

**PUTTING WIND
ENERGY TO WORK**
STEM²D Topics:
Design

Target Population:
Students, ages 10–15



Putting Wind Energy to Work is part of the Student Activities Series developed by FHI 360 for Johnson & Johnson's WiSTEM²D initiative (Winning in Science, Technology, Engineering, Math, Manufacturing, and Design). The series features interactive and fun, hands-on activities for youth.

PUTTING WIND ENERGY TO WORK

STEM²D Topic: Design

Target population: Students, ages 10–15

ACTIVITY DESCRIPTION

In this team-based, hands-on activity, students will learn how wind is used to generate energy and will learn about the design process by designing a wind turbine.



ESTIMATED TIME

This session typically takes **140 minutes** to complete and should be conducted in **one** session.

STUDENT DISCOVERIES

Students will:

- Participate in a team-based learning experience.
- Build important STEM²D—Science, Technology, Engineering, Math, Manufacturing, and Design—skills, such as creative thinking, critical thinking, problem solving, testing, and teamwork.
- Realize that STEM²D offers diverse and exciting career opportunities.
- Have fun experiencing STEM²D.

GETTING READY

Materials:

- Pre-Activity Checklist
- Tell My Story Form
- Computer with projector, speakers, and Internet access
- Video: What Is the Engineering Design Process? (PBS Learning Media) <https://thinktv.pbslearningmedia.org/resource/phy03.sci.engin.design.desprocess/what-is-the-engineering-design-process/#.XV2zR5NKjOQ>
- PowerPoint: Putting Wind Energy to Work



STEM²D Skills

- Collaboration
- Communication
- Creative Thinking
- Critical Thinking
- Decision Making
- Teamwork
- Testing

- Student Handout: Putting Wind Energy to Work Challenge, *1 per student*
- Student Handout: Wind Turbine Templates, *1 per team*
- Pencils, *1 per student*
- Wind Turbine Challenge Kit, *1 set of the following items per team of three to four students:*
 - 3 sheets of plain paper, 8 ½ in. x 11 in. (22 cm x 28 cm)
 - 3 sheets of construction paper, 8 ½ in. x 11 in. (22 cm x 28 cm)
 - 1 single-hole punch
 - 1 pair of scissors
 - 4 rubber bands
 - 6 straws
 - 2 paper cups
 - Piece of string (20 in. or 51 cm)

Estimated Materials Cost:

Activity leaders can expect to incur less than \$40.00 in materials costs when completing this activity with 30 students organized into teams of three or four students.

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 STEM2D.org.
2. Review the **Pre-Activity Checklist** (at the end of this document) for details and specific steps for planning, preparing, and implementing this activity.
3. See the **STEM²D Student Activities Overview** for additional information.



STEP-BY-STEP INSTRUCTIONS: PUTTING WIND ENERGY TO WORK

1. Welcome and Introductions (5 minutes)

- Welcome the students.
- Introduce yourself by saying your name, title, and your organization/company.
- Share that students will be learning about STEM²D careers and will be applying STEM²D skills during the session.
- **(What is STEM²D? Slide)** Explain that **STEM²D** refers to: Science, Technology, Engineering, Math, Manufacturing, and Design.
- Ask students and other volunteers to introduce themselves and state their favorite area of STEM²D and why it is their favorite.
- **(Today's Plan Slide)** Review the agenda. Explain that today students will design a **wind turbine**. Share that they will be able to put their own skills to use in the team design activity.

2. Career Awareness: Design and Engineering in the World of Work (10 minutes)

- **(STEM²D in the World of Work Slide)** Initiate an opening discussion and brainstorming activity. Consider asking:
 - How do you think design is used every day in the workplace?
 - What kinds of careers do you think people with an interest, aptitude for, or degree in design would have?
- **(Tell My Story Slide)** Talk about your educational and career path. Use the Tell My Story form as the basis for your remarks. Be prepared to describe your job or a typical day, and provide information about your background including:
 - When/why you developed an interest in design and/or engineering.
 - The classes/courses you took in secondary school.
 - Your post-secondary 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 design and/or engineering and what you do on a typical work day.*



KEY WORDS

- Biomass Energy
- Constraint
- Cost-Effective Energy
- Fossil Fuels
- Geothermal Energy
- Hydropower
- Pollute
- Prototype
- Renewable
- Solar Energy
- Sustainable
- Wind Energy
- Wind Turbine



TIPS ON STARTING CONVERSATIONS

- What area of STEM²D is your favorite?
- Why did you choose that area of STEM²D as your favorite?
- What would your dream job be?
- Where do you see yourself in 5–10 years?



