




THE AMAZING EYE

STEM²D Topics:
Science, Technology, Mathematics

Target Population:
Students, ages 12–16

The Amazing Eye is part of the **Student Activities Series** developed by FHI 360 for Johnson & Johnson's WiSTEM^{2}D initiative (**W**omen in **S**cience, **T**echnology, **E**ngineering, **M**athematics, **M**anufacturing, and **D**esign). The series features interactive and fun, hands-on activities for girls and young women.

The Amazing Eye

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ACTIVITY DESCRIPTION

In this hands-on activity, students will have fun as they learn about the amazing eye. Using the information and materials provided, they will calculate the eye color distribution for their class and learn how the cornea and lens focus light to create the images we see. They will also work in teams as polymer scientists to design the newest polymer-based (hydrogel) contact lens.

ESTIMATED TIME

This session typically takes **120 minutes** to complete and should be conducted in **one** session.

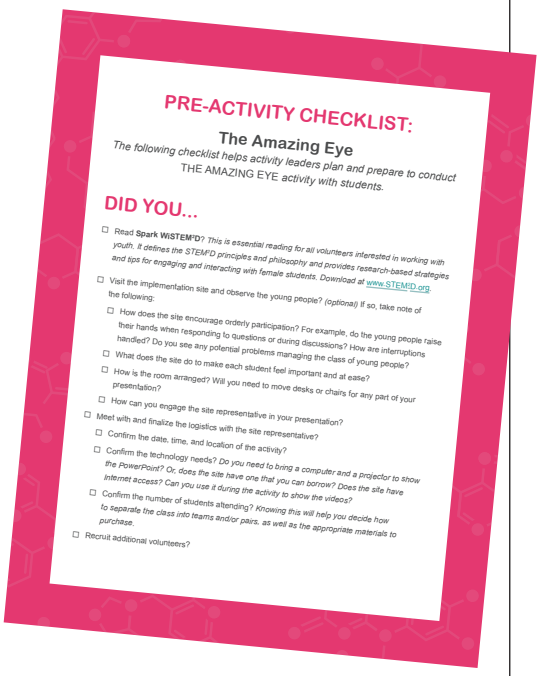
STUDENT DISCOVERIES

Students will:

- Learn how STEM²D knowledge and skills are relevant to and essential in vision and corrective eye care.
- Consider STEM²D concepts including polymers, hydrogel, and hydration.
- Participate in a team-based learning experience.
- Build important STEM²D—Science, Technology, Engineering, Mathematics, Manufacturing, and Design—skills, such as critical thinking, analyzing data, drawing conclusions, and teamwork.
- Recognize that mathematics can be used to solve complex challenges in the workplace.
- Realize that STEM²D offers diverse and exciting career opportunities.
- Have fun experiencing STEM²D.

STEM²D Skills

- Analyzing Data
- Collaboration
- Communication
- Critical Thinking
- Decision Making
- Drawing Conclusions
- Laboratory Skills
- Problem Solving
- Teamwork



PRE-ACTIVITY CHECKLIST:

The Amazing Eye

The following checklist helps activity leaders plan and prepare to conduct THE AMAZING EYE *activity with students.*

DID YOU...

- ☐ Read **Spark WiSTEM'D**? *This is essential reading for all volunteers interested in working with youth. It defines the STEM'D principles and philosophy and provides research-based strategies and tips for engaging and interacting with female students. Download at www.STEMD.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 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 and/or pairs, as well as the appropriate materials to purchase.*
- ☐ Recruit additional volunteers?

GETTING READY

Materials:

- Pre-Activity Checklist
- Tell My Story Form
- Activity Leader Guide: The Amazing Eye Challenge
- Extended Learning Activity: Calculating Eye Color Distribution Activity
- PowerPoint: The Amazing Eye
- Computer with projector, speakers and Internet access
- Student Handout: Market Research, *1 per student*
- Student Handout: The Amazing Eye Challenge, *1 per student*
- Pen/pencil, *1 per student*
- Ziploc bags, *1 per team*
- Jelly Spheres* soaked 3–4 hours or overnight in water, *2 per team*
- Plastic Wrap
- Plastic Spoon
- Paper towels
- The Amazing Eye Challenge Materials, *1 set of the following materials per team of two students:*
  - 1 Ziploc bag containing 2 Swedish Fish
  - 1 Ziploc bag containing 4 Jelly Spheres*
  - 4 clear plastic cups
  - 2 plastic spoons or toothpicks
  - 1 ruler
  - 1 marker
  - 1 16 oz. (.5 liter) Bottle of Water

* Jelly Spheres can be purchased from Steve Spangler Science at this link: https://www.stevespanglerscience.com/store/jelly-marbles-clear-spheres.html. If Jelly Spheres are unavailable, Activity Leaders can make them using common household ingredients. This process takes approximately 4 hours. A quick Google search for Jelly Spheres or Gelatin Pearls will result in a list of potential recipes.

Estimated Cost

Activity leaders can expect to incur less than $50.00 (excluding optional items) in materials costs when completing this activity with 25–35 students organized into teams of two students.

