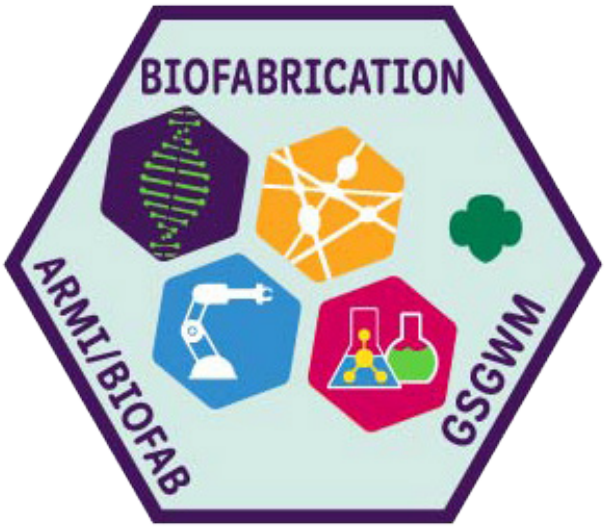
girl scouts of the green and white mountains

Biofabrication

PATCH PROGRAM



GIRL SCOUTS OF THE GREEN AND WHITE MOUNTAINS
Serving New Hampshire and Vermont

Developed in cooperation with ARMI/BioFabUSA

a program of armi

biofabusa

Biofabrication – The science of making living tissue

Girl Scouts are natural-born scientists. Learn how biology and fabrication come together to build something that is alive! How can we use creative and innovative ways to help people who are sick, get hurt, or just need extra help? Can we help a person who needs a new heart? Scientists are combining biology and manufacturing to do just this.

When you have earned this patch, you will have an understanding of what biofabrication is, how it works, and what it may do for us in the future.

To earn the Biofabrication patch, complete the steps in each of four sections.

Step 1 – Biology 101

Biology explores things that are alive. What does it mean to be alive? What is the smallest thing you can think of that is alive? Many things that are alive have many parts. In this step, you will learn about how we decide if something is alive or not, and about the tiny things called cells, which keep everything alive.

All living things grow, breathe, reproduce (make more of themselves), remove waste, respond to things happening around and to them, and have basic needs like nourishment. Explore what it means to be alive.

1. **Is it alive?** Pick two activities from this list:

   For Daisies and Brownies:

   - See how living things have traits that are passed from parent to baby in the NH PBS From the Start video: bit.ly/2QkEASl. Or check out one of their other STEM videos and activities. stemfromthestart.org.

   For Daisies, Brownies, and Juniors:

   - Watch *Is it Alive* video
     bit.ly/32vQjjI
   - Watch SciShow Kids *It's Alive!*
     bit.ly/3dwFKTG

   For Cadettes, Seniors, and Ambassadors:

   - Is it Alive alien activity – Watch this video: bit.ly/3aoe0i9.

     Observe the samples and explain how you would know if the object is alive or not. Does something have to meet all the rules to be alive, or just a few?

   For all levels:

   - Alien Goo – is it alive? Make an alien goo like slime or oobleck, or find pictures of gooey slime.
     To make stretchy slime: bit.ly/3dzh3pu
     To make oobleck: bit.ly/3tuax9c

     Imagine you are one of the top scientists in the world and are happily working in your lab one day when a stranger bursts in to say she found something that fell from the sky and thinks it may be an alien life form. How would you verify if it is alive or not? What observations can you or your group make about the alien goo to support your theory of whether it is alive or not?

     As a group, share your evidence and determine which theory the evidence supports. Perhaps you can split into groups, present your evidence, and see who switches sides.

2. **Big things are made of smaller things** – Just as a LEGO house is made of small bricks, your body is made of smaller parts. Every part of your body is made of cells, which are so tiny we can't see them with just our eyes. Each cell has even smaller parts inside that make them work. Those parts may not all be alive themselves, but they create a system that provides living functions. Think about the definition of being alive, and how those different parts make life possible. Learn more with the book *You're Full of Genes* by Claudia Zylberberg: yourefullofgenes.com

Daisies, Brownies, and Juniors, pick one activity:

- Use LEGOs or a similar building toy to build a house, person, animal, etc.
- Use lots of small snacks to make a big snack.
- Dissect (pull apart and list) the parts of a meal
- How small can you go? Draw a series of pictures that go from something big to something small (such as a person to an arm, to a forearm, to a hand, to a finger, to bones, to blood); or rip a piece of paper into the smallest piece possible. How small can you go? Can you put the piece of paper back together? What if you use a magnifying glass or tweezers to help?

Juniors, Cadettes, Seniors, and Ambassadors, complete this activity:

- Cell City – learn about the parts of a cell from bit.ly/3dx7fwt or bit.ly/2P4qhAX. Perhaps you would like to share more videos from The Amoeba Sisters or The Cell Song from sciencemusicvideos.com, or do interactive activities from the Cell World app. Pick one of the following activities to do:
    1. Draw a city, thinking of all the things a city needs, such as power, a leader, ways to bring food and water in, ways to process food and water, ways to get waste out, and a place to store information. Living things need to do that, too! Label the parts of your city that correspond to parts of a cell, such as mitochondria that power a cell matching to a power station in a city.
    2. Use another metaphor for a cell, such as a school, country, restaurant, house, etc., and draw a picture labeling the areas and parts that correspond to the parts of a cell.
    3. Made a 3-D model of a cell using common household supplies.