TIPS ABOUT STEM²D CAREERS

Share with students that there are many different kinds of careers related to STEM²D.

Possible STEM²D careers related to this activity:

- Architectural Engineer
- Design Engineer
- Industrial Design Engineer
- Manufacturing Engineer
- Mechanical Engineer
- Production Engineer

TIPS FOR MAKING CONNECTIONS

Encourage students to:

- Ask questions if they don't understand
- Summarize what they have learned
- Explain their thinking process aloud
- Generate multiple ideas before choosing the idea they believe is best
- Make changes to their design when they feel these are needed

- Weave in facts about design, engineering, and STEM²D careers:
 - Tell the students that your career is only one of the many careers available in the STEM²D disciplines.
 - Explain that STEM²D careers are high-demand, high-growth careers and are predicted to remain in demand for at least the next ten years.
 - Share a few Johnson & Johnson job titles and careers that align with the design or engineering concepts addressed in this activity.

3. Content Presentation (30 minutes)

- **(What is Energy? Slide)** Explain: **Energy** is the ability to do work. It is also known as power. Energy exists all around us. The main source of energy is the sun. Other sources of energy are: wind, water, geothermal, and biomass.
- **(Types of Energy Slide)** Review and define the following types of energy:
 - **Wind Energy:** energy that is created using the wind
 - **Solar Energy:** energy that comes from the sun
 - **Hydropower Energy:** energy that is generated from moving waters, such as rivers
 - **Geothermal Energy:** energy that comes from inside the Earth that can be converted into electricity
 - **Biomass Energy** a form of energy where organic matter is turned into heat, electricity, or liquid fuel
- **(What Runs on Energy? Slide)** Ask students: What runs on energy? Give a few examples if needed: television, lights, washer and dryer, automobiles.
- **(Why is Wind Energy Important? Slide)** Highlight the important aspects of wind energy; provide definitions, as needed:
 - It is **renewable**. (*Define **renewable**: replaced naturally and can be used again.*)
 - It is **cost-effective**. (*Define **cost-effective**: productive in relation to its cost.*)
 - It is **sustainable**. (*Define **sustainable**: able to be maintained at a certain rate or level.*)

- It does not **pollute**. (*Define **pollute**: to contaminate with harmful or poisonous substances.*)
- It reduces the use of **fossil fuels**. (*Define **fossil fuels**: fuels that come from old life forms that decomposed over a long period of time.*)
- Initiate a discussion. Call on one or two students to respond to the following questions. *Note: Correct answers are not required. You are simply looking to gauge the level of knowledge before you start the activity.*
 - Have you ever seen a wind turbine?
 - What does it look like?
 - What do you think wind turbines are used for?
 - How do you think wind turbines work?
- **(Wind Turbines Slide)** Show students pictures of wind turbines. Explain that a **wind turbine** converts kinetic energy (movement from the wind) into electrical power.
- **(Parts of a Wind Turbine Slide)** Indicate: a simple wind turbine consists of five main parts: blades, shaft, gear box, generator, and brake.
- Explain how wind turbines work:
 - When the wind blows, it turns the blades on the turbine, causing them to rotate or spin. The motion of the blades turning is kinetic energy. It is this power that we need to generate electricity.
 - A shaft connects the spinning blades with the gear box.
 - The movement of the blades drives the gear box and turns the generator, producing electricity.
 - The turbines are also fitted with a brake.
 - Wind turbines are mounted on towers to maximize the energy that can be captured from the wind. The higher the blades, the more they can take advantage of faster and less turbulent wind.
- **(Putting Wind Energy to Work Challenge Slide)** Introduce the challenge. Indicate that students will work as a team and use the six-step design process to design, build, and test a wind turbine.
- Break the group into teams of three to four students.