Activity Leader Preparation

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

Step-by-Step Instructions: THE AMAZING EYE

1. Welcome and Introductions (5 minutes)

- Welcome the students.
- Introduce yourself by saying your name, title, and your organization/company.
- **(Today's Plan Slide)** Review the agenda. Explain that today students will learn about eyes and careers in the eye care industry. In addition, students will test different polymers and make suggestions about how to improve contact lenses.
- Break the large group into teams of two students per team and instruct them to sit together for the remainder of the session. Distribute the Amazing Eye Challenge Materials and several paper towels to each team.
- **(Amazing Eye Challenge Slide).** Explain that the hands-on activity, which will be completed later in this session, requires teams to complete some preliminary tasks. Ask teams to:
  - Use the marker to label and number the four clear plastic cups: Cup #1, Cup #2, Cup #3, and Cup #4.
  - Fill all cups with water, about halfway full.
  - Put a Swedish Fish in Cup #1.
  - Place 2 Jelly Sphere beads into Cup #2.
- Set the four cups and all other challenge materials aside until later in the session.

KEY WORDS

- Cornea
- Hydration
- Hydrogel
- Farsighted
- Iris
- Lens
- Nearsighted
- Optic nerve
- Polymer
- Pupil
- Refraction
- Retina
- Scientific Method
- Sclera

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:

- Optometrist
- Polymer Scientist
- Optical Engineers
- Clinical Operations Manager
- Patent Counsel
- Quality Engineer
- Optician
- Ophthalmic Technician
- Eyewear Specialist
- Contact Lens Specialist

TIPS ON STARTING CONVERSATIONS

- When you consider your future, what are you most excited about?
- Do you see yourself working with others, for a large company, with your friends, for yourself? Why or why not?
- Do you imagine yourself solving problems? Are you fixing or building things?
- What does the perfect work day look like to you?

2. Career Awareness: STEM²D in the World of Work (10 mins)

- **(What is STEM²D? Slide)** Explain that **STEM²D** refers to: Science, Technology, Engineering, Mathematics, Manufacturing, and Design.
  - Tell the students there is high growth among STEM²D careers and high demand in this area. Tell them your own career is only one of many in STEM²D fields.
  - Explain that some STEM²D careers do not require college degrees and still offer exciting, high-paying opportunities. Stress the importance of gaining mathematics skills to succeed in any STEM²D career.
- **(Science and Mathematics in the World of Work Slide)** Initiate an opening discussion and brainstorming activity around STEM²D careers. Consider asking:
  - How do you think science and mathematics are used every day in the workplace?
  - How might they be used in the vision/eye care fields?
  - What kinds of careers do you think people with an interest, aptitude for, or degree in science or mathematics would have?
  - Give examples of Johnson & Johnson careers and job titles and other careers that align with this activity and the vision and eye care field.
- **(My Story Slide)** Continue the introductions by talking about your educational and career path. Use the **Tell My Story** form as a basis for your remarks and be prepared to share your interest in STEM²D and how your work is connected to STEM²D. Be prepared to describe your job or a typical day and provide information about your background including:
  - When/why you developed an interest in your field
  - 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 STEM²D concepts and skills and what you do on a typical workday.*

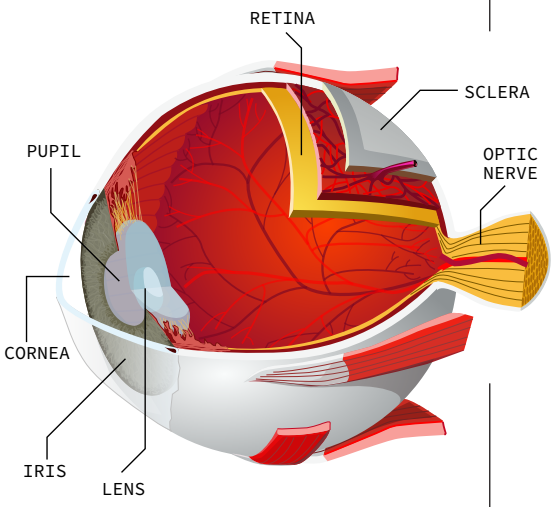
3. Content Presentation: The Amazing Eye (20 minutes)

- **(All About The Eye Slide).** Set the stage. Instruct students to close their eyes. Ask them to think about the following questions:
  - What would the world be like without sight?
  - What would you miss seeing?
  - What are some things that sight allows us to do?
- **(How Do We See? Slide)** Indicate that the eye is an important sensory organ of the visual system. The eyes are constantly at work during a person's waking hours, taking in information about the world and sending it to the brain for processing. State that the eye is comprised of several parts:
  - The **sclera** is the white part of the eye that surrounds the cornea. The sclera helps maintain the shape of the eyeball, protects the eye from serious damage, and provides a sturdy attachment for the muscles that control the movement of the eyes.
  - The **cornea** is a clear lens (surface) in front of the colored portion of the eye. Its primary function is to focus the light that enters the eye.
  - The **iris** is the colored portion of the eye that surrounds the pupil.
  - The **pupil** is a hole in the center of the iris. It allows light to enter the eye. The pupil appears black because light rays entering the pupil are absorbed by the tissues inside the eye.
  - The muscles of the iris control how much light enters the eye:
    - When it is dark, the pupil gets larger to allow more light to enter.
    - When it is very bright, the pupil gets smaller, to limit the amount of light that is entering the eye.
  - The eye's **crystalline lens** is located directly behind the pupil and further focuses light. The lens allows us to see objects near and far.
  - The **retina** is the light-sensitive inner lining of the back of the eye. It acts like the image sensor of a digital camera, converting optical images into electronic signals.
  - The **optic nerve** transmits signals to the visual cortex—the part of the brain that controls our sense of sight.