Cadettes, Seniors, and Ambassadors, complete this activity:

- Watch the *Powers of 10* video to get an idea of how small and big things can get: bit.ly/3tAsjHN

Step 2 – Growing, harvesting, and building

Because everything is made up of little things, we often need to grow, harvest, or build what we want from smaller things. Harvesting means taking smaller parts from a larger system to use in a new system, like harvesting seeds from vegetables to grow new vegetables. In a similar way, scientists are working on harvesting cells from people to grew new organs, proteins, and more.

All levels, complete the following four steps:

1. Let's grow something! Pick one activity:
    - Plant a seed and watch it grow. Radishes, sunflowers, and lettuce greens are all good options. Alfafa seeds don't even need dirt.
    - Yeast activities – Growing yeast, and yeast-powered balloons (See Supplemental Materials at the end of this document)
    - Bring a dying plant back to life, such as celery from a celery stalk, or a potato half suspended partway in a cup of water by toothpicks.
    - Use the Ghostly Heart Kit (available to GSGWM troops or through our STEM mobile workshop; contact Customer Care at customercare@girlscoutsgwm.org)

2. Let's build something! Biofabrication is building something that is alive, so practice the idea by doing one of the following:
    - *For all*
      Make as many SWAPS (Special Whatchamacallits Affectionately Pinned Somewhere) as you can.
      bit.ly/3tB87Wl
    - *For all*
      Get a bunch of LEGOs, pick a simple classic creation and build as many as you can.
    - *For Daisies, Brownies, and Juniors*
      Pick a simple picture for everyone to draw and make as many copies as you can.

3. In biofabrication there are many steps with different equipment that does each step. Make an assembly line to make the work easier!
    - *For all*
      Do the same activity you did in step 2, but assign each girl one step in the process. Try it with something rugged like a LEGO creation, then with something more fragile, like a flower or heart design that is put together with toothpicks, mini marshmallows, and icing with sprinkles on top. Living things are often fragile, so care must be taken in building them. Talk about what the difficulties are, how fast you could go, whether you had to pay more attention to handing it off to the next person, the types of containers needed to support the product, etc.

4. Because assembly lines can be boring and difficult, we often use robots and machines to automate the process.

    - *For all*
      Learn about robots by watching this video from SciShow Kids (bit.ly/3dxnWb9) or this one from Science Trek (bit.ly/32w9ObC).

        - Troop leaders can explore more with the Automation in Biofabrication sheet in the Supplemental Materials section.

    - *Optional activities:*

        - Learn about 3-D printing
          bit.ly/3gtDEGd

        - Learn about Rube Goldberg machines (a machine intentionally designed to perform a simple task in an indirect and overly complicated way)
          bit.ly/3as5AWS

Step 3 – Keep it Safe! Preservation and Packaging

Now you've built an item and you need to keep it safe. Anything that needs to travel must be protected and preserved so it arrives in good condition. Let's use household items to get your item safely from one place to another.

1. Engineer for protection. Build a case to keep something valuable or breakable safe. Pick one activity:
    - *For Daises, Brownies, or Juniors*
      Make a cardboard box from scratch or make a cardboard box stronger.
    - *For Juniors, Cadettes, Seniors, or Ambassadors*
      Design a container that keeps an egg unbroken if dropped from a certain height.

2. Engineer to preserve. Pick one activity:
    - *For all*
      Keep it Cold: Cells and organs need to stay cold. Find a way to keep something as cold as you can for as long as possible. Build a cooler out of common household items to keep your specimen cold.
    - *For Juniors, Cadettes, Seniors, or Ambassadors*
      Liquid in Motion: Cells and organs need liquids like blood to stay alive and in order to flush away waste. Shipping liquids takes additional thought because of how they behave when in motion. Experience how liquid reacts in open containers when in motion. Use a variety of different materials like large and small buckets, cups, tubes that are flexible and can be pinched, tubes that are inflexible, etc. Explore how they move with water inside them, as though they were in an airplane, car, or train. (This is best done outside!) What happens if you take off quickly? What happens if you stop quickly? What happens to different amounts of liquid in your container? Does it change the amount that spills?

Step 4 – Take action! Think about how you would make the world a better place through biofabrication

Biofabrication is about combining the idea of growing something with building something – building something that is alive. We use automation and manufacturing assembly lines to make cars, phones, and other nonliving items. Eventually we hope to grow cells, tissues, and organs like skin, muscles, nerves, kidneys, livers, and more to help save lives.

Explore at least **three** of the following resources to learn how biofabrication today is creating the world of tomorrow. Then think about what problems you would solve with biofabrication, and share your thoughts with someone about what you have learned through this patch.