- **(What is the Engineering Design Process? Slide)** Indicate that having a basic understanding of the design process will help them succeed in this challenge. Click the link in the PowerPoint to watch the 5-minute video, which provides an overview.
- **(The Design Process Slide)** State that there are many different design processes; in today's activity, teams will use a six-step design process to create the wind turbines:
 1. **(Identify the Challenge Slide)** Determine what the problem is that you're trying to solve. Identify any constraints (size, weight, budget, what materials are available, etc.).
 2. **(Brainstorm Slide)** Exchange ideas with your team for tackling the challenge. Record or sketch ideas. There is no such thing as a bad idea!
 3. **(Design a Solution Slide)** Use the information from the research and brainstorming sessions to determine which brainstormed ideas are really possible given available time, tools, and materials. Agree on an idea to take forward and determine materials to be used.
 4. **(Test Ideas Slide)** Build a prototype and test it.
 5. **(Evaluate Slide)** Look at your solution and see if it solved the problem. If your initial design didn't solve the problem or satisfy the constraints, then revise the design, research or brainstorm new ideas, and then retest. The design process is only complete when the best solution has been identified.
 6. **(Build It! Slide)** Build the final – best solution – design!
- **(Questions? Slide)** Ask the students if they have any questions about the design process or how wind turbines work.

4. Learning Activity: Putting Wind Energy to Work Challenge (40 minutes)

- **(Putting Wind Energy to Work Challenge Guidelines Slide)** Reiterate the challenge guidelines: Students will work as a team and use the six-step design process to design,

build, and test a working wind turbine. Teams can use the design templates provided or they can create their own design. Teams have 30 minutes to complete the challenge.

- **(Putting Wind Energy to Work Challenge Kit Slide)** Distribute the Challenge Kits to each team. Review the materials. If there are additional volunteers, ask them to help assist with distribution and assign them to work with specific teams.
- **(Putting Wind Energy to Work Challenge Instructions Slide)** Give the following instructions:
 1. *Review the Challenge.* As a team use the Student Handouts to review the challenge.
 2. *Brainstorm ideas for your wind turbine.* You may use one of the templates provided (as is or with changes) or sketch new designs for your wind turbine. Keep in mind, you may only use the materials provided when building your design.
 3. *Design a Solution.* Together with your teammates, choose one wind turbine design. Use the materials provided to build a prototype or preliminary model of your wind turbine based on your design. For more details on building a wind turbine, follow the instructions on the Putting Wind Energy to Work Challenge. Test the prototype. As you blow on the wind turbine, the blades should turn (with straw rotating), winding the string and lifting the cup.
 4. *Evaluate.* Make changes as needed based on the results of your test.
- Teams have 30 minutes to build a wind turbine. Keep an eye on the time.
- Once all wind turbines are built, we will test the wind turbines to see if they are successful in lifting the cup.
- Facilitate group work by walking around the room observing and asking students questions about their designs. Do not give suggestions—this will ensure that students maintain ownership of their designs. Provide support and answer questions as needed.
- Ensure all students are participating in the team task; give encouragement to students who may not be as involved/engaged.



TIPS FOR WORKING WITH STUDENTS

- Encourage students to be creative in their designs.
- Ask open-ended questions to encourage student reflection and discussion.
- For example:
 - Can you tell me about your design?
 - What do you think you could do to make the cup lift faster?
- Help students stay on track with time during the group challenge.
- Encourage all students to participate in the different stages of the challenge.
- Move around the learning space and provide support when necessary.

- Remind students that, before the 30-minute deadline, they may make as many alterations to their designs and test as often as needed.