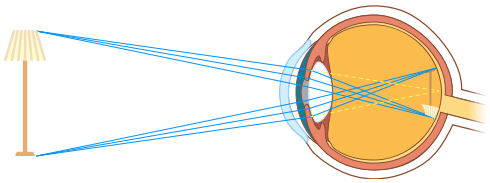
TIPS FOR MAKING CONNECTIONS

Encourage students to:

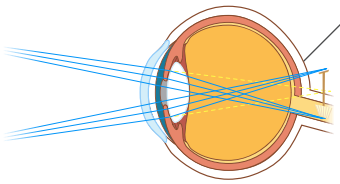
- Ask questions if they don't understand.
- Summarize what they have learned.
- Explain their thinking process aloud.
- Explain in their own words the process of hydration.
- Outline the solution.
- Describe how they applied the scientific method to solve the challenge.
- Compare and contrast the different types of polymers.



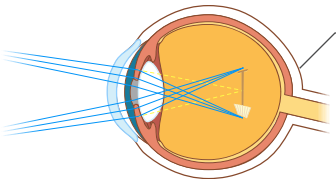
- **(Focusing: The Cornea and Crystalline Lens Slide)** Explain to students that there are two types of lens in the eye that focus light:
  - The cornea, the clear lens on the front surface of the eye, does most of focusing.
  - The crystalline lens helps to fine-tune the focus. This lens can only focus on a small field of depth or one distance at a time (near or far). This is why we cannot see objects near and far simultaneously.
- Help students understand this concept. Instruct students to hold up one thumb, about a foot away from their eyes and in the direction of the presenter. Then, ask them to switch their focus from their thumb to the presenter (right above the thumb).
- Encourage students to share what they observe; they should note that they cannot see both the presenter and their thumb sharply (in focus) at the same time.
- Ask:
  - What happens if the eye isn't able to focus properly?



- **(Focusing Problems Slide)** Explain to students that when light rays entering the eye do not bend as they should, this is known as a "refractive error." State that **refractive errors** are responsible for the two major problems eyes may experience in focusing: Farsightedness and Nearsightedness.

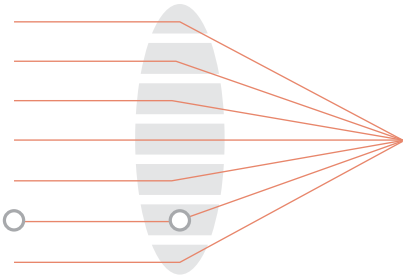


- **(Refractive Error: Farsighted Slide) Explain:**
  - **Farsightedness** or **hyperopia** is difficulty seeing objects that are *close* (e.g., blurry vision when reading); distant objects remain clear.
  - It is caused by the distance between the lens and retina being too short; it can also happen if the cornea or lens are flat.
  - As light enters the cornea, it is focused behind the retina (instead of right on it).
  - This problem is corrected with a lens that brings the point of focus forward (so that it "converges").

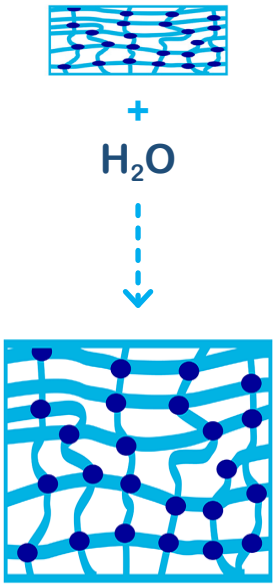


- **(Refractive Error: Nearsighted Slide)** Continue the discussion about refractive errors. Introducing nearsightedness. State:

- **Nearsightedness** or **myopia** is difficulty seeing objects that are *far away*.
- It is caused by the distance between the lens and the retina being too great; it can also happen if the cornea is too curved.
- As light enters the cornea, it is focused in front of the retina, instead of right on it.
- This problem is corrected with a lens that spreads light outwards and moves the point of focus back (so that it "diverges").



- **(Vision Correction Slide)** Explain to the students that many STEM²D professionals work in different areas of vision care. Give the example of Optical Engineers. Say:
  - Optical Engineers use their STEM²D skills to design corrective lenses to improve blurred vision associated with nearsightedness or farsightedness.
  - This is done by bending or changing the focal length of light entering the eye.
  - The most common products Optical Engineers design to bend light are eyeglasses and contact lenses to suit patient needs.
  - The less common and more expensive method to correct blurred vision is LASIK surgery. In this surgery, the cornea is reshaped to correct the focal length. LASIK is mostly used to correct myopia (nearsightedness), because the ophthalmologist can make the cornea flatter.
- **(Eye Exams Slide)** Introduce a data-gathering activity with the following text:
  - 80% of what children learn is visual—by watching. However, only 14% of children have a comprehensive eye exam prior to kindergarten or first grade.
  - Without a vision test or the proper diagnosis, learning can be challenging.
  - An eye exam is a series of tests to check vision and the ability to focus the eyes at different distances.
  - The 20/20 vision test assesses vision "sharpness" or "acuity." It tests the ability to read letters or numbers at a distance.



