Prepare for the activity? Did you:
  - ☐ Read the entire activity text prior to implementation?
  - ☐ Customize the activity, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
  - ☐ Complete the **Tell My Story Form**, which will prepare you to talk about your educational and career path with the students? *(optional)*
- ☐ Obtain the required materials? *See the Materials and Estimated Materials Costs sections.*
- ☐ Chill the water? Did you:
  - ☐ Place two bottles (per demonstration) of purified water into a freezer 2–3 hours prior to the event?
  - ☐ Have additional bottles of water available for the subsequent demonstrations?

- ☐ Practice your presentation? Do the demonstration activity? *Make sure you can explain the concepts to students, if needed, and that you know the correct answers.*
- ☐ Set up the site appropriately for the activity? Did you:
  - ☐ Line table(s) with a tablecloth to contain spills or leaks and ease cleanup?
  - ☐ Place a bowl of ice on the table?
  - ☐ Have the chilled, purified bottled water readily available? *If a freezer is available on-site, the water can remain there, but you may also want to consider using a cooler so the chilled water and ice can be in close proximity.*
- ☐ Bring a camera, if desired, to take photographs?
- ☐ Obtain and collect permission slips and photo release forms for conducting the activity, if applicable?
- ☐ **Have fun!**





Tell My Story Form

This form will help activity leaders and other volunteers prepare to talk about their STEM²D interests, education, and career path.

ABOUT YOU

Name: _____

Job Title: _____

_____

Company: _____

When/Why did you become interested in STEM²D? _____

_____

_____

What do you hope young people will get out of this activity?_____

_____

FUN FACT:

Share a little about your background. Ideas:

- Share a memory from childhood when you first had your 'spark' or 'interest' in STEM²D.
- Detail your journey—highlight what you've tried, what you learned, steps to success, etc.
- Failures or setbacks are also great for talking about difficulties and/or challenges and how you overcame them.

EDUCATION AND CAREER PATH

What classes/courses did you take in secondary school and in college that helped or interested you most? _____

_____

How did you know you wanted to pursue a STEM²D career? _____

_____

What was your postsecondary path, including the institution you attended and your degree? *If you switched disciplines, make sure you explain why to the students.* _____

_____

What your current position entails. *Be sure to include how you use STEM²D during a typical work day.* _____

_____

This activity was written by Johnson & Johnson's Bridge to Employment (BTE) Student Ambassadors 2018: William Green, BTE–Trenton, New Jersey; Ivy Machaka, BTE–Leeds, UK; and Maria Rana, BTE—High Wycombe, UK.

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