5. Putting Wind Energy to Work Testing (40 minutes)

- After 30 minutes, reconvene the large group. Explain that the teams will now test their prototypes. Indicate that all students must observe the testing; no further work can take place on wind turbines during testing.
- **(Testing Our Wind Turbines Slide)** Ask each team to send a representative with the team's wind turbine to a designated testing area.
- Once all wind turbines are in the designated area, inform the teams that they cannot remove their wind turbines or make any alterations.
- Choose a team at random to join their representative in the testing area.
- Ask the team to show their wind turbine to the group and describe it.
- Ask the team the following two questions:
 1. What is the best feature of your design?
 2. What was difficult about designing and building your wind turbine?
- Ask the team to test their wind turbine by blowing on the blades in order to raise the cup with the string.
- Following the test, allow the first team to sit down, and randomly choose the next team to test their wind turbine. Have the team show their wind turbine to the group and describe it. Ask the two questions, as noted above.
- Repeat this process until all teams have tested their wind turbines.

6. Recap (10 minutes)

- **(What Did We Learn? Slide)** Have students recap the lessons learned during the activity by asking one or more of the following questions:
 - What did you notice about the size of the wind turbine blades and how fast or slow the cup was lifted?
 - What would you change about your design if you were to do it again?
 - Why did some wind turbines work better than others? What was different about the wind turbine designs?

7. Reflection (5 minutes)

- **(Reflection Slide)** Ask students to reflect on the activity. Pose one or more of the following questions; encourage students to write their thoughts or share with a partner:
 - What did you learn about the design process?
 - How do you think this activity relates to a career in design or engineering at Johnson & Johnson?
 - Can you see yourself as a STEM²D professional? Why or why not? Which roles?
 - What would you need to do to make that happen?

Extended Learning

You can extend student learning by having students (or teams):

- Research the design of wind turbines currently in service or used throughout history around the world.
- Use all stages of the design process to bring an idea to life for a new product or for an improvement of an existing product.
- Research the use of wind energy in your country.

Key Words

- **Biomass Energy:** a form of energy in which organic matter is turned into heat, electricity, or liquid fuel
- **Constraint:** a limitation or restriction
- **Cost Effective:** productive in relation to its cost
- **Energy:** the ability to do work. It is also known as power.
- **Fossil Fuels:** fuels that come from old life forms that decomposed over a long period of time
- **Geothermal Energy:** energy that comes from inside the Earth that can be converted into electricity
- **Hydropower:** energy that is generated from moving water, such as rivers
- **Pollute:** to contaminate with harmful or poisonous substances
- **Prototype:** a simple model that lets you test your idea
- **Renewable:** replaced naturally and can be used again
- **Solar Energy:** energy that comes from the sun
- **Sustainable:** able to be maintained at a certain rate or level
- **Wind Energy:** energy that is created using the wind
- **Wind Turbine:** generates electricity through wind energy

Resources and References

This activity was adapted from content and materials created by the Johnson & Johnson Global Strategic Design Office.

The following resources provide additional information or activities:

- Building Your Own Wind Turbine: <https://www.sustainablelearning.com/resource/build-your-own-wind-turbine>
- Environment for Kids: Wind Power: https://www.ducksters.com/science/environment/wind_power.php
- Wind Power: <https://www.nationalgeographic.com/environment/global-warming/wind-power/>
- PBS Design Squad: <http://pbskids.org/designsquad/>

PRE-ACTIVITY CHECKLIST:

PUTTING WIND ENERGY TO WORK

The following checklist helps activity leaders plan and prepare to conduct the Putting Wind Energy to Work 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 implementation site and observe the young people? (optional) If so, take note of the following:
 - How does the site encourage orderly participation? For example, do the young people raise their hands when responding to questions or during discussions? How are interruptions handled? Do you see any potential problems with managing the class of young people?
 - What does the site do to make each student feel important and at ease?
 - How is the room arranged? Will you need to move desks or chairs for any part of your presentation?
 - How can you engage the site representative in your presentation?
- Meet with and finalize the logistics with the site representative?
 - Confirm the date, time, and location of the activity?
 - Confirm the technology needs? *Do you need to bring a computer and a projector to show the PowerPoint? Or, does the site have one that you can borrow? Does the site have Internet access? Can you use it during the activity to show the videos?*
 - Confirm the number of students attending? *Knowing this will help you decide how to separate the class into teams, as well as the appropriate materials to purchase.*
- Recruit additional volunteers, if needed?
- Prepare for the activity? Did you:
 - Read the entire activity text prior to implementation?
 - Customize the activity and tailor the PowerPoint, if desired, to reflect your background and experiences, as well as the cultural norms and language of the students in your community?
 - Review the notes section of the slides in the PowerPoint for information to be shared?
 - Pre-view the video?