- Distribute the Market Research handout. Count the number of students in the class, together. Tell students to record the total number on the handout.
- Ask the students to respond to a series of questions by raising their hands. Instruct students to record the relevant numbers on the table in the handout. Indicate that they will need this data later in the challenge. Ask:
  - Who has had their eyes tested by a doctor?
  - Who is wearing glasses today?
  - Who is wearing contacts?
- **(Contact Lenses Slide)** Indicate the following:
  - 45 million people in the U.S wear contact lenses.
  - 3.6 million (or 8% of them) are under 18 years old.
- Explain that people wear contact lenses for several reasons:
  - They provide freedom from wearing glasses.
  - They do not fog up with changes in temperature (e.g., when going in and out of doors in different seasons).
  - They are more convenient when playing sports.
  - To be commercially desirable to customers, contact lenses must be:
    - Soft, so that they drape closely on the eye
    - Clear
    - Strong enough to withstand blinking (up to 28,800 times per day)
- Encourage students to keep these factors in mind for the challenge they will complete later.
- **(About Contact Lens Slide)** Give the following overview:
  - The first contact lens was invented in 1887 and made of glass.
  - Glass was replaced with hard (rigid) plastic in the 1940s.
  - Soft plastics (**hydrogels**) were introduced in the 1970s.
  - A hydrogel is a specific type of **polymer** that absorbs many times its weight in water. The addition of water is known is **hydration**.
  - Some hydrogels can grow to almost 100 times their dry size when wet. The material absorbs water like a sponge.
  - This is because hydrogels are crosslinked—which means the polymer chains are connected to each other via bridges or **cross-links** (these are the dark blue dots in animated image on the slide).

- Once a dry hydrogel begins to absorb water, its physical properties (such as how hard or soft it is) changes.

- **(What are Polymers? Slide)** Remind students that contact lenses are made of polymers. Indicate:
  - Polymers are large molecules of repeating smaller units.
  - Each unit is called a monomer.
  - Mono means one, and poly means many.
  - Polymers are made by reacting monomers (the yellow dots in the slide).
  - A reaction is started when a stimulus, like light or heat, activates an initiator (the green dots on the slide) that links with a monomer.
  - As the monomers link, the polymer begins to grow and increase in size.
  - **Non-crosslinked polymers** grow and increase like beads on a necklace.
  - **Crosslinked polymers** resemble mesh.
- **(Polymers You Know Slide)** Tell students:
  - There are two types of polymers: natural and synthetic.
  - Natural polymers include the proteins and carbohydrates found in plants and animals.
  - Synthetic polymers are artificially created by man and are used in a variety of everyday materials.
    - They include rubber, plastic bags, bottles, paint, and housewares including plates, cups, and Tupperware.
    - Synthetic polymers are also used in the medical field; for example, to make surgical sutures and contact lenses.

4. Hands-on, Minds-on Learning Activity: Amazing Eye Challenge (80 mins)

- **(About the Amazing Eye Challenge Slide)** Distribute the Amazing Eye Challenge handout. Introduce the challenge with these instructions:
  - Today, we are going to do a team-based activity in which you will play the role of a polymer scientist.
  - Your goal is to help the Johnson & Johnson Vision Research Team evaluate three polymer materials for potential use in a new type of corrective lens.
  - At the conclusion of your testing, your team will recommend one of the polymers to move onto a subsequent round of testing.

TIPS FOR WORKING WITH STUDENTS

- Ask open-ended questions to encourage student reflection and discussion. For example:
  - Encourage the teams to think about why hydration might be important in contact lens care.
  - Reinforce the need for a polymer that would be long lasting.
  - Why might someone be interested in contact lenses instead of prescription glasses and vice versa?
  - What have you learned so far in this process?
- Encourage students to think of refraction as they decide which polymer is best.
- Help students stay on track with time during the group challenge.
- Move around the learning space and provide support when necessary.
- Encourage all students to participate.
- Encourage girls to take on leadership roles in their groups.
- Provide support and answer questions, as needed.

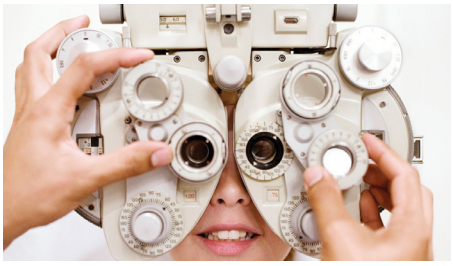
- Your team will also use the eye exam data collected earlier to support the need for a new type of contact lens on the market.

- **(Scientific Method Slide)** Explain to students that they will use the Scientific Method to discover the behavior and properties of the three polymers. State:
  - The scientific method is a set of procedures scientists use to answer questions and create solutions that help people, animals, and the environment.
  - It involves observation and asking questions to formulate a hypothesis.
  - The hypothesis is tested through a series of experiments and the data collected are analyzed to report the findings of the study.
- **(Amazing Eye Challenge Instructions Slide)** Review the main tasks of the challenge:
  - Work with your partner to evaluate three different "polymers:"
    1. *Swedish Fish.* A Swedish Fish is a fish-shaped chewy candy, like Gummy Bears or Sour Patch Kids. It is a non-crosslinked polymer.
    2. *Jelly Spheres.* Jelly Spheres are made of polymers that are crosslinked and fully connected to each other.
    3. *Plastic Cups.* The cups are made of a material that is also an example of a type of polymer.
  - For each polymer, observe and think about its properties (i.e., look, feel, size, etc.) as it is exposed to water and undergoes hydration.
  - Record all observations in the student handout and answer the associated questions.
  - Discuss the advantages and disadvantages of each polymer.
  - Determine the market demand for a new contact lens using the data collected at the start of today's session and recorded on the Market Research handout.
  - Based on your findings, make a final recommendation to Johnson & Johnson Vision Care researchers about the best polymer to use for a new contact lens.

- Once the students begin the challenge, distribute 2 pre-soaked Jelly Spheres to each team, placing into Cup #3 with a plastic spoon.
- **(Challenge Recap)** After 60 minutes, reconvene the large group. Spend 10 minutes recapping the Challenge. Ask:
    - Which of the three polymers did your team recommend to Johnson & Johnson? Why?
- **(What Did We Learn? Slide)**
    - What did you learn about the eye? Vision?
    - How did hydration impact the polymers?
    - What were the advantages and disadvantages for each polymer?
    - What did you learn about working in a team?

5. (Reflection Slide) 10 minutes

- Ask students to reflect on the challenge. Have students spend a few minutes thinking about the listed questions and then ask for volunteers to share their thoughts on any v of the following:
    - How do you think this activity relates to a career in science and/or working at Johnson & Johnson?
    - Can you see yourself as a STEM²D professional? In what role? Why or why not?
    - What do you need to do to make this happen?
    - What is one thing you learned that you did not know coming in today?
- Thank students for joining you today and encourage them to continue exploring careers in STEM²D.

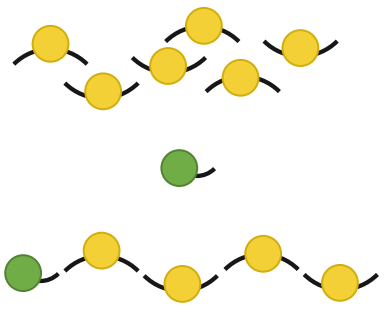


Extended Learning

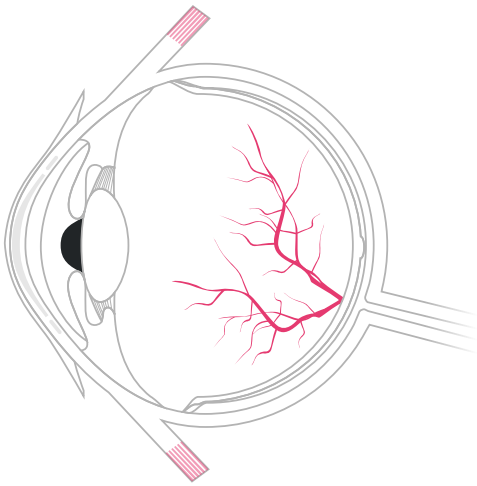
- Here are a few ways to extend the learning:
  - Try **Magic Slime** (a STEM²D Ignite! activity). Explore the use of synthetic polymers and learn how polymers are used in the manufacturing process.
  - Test the “polymers” used in this activity in different solutions (saltwater, sugar water) and concentrations. Examine how different solutions and concentration affect the polymers.
  - For fun, try **Calculating Eye Color Distribution** activity (see the Extended Learning Activity in this document).

Key Words

- **Cornea:** The clear lens/surface in front of the eye that focuses light
- **Hydration:** The process of causing something to take in or soak up water
- **Hydrogel:** A network of polymers that can absorb water
- **Farsighted:** The inability to see clearly at short distances. Objects at a distance are more visible. Farsightedness is commonly known as **hyperopia**.
- **Iris:** The colored portion of the eye. The muscles of the iris control how much light enters the eye.
- **Lens:** The part of the eye that is located directly behind the pupil and further focuses light. The lens allows us to see objects near and far.
- **Nearsighted:** The inability to see clearly at far distances. Objects further away appear blurry. Nearsightedness is commonly known as **myopia**.
- **Optic nerve:** The part of the brain that controls our sense of sight
- **Polymer:** Long chain of molecules of many repeating subunits
- **Pupil:** The hole in the center of the iris. It allows light to enter the eye. The pupil appears black because light rays entering the pupil are absorbed by the tissues inside the eye.
- **Refraction (Refractive error):** The bending of light as it passes from one substance to another



- **Retina:** The light-sensitive inner lining of the back of the eye. It acts like the image sensor of a digital camera, converting optical images into electronic signals.
- **Scientific Method:** A set of procedures scientists use to answer questions and create solutions to help people, animals, and the environment
- **Sclera:** The white part of the eye that surrounds the cornea. The sclera helps maintain the shape of the eyeball and protect the eye from serious damage.



Resources and References

Special thanks to Karen Harding, Patent Counsel and April Fogel, Postdoctoral Fellow, Johnson & Johnson Vision Care Inc. for their insights and help developing this activity.

The following resources provide additional information or activities.

- All About Vision: https://www.allaboutvision.com/resources
- American Academy of Ophthalmology: https://www.aao.org/eye-health/tips-prevention/your-blue-eyes-arent-really-blue
- Centers for Disease Control: https://www.cdc.gov/contactlenses/fast-facts.html
- Optics4Kids: https://www.optics4kids.org/home

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- ☐ Recruit additional volunteers?

- ☐ Prepare for the activity? Did you:
  - ☐ Read the entire activity text prior to implementation? If doing the activity virtually, include a tip for the students to hydrate their Jelly Spheres overnight? *(see instructions)*
  - ☐ 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?

- ☐ 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**).*

☐ Obtain the required materials? *(See the **Materials** and **Estimated Materials Costs** sections.)*

☐ Prior to the session, prepare essential Amazing Eye Challenge materials:

- ☐ Place 2 Jelly Spheres per team into a cup of water for 3–4 hours or overnight; cover the cup with plastic wrap.
- ☐ Put 2 Swedish into a Ziploc bag for each team.
- ☐ Put 4 Jelly Spheres into a Ziploc bag for each team.

☐ Photocopy the two **Student Handouts**?

☐ 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.

☐ Set up the site appropriately for the activity? Specifically:

- ☐ Arrange the tables and chairs to accommodate teams of two students.
- ☐ Set up the computer and projector for the PowerPoint presentation.
- ☐ If additional volunteers are available, assign adults to specific teams.