- Complete the Tell My Story Form, which will prepare you to talk about your educational and career path with the students? *If desired, include key points about your story on the PowerPoint (see **Tell My Story Slide**).*
- Create a designated area for testing the wind turbines?
- Practice your presentation, including the hands-on, minds-on activity? Be sure to:
 - Do the activity; make sure you are able to explain the concepts to students, if needed, and that you know the correct answers.
- Obtain the required materials? (see the **Materials** and **Estimated Materials Costs** sections)
 - Set up the site appropriately for the activity? Specifically:
 - Make sure tables and chairs are arranged to accommodate teams of 3-4 students.
 - Choose an area to be used for testing wind turbines.
 - If additional volunteers are available, assign adults to specific teams.
 - Set up the computer and projector for the PowerPoint presentation; be sure that speakers and an Internet connection are available to show the video.
 - Bring a camera to take photographs, if desired.
 - 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 volunteers prepare to talk about their STEM²D interests, education, and career path in a relevant and personal way.

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:

- o Share a memory from childhood when you first had your spark or interest in STEM²D.
- o Detail your journey, highlighting what you have tried, what you learned, steps to success, etc.
- o Failures or setbacks are also great to talk 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. _____

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

PUTTING WIND ENERGY TO WORK CHALLENGE¹

Student Handout

The Challenge:

As a team, design, build, and test a working wind turbine. Use only the materials provided.

Successful designs ensure that the wind turbine moves as a unit – the blades smoothly turn (with straw rotating), winding the string and lifting the cup.

Time:

30 minutes

Materials:

- Student Handout: Wind Turbine Templates
- 3 sheets of plain paper
- 3 sheets of construction paper
- 1 single-hole punch
- 1 pair of scissors
- 4 rubber bands
- 6 straws
- 2 paper cups
- String (20 in. or 51 cm)
- Pencil

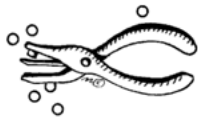
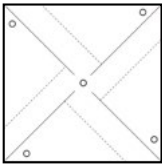
Instructions:

1. **Review the Challenge.** Determine what the problem is that you're trying to solve. Identify any constraints. Review the challenge materials.
2. **Brainstorm.** Look at the templates. Exchange ideas with your team about the templates, modifications or new designs. Teams may use one of the design templates (as is or with changes) or elect to create a unique design. If altering the design or creating a new design, use the steps in the "Test Your Ideas" section to guide your thinking. Record the ideas. There is no such thing as a bad idea!

¹ Source: PBS Learning Media. https://whut.pbslearningmedia.org/resource/phy03.sci.engin.design.lp_windmill/windmills-putting-wind-energy-to-work/.

3. **Design a Solution.** Use the information from the research and brainstorming sessions to determine which brainstormed ideas are really possible given available time, tools, and materials. Agree on an idea (template or design) to take forward and determine materials to be used.

4. **Test Ideas.** Build a prototype wind turbine and test it. Follow the detailed instructions:



- Using the selected template or new design, draw the pattern on a sheet of plain or construction paper. Transfer all of the lines and circles of the pattern.
- Use a pencil or single-hole punch to punch a hole through the circle in the center. (You may need to fold the pattern in half to reach the circle with the single-hole punch). Then punch a hole in each corner circle.
- Cut along the solid lines, making sure not to cut into the center hole.
- Insert a straw through the center hole.
- Fold each corner back along the dotted lines. Insert the straw through each corner hole. Slide the wind turbine to the center of the straw.
- Wrap a rubber band around the straw on each side of the wind turbine to keep the wind turbine in place.
- Punch holes on opposite sides of a small paper cup. Thread one end of the string through first one hole and then another and tie it back on itself over the middle of the cup, as shown. Tie the other end of the string to one end of the straw.
- Hold the straw with both hands as shown. Blow on the wind turbine. As the wind turbine turns, the straw will rotate, winding the string and lifting the cup.