☐ 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, especially girls, will get out of this activity?_____

_____

FUN FACT

Share a little about your background. Ideas:

- Share a memory from childhood when you had your first 'spark' or 'interest' in STEM.
- Detail your journey. Highlight what you've tried, what you learned, steps to success, etc.
- Failures or setbacks are also great to talk about, as well as 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.* _____

_____

THE AMAZING EYE CHALLENGE

Activity Leader Guide

This guide provides sample observations, student responses, and calculations. It will help activity leaders guide the discussion and provide informed responses.

Test Polymer I: Swedish Fish

Table 1: Swedish Fish Observations

	Cup #	Polymer I Observations
Swedish Fish (with no hydration)	N/A	The fish is hard, red in color, and very compact/rigid/firm.
Swedish Fish (after hydration)	Cup #1	The fish became bigger in size (swollen) and looked bigger from the side of the cup. It absorbed the water and became a bit mushy and soft.
Water (with fish)	Cup #1	The water changed to the color of the fish. (Some students might know this is by osmosis, or the movement of the water molecules to area of high solute concentration.)
Water (with no fish)	Cup #4	The water is clear and unchanged.

Sample Question Responses:

- Did the Swedish Fish dissolve or grow when left in water? The fish grew and eventually started to dissolve in the water.
- Did the fish get harder or softer when hydrated? Did it stay the same shape throughout hydration? Why or why not? The fish got softer and began to change shape. This is because the water molecules moved into the fish, making it swell. As more water got in, the fish could no longer hold its shape.
- When you looked at the fish from the side of the cup, did it look bigger or smaller? Why might this be? The fish looked bigger. With time, the fish absorbed more water and got bigger.
- What do you think would happen if the fish was left in the water longer (overnight)? There would be no more fish. It would dissolve altogether, leaving colored water.

Discussion Tips:

- The Swedish Fish looked different in size when it was in the cup with the water.
- The fish appeared larger for two reasons: 1) the curved shape of the cup made the object appear larger (see below), and 2) as the fish absorbed water, it became swollen.
- When water is curved (as by the shape of the cup), it creates a convex lens that makes the image seem closer than it really is.

Test Polymer II: Jelly Spheres

Table 2: Jelly Sphere Observations

	Cup #	Diameter (mm) (Sample Measurements)	Polymer II Observations (Sample Observations)
Jelly Sphere 1 (No hydration)	(None)	Sphere 1: 1mm Sphere 2: 1.5mm	The spheres are hard, very small, and clear.
Jelly Sphere 2 (Hydration—start of activity)	Cup #2	Sphere 1: 6mm Sphere 2: 7.5mm	The spheres grew but not as big as the ones from overnight—maybe half the size or less. They are clear and otherwise looks like the overnight beads.
Jelly Sphere 3 (Hydration—overnight)	Cup #3	Sphere 1: 15mm Sphere 2: 13mm	The spheres are clear, round, and very large. They feel soft and a bit mushy, but not too soft. I cannot see them when they're fully covered in water.

Sample Question Responses:

- Did the Jelly Spheres dissolve or grow when left in water? The Jelly Spheres grew when they were left in water. (Encourage students to think of how polymers can form beads on a necklace or a mesh. See discussion notes for further explanation about crosslinking.)
- How do the Jelly Spheres from overnight hydration (Cup #3) compare to the ones you started hydrating at the start of the activity (Cup #2)? The spheres in Cup #3 were much bigger; they grew almost twice as big as the ones in Cup #2. The spheres in Cup #3 had a longer time for water to get into the spheres
- Did the Jelly Spheres get harder or softer when hydrated? Did the Jelly Spheres stay the same shape throughout hydration? Why or why not? The Jelly Spheres in water got softer than the spheres that weren't exposed to water, but they didn't become mushy or soft enough to break apart. The beads stayed the same shape. They have an outer layer/surface than seems strong.
- When fully hydrated, can you see the Jelly Spheres in the cup of water? Why or why not? No, I cannot see the Jelly Spheres. They are just as clear as the water. (See discussion notes for additional explanation to share with students.)

- Roll the overnight hydrated Spheres on the paper towel to remove excess water. Then roll it over the words on this sheet. Are you able to read the words through it? Do they look larger, smaller, or the same? The text looks bigger. It is also upside down and backwards. (See discussion notes for additional explanation to share with students.)

Discussion Tips:

- The Jelly Spheres do not dissolve in water because of their crosslinking properties.
  - Why does the Swedish Fish dissolve, but the Jelly Sphere does not?
    - They are made from different polymers, but one difference is crosslinking.
    - Crosslinks are bridges between polymer chains (making a 3D net structure).
    - They make the polymer stronger and keep it from dissolving.
- The Jelly Spheres are not visible in water.
  - They have the same light-bending (refractive) properties as water.
  - As the Jelly Spheres absorb water, their refractive index becomes closer to that of water, making them seem to disappear.
- The Jelly Spheres and text:
  - When you at text through the Jelly Sphere, the words will appear larger, upside down, and backwards, due to the curvature of the lens.
  - This is an extreme example of how the shape of a lens bends light.

Test Polymer III: Plastic Cup

Table 3: Plastic Cup Observations

	Polymer III Observations (Sample Observations)
Clear Plastic Cups	The plastic cup is clear, and it does not dissolve in water but instead holds the water. I can see the water through the plastic cup. The cup is hard and strong; it does not break easily.

Sample Question Responses:

- What properties do the cups have and how do they compare to the properties of the Swedish Fish and Jelly Spheres?
  - Swedish Fish: The cup does not dissolve like the fish. The cup is clear, unlike the fish, and I am able to see the fish through it.
  - Jelly Spheres: The cup is clear like the Jelly Spheres and would disappear if I put it into a big container with water. The cup is much harder and stronger than the Spheres. It also has an opening, whereas the Spheres are round and keep water trapped inside.

Review Advantages & Disadvantages of Polymers

Table 4: Advantages & Disadvantages of Polymers (Sample Responses)

Polymer Source	Advantage(s) (Strengths)	Disadvantage(s) (Weaknesses)
Swedish Fish		• Colored, might be hard to see through • Dissolves in water and will not "last." It is a non-crosslinked polymer. • Bleeds its color into water. Do not want for contacts
Jelly Sphere	• Clear • Soft, but also firm • Does not dissolve/fall apart in water. It is a crosslinked polymer. • Is not visible when in water (same refraction index as water) • Magnifies the size of letters when viewed through	• Has the potential to rip, tear, or burst
Plastic Cup	• Clear • Firm/hard • Has the potential to last long-term • Does not dissolve in water • Is not visible when in water (same refraction index as water) • Magnifies the size of the fish	• Extremely hard, might hurt the eyes

Complete Market Research

Table 4: Demand for Corrective Lenses (Sample Data and Calculations)

Total Students (#): 26	Yes (#)	No (#)	% Yes	% No
Exam:	18	8	(18/26)*100 = 70%	30%
Glasses:	5	21	(5/26)*100 = 19%	81%
Contacts:	9	17	(9/26)*100 = 35%	65%
No correction:	12	14	(13/26)*100) = 46%	54%

Sample Question Responses:

- What percentage of your class currently use vision correction (glasses or contacts)?
  - 19% of the students wear glasses
  - 35% of the students were contacts
  - 54% of the class currently use vision correction lenses (19% + 35% = 54%)
- How do you think this percentage compares to the U.S. overall? What about the world?
  No. Students may say that the class value is lower, the same or, higher than the U.S. They may also say the same for comparison with the world. This question is really to get them to think outside of the classroom and possibly who they encounter daily outside of class.
- Does the research show a need for corrective lenses? If so, which type?

Make a Recommendation

Discussion Tips:

- Encourage the students to think of refraction as they decide which polymer is best.
- Ask each team to report which polymer they decided on.
- If there is enough time, have one or two teams explain why they chose the polymer source.
- Summarize by explaining why the Jelly Sphere is the best option to move forward. Use the information in the table above to expand.
- Note that you may have additional things you want to add that are not in the table.

MARKET RESEARCH

Student Handout

Overview:

Collect data on the prevalence of eye exams and the use of corrective lenses among your peers. Record the data in the table below. You will use this data in the Amazing Eye Challenge.

	#
Total Number of Students:	
Total Number of Students who have had their eyes examined by a doctor:	
Total Number of Students Wearing Glasses:	
Total Number of Students Wearing Contacts:	
Total Number of without Corrective Lenses:	

AMAZING EYE CHALLENGE

Student Handout

Challenge:

Recommend the best polymer for further testing and potential use in a new form of corrective lenses to a research team from Johnson & Johnson Vision Care.

Task Overview:

As a team of polymer scientists:

- Evaluate three different polymers:
  - *Swedish Fish.* A Swedish Fish is a fish-shaped chewy candy, like Gummy Bears or Sour Patch Kids. It is a non-crosslinked polymer.
  - *Jelly Spheres.* Jelly Spheres are made of polymers that are crosslinked and fully connected to each other.
  - *Plastic Cups.* The cups are made of a material that is also an example of a type of polymer.
- Determine the advantages and disadvantages of each polymer
- Calculate market demand
- Make an informed recommendation to the research team

Time:

60 minutes

Materials:

- 1 Ziploc bag containing 2 Swedish Fish
- 1 Ziploc bag containing 4 Jelly Spheres
- 4 clear plastic cups
- 2 plastic spoons or toothpicks
- 1 ruler
- 1 16 oz. Bottle of Water
- 1 Marker
- Paper towels

Instructions:

1. Review Pre-Work.

- At the start of the session, your team should have:
  - Labeled and numbered the four clear plastic cups:
    Cup #1 Cup #2 Cup #3 Cup #4
  - Filled all cups with water, about halfway full.
  - Added a Swedish Fish in Cup #1.
  - Placed 2 Jelly Spheres into Cup #2.

2. Test Polymer I: Swedish Fish

- Remove a Swedish Fish from the Ziploc bag and place it on the counter.
- Compare the fish with the fish in Cup #1 (the fish soaking in water).
- Ask yourself:
  - What does the fish in Cup #1 (after hydration) look like?
  - Look at the fish in Cup #1 from the side, does it look bigger or smaller than when viewing from above?
  - How does it compare to the fish on the table (no hydration)?
  - Are the fish the same size? Shape? Color? Texture?
- Record your observations in Table 1.
- With the plastic spoon or toothpick, remove the fish from the water and place it on paper towel on the table next to the non-hydrated fish.
- Using the ruler, measure each fish (length, width, and thickness). Record your measurements in Table 1.
- Recording your observations in Table 1, ask yourself:
  - How does each fish feel?
  - What color is the water? How does it compare to the water in Cup #4? Can you read this handout *through* the water in each cup?



Table 1: Swedish Fish Observations

	Cup #	Polymer I Observations
Swedish Fish (with no hydration)	N/A	
Swedish Fish (after hydration)	Cup #1	
Water (with fish)	Cup #1	
Water (with no fish)	Cup #4	

- Answer the following questions:
  - Did the Swedish Fish dissolve or grow when left in the water?
  - Did the fish get harder or softer when hydrated? Did it stay the same shape throughout hydration? Why or why not?
  - When you looked at the fish from the side of the cup, did it look bigger or smaller? Why might this be?
  - What do you think would happen if the fish was left in the water longer (overnight)?