5. **Evaluate.** Look at your solution and see if it solved the problem. For a good working design, you need to make sure the wind turbine and straw move as a unit and the string doesn't slip as the straw rotates.

If your initial design didn't solve the problem or satisfy the constraints, then research and brainstorm new ideas, create new designs, and then test.

6. **Build It!** Build the final prototype.

Performance Testing:

After 30 minutes, we will test each team's prototype as a group and see which design works the best.

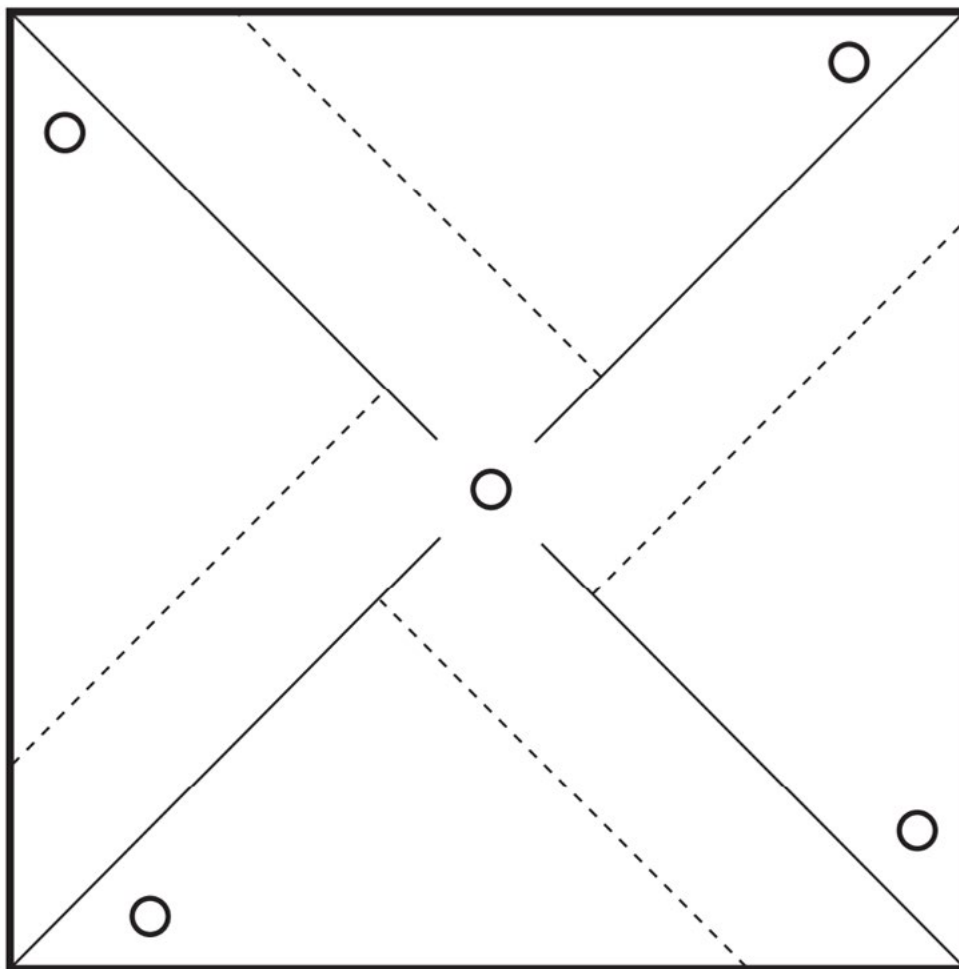
Teams should be able to answer the following questions as part of performance testing:

- What is the best feature of your design?
- What was difficult about designing and building your wind turbine?