3. Test Polymer II: Jelly Spheres

- Remove 2 Jelly Spheres (non-hydrated) from the Ziploc bag.
- Using the ruler, measure their diameter and record the measurements in the first row (Sphere 1, no hydration) of Table 2.
- If not already provided, ask the Activity Leader to place 2 Jelly Spheres soaked overnight in water into Cup #3.
- Compare the Jelly Spheres. Ask yourself:
  - What do the spheres look like? Do the spheres in Cup #2 (after short hydration) and Cup #3 (overnight hydration) look similar? Different? How do they compare to the non-hydrated Jelly Spheres?
- Remove the Jelly Spheres from Cup #2. Place them and the cup on a paper towel. Measure the diameter of each. Record the measurements in Table 2 (Row 2: Jelly Sphere 2).
- Repeat the process for the Jelly Spheres in Cup #3. Record the measurements in Table 2 (Row 3: Jelly Sphere 3).
- Recording your observations in the table, ask yourself:
  - What do the spheres look like? How they feel?
  - Are the similar or different?

Table 2: Jelly Sphere Observations

	Cup #	Sphere Diameter (mm)	Polymer II Observations
Jelly Sphere 1 (No hydration)	N/A	Sphere 1:	
		Sphere 2:	
Jelly Sphere 2 (Hydration—start of activity)	Cup #2	Sphere 1:	
		Sphere 2:	
Jelly Sphere 3 (Hydration—overnight)	Cup #3	Sphere 1:	
		Sphere 2:	

- Answer the following questions:
  - Did the Jelly Spheres dissolve or grow when left in water?

  - How do the Jelly Spheres from overnight hydration (Cup #3) compare to the ones you started hydrating at the start of the activity (Cup #2)?

  - Did the Jelly Spheres get harder or softer when hydrated? Did the Jelly Spheres stay the same shape throughout hydration? Why or why not?

  - When fully hydrated, can you see the Jelly Spheres in the cup of water? Why or why not?

  - Roll the overnight hydrated Spheres on the paper towel to remove excess water. Then roll it over the words on this sheet. Are you able to read the words through it? Do they look larger, smaller, or the same?

4. Test Polymer III: Plastic Cup

- Think about the appearance of the plastic cups, the feel, what happens when water is added to them, and anything else you may want to consider.

Table 3: Plastic Cup Observations

	Polymer III Observations
Clear Plastic Cups	

- Answer the following questions:
  - What properties do the cups have and how do they compare to the properties of the Swedish Fish and Jelly Spheres?

5. Review Advantages & Disadvantages of Polymers

- Each of the three polymers evaluated has advantages and disadvantages for use as a new material for corrective lenses. Summarize the strengths and weaknesses of each in Table 4.
- Write as many things as you can for each polymer.
- Consider things like color, feel, properties in water, factors related to a person's interest in wearing contact lenses: durability, comfort, ease of use.

Table 4: Advantages & Disadvantages of Polymers

Polymer	Advantage(s) (Strengths)	Disadvantage(s) (Weaknesses)
Swedish Fish		
Jelly Spheres		
Plastic Cup		

6. Complete Market Research

- Determine the market share (patients or customers) that require corrective lenses; this data should be used to inform your recommendation to the research team.
- Transfer the data from the Market Research handout to appropriate row in the YES column of Table 5.
- Determine number of students in each row of the NO column.
  - Formula:
    - Subtract the YES number in each row from TOTAL STUDENT NUMBER.
- Calculate the percentage of students who have had and not had an exam.
  - Formula:
    - (YES# Students Examined / Total Students) x 100 = % YES
    - (NO# Students Examine / Total Students) x 100 = % NO
      - Or, 100% – % Yes = % NO

- Calculate the percentage of students who use corrective lenses (glasses or contacts) to improve their vision. Adjust the formula provided above to determine the percentages.
- Calculate the percentage of students who don't require corrective lenses to improve their vision. Adjust the formula provided above to determine the percentages.

Table 4: Demand for Corrective Lenses

Total Students (#):	Yes (#)	No (#)	% Yes	% No
Exam:				
Glasses:				
Contacts:				
No correction:				

- Ask yourself:
  - What percentage of your class currently use vision correction (glasses or contacts)?
  - How do you think this percentage compares to the U.S. overall? What about the world?
  - Does the research show a need for corrective lenses? If so, which type?

7. Make a Recommendation

- Use the information in the tables above to present to your final recommendation to the Vision Team.

- Recommended Polymer:
  - Why?

CALCULATING EYE COLOR DISTRIBUTION

Extended Learning Activity

Background:

The color of your eyes depends on melanin. Melanin is a natural pigment, or color, that can be present in the tissue of the iris, skin cells, and hair follicles. In the United States, eye color distribution varies widely. The most common color is brown, and the least common is green (see the chart below).

You can use this activity to measure the eye distribution of your family members, friends, or even classmates.

Calculate:

Use the table to record the eye color of the group (family, friends, classmates, etc.) you are interested in learning more about. Then calculate the percentage for each color.

- Percent eye color = (# of people with color /total # of people) x 100

Record your observations here:

Eye Color	% U.S.	# of People	% Eye Color for Group Studying	Observations
Brown	45%			
Blue	27%			
Hazel	18%			
Green	9%			
Other	1%			

Think About It:

Answer the following questions.

- How does the eye color distribution of your group compare or differ from the U.S. data?
- What does this tell you?
- How do you think this distribution compares with or differs from the world overall?

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