WIND TURBINE TEMPLATES²

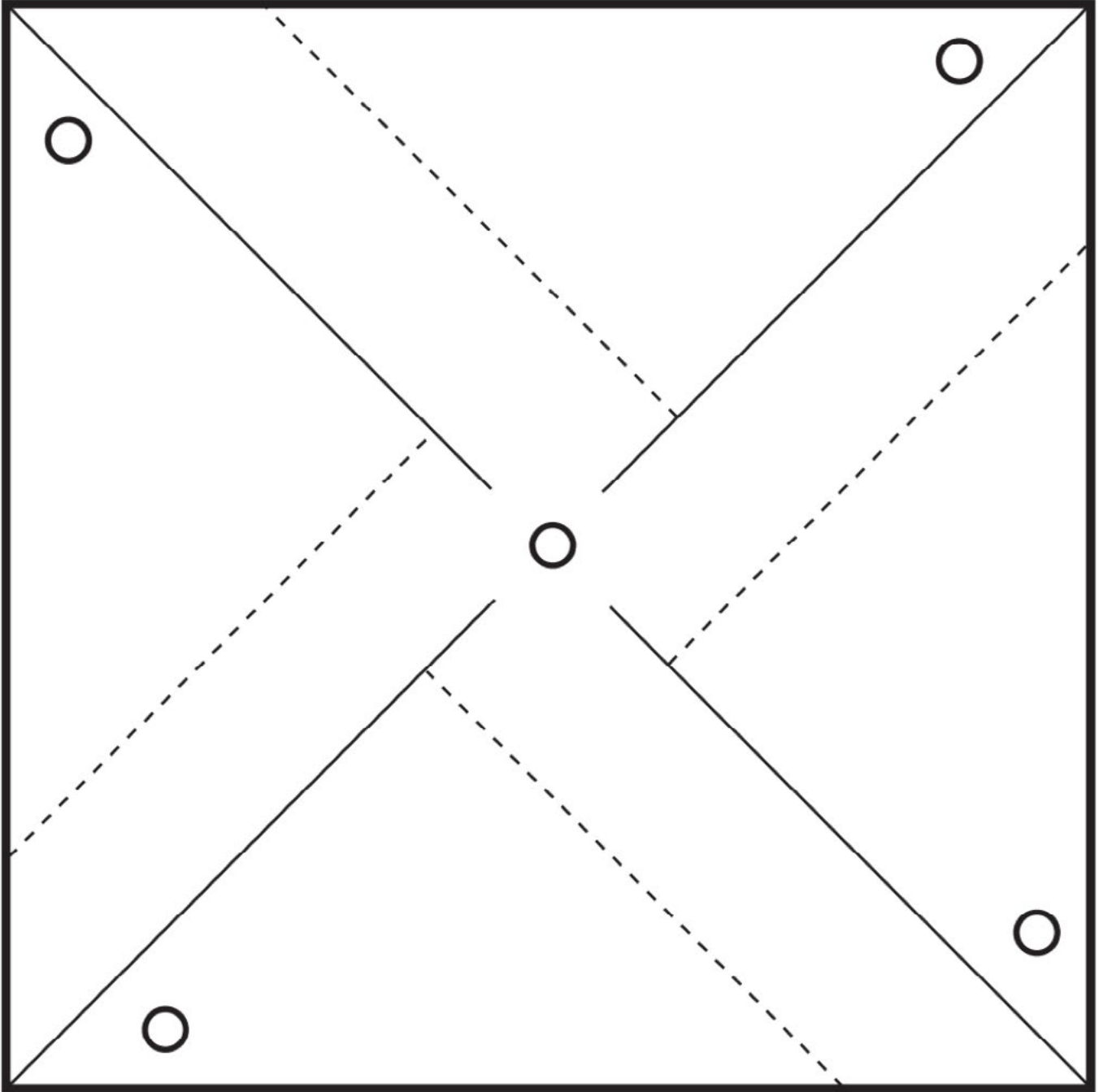
Student Handout

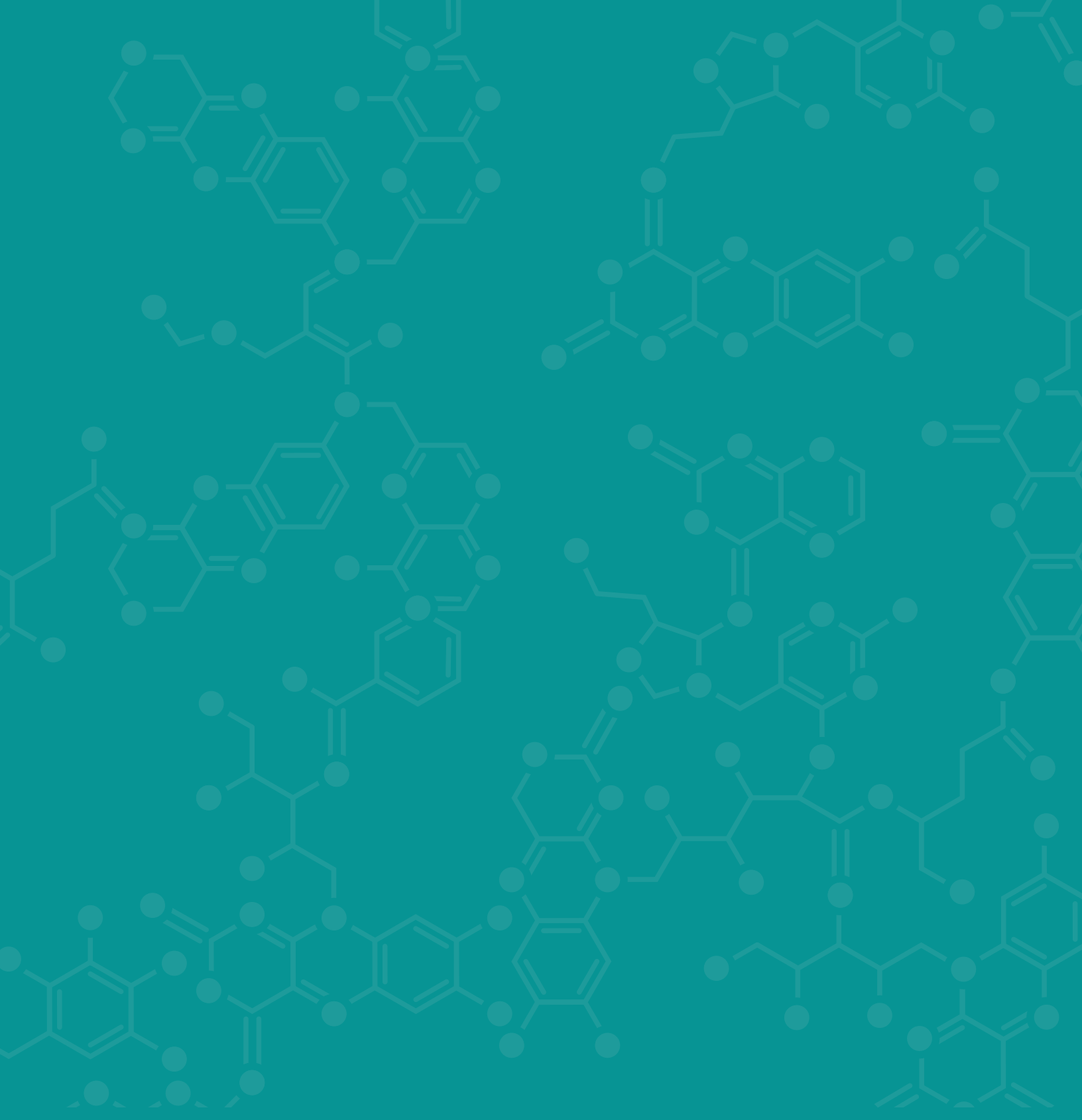
TEMPLATE 1 (5" X 5" DESIGN)



² Source: PBS Learning Media. https://whut.pbslearningmedia.org/resource/phy03.sci.engin.design.lp_windmill/windmills-putting-wind-energy-to-work/.

TEMPLATE 2 (7" X 7" DESIGN)





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