For all:

- Ghostly Heart Activity videos with Dr. Doris Taylor (All levels, but it's recommended that leaders of younger girls use the curriculum for background information and guide the girls in watching and discussing the video): bit.ly/3sxxkQn or if you are part of the GSGWM council, contact Customer Care (customercare@girlscoutsgwm.org or 888-474-9586) to borrow a Ghostly Heart Kit.

For Daisies, Brownies, and Juniors:

- *You're Full of Genes* by Claudia Zylberberg

For Daisies, Brownies, Juniors, and Cadettes:

- How 3D Printers Work- How Things Work with Kamri Noel
  bit.ly/3gtDEGd

For Juniors, Cadettes, Seniors, and Ambassadors:

- Life-saving advancements of the Advanced Regenerative Manufacturing Institute (ARMI)
  bit.ly/32vOKlA
- 3D Bioprinting at the Children's National Health System:
  bit.ly/2P326mp
- NASA Three-Dimensional BioPrinting in Space
  go.nasa.gov/3eeLOPU
- TechShot- Success: 3D bioprinter in space prints with human heart cells
  bit.ly/3v6OqWD
- Cellink- Why are there bioprinters in space?
  bit.ly/3edirNX
- Cellink- Have a heart- saving lives one organ at a time
  bit.ly/3n0KlRa

For Cadettes, Seniors and Ambassadors:

- How to 3D Print Human Tissue by Taneka Jones, TED-Ed
  bit.ly/2P2MDTf

- Why “biofabrication” is the next industrial revolution- Suzanne Lee Ted Talk
  bit.ly/3elPDTA

For Troop Leaders:

Leaders can help girls earn related badges. Ask them to find out what the first Girl Scout science badge was! Younger girls may earn badges on things that are alive and home scientist. Seniors may want to earn the Voice for Animals badge. If this is an issue they feel strongly about, check out the Girl Scout Advocacy badge.

Supplemental Materials

YEAST-POWERED BALLOONS

GROWING YEAST

AUTOMATION IN BIOFABRICATION

ROBOTS DO JOBS HUMANS FIND BORING!

Yeast-Powered Balloons

When baking, we often need to use what we call a leavener to get the dough to rise. This creates wonderful pockets of air that trap yummy smells and flavors. But how does that happen? How does it work? Yeast does this by feeding on the sugars in flour, and expelling carbon dioxide in the process. Yeast are fungus cells that we can feed and grow. Today we will capture that air to power balloons!

Materials for each yeast bottle:

- 1 packet of active dry yeast
- 1 cup very warm water (105° F–115° F)
- 2 tablespoons sugar
- a large rubber balloon
- a small (1-pint to 1-liter) empty water bottle

Steps:

1. Warm up the water in a microwave, electric kettle, etc. It does not need to be boiling, just warm.
2. Stretch out the balloon by blowing it up repeatedly, and then lay it aside.
3. Pour the yeast packet, sugar, and warm water into one bottle and stir/ swirl. Then cover the neck of the bottle with the balloon.
4. Then pour a yeast packet and warm water into the other bottle and cover the neck of the bottle with a balloon.
5. Wait about 20 minutes and observe. As the yeast feeds on the sugar, it produces carbon dioxide. With no place to go but up, this gas slowly fills the balloon.

(Images Courtesy of Science Bob)

We just fed and grew yeast, a group of real fungus cells! Scientists are growing living cells to test new medicines or even grow the cells into organs for someone who needs a new heart or other organ. These are called Tissue-Engineered Medical Products and will someday change the world of health care.

We aren't there yet, but scientists are working on making this a reality in the near future. Growing living cells is a critical component required in most TEMP processes.

Growing Yeast

When baking, we often need to use what we call a leavener to get the dough to rise. This creates wonderful pockets of air that trap yummy smells and flavors. But how does that happen? How does it work? Yeast does this by feeding on the sugars in flour, and expelling carbon dioxide in the process. Yeast are fungus cells that we can feed and grow. Scientists are experimenting with growing all kinds of cells to help with real problems, especially helping people who are sick or hurt. Someday, we will be able to grow a group of cells into a heart, other organs, skin, tissue, etc. that will help people who need them. Growing cells is the first and foundational step in this process.

Background info: While there are about 160 known species of yeast, Saccharomyces cerevisiae, commonly known as baker's yeast, is the one most often used in the kitchen. Yeast is tiny: Just one gram holds about 25 billion cells. That amount of fungi can churn out a significant amount of carbon dioxide, provided it has the simple sugars it uses as food. Fortunately, yeast can use its own enzymes to break down more complex sugars—like the granulated sugar in the activity below—into a form that it can consume.

Today we are going to experiment with yeast to produce air bubbles that would make dough rise.

Materials for each yeast bottle:

- 1 packet of active dry yeast
- 1 cup very warm water (105° F–115° F)
- 2 tablespoons sugar
- a large rubber balloon
- a small (1-pint to 1-liter) empty water bottle

Steps:

1. Warm up the water in a microwave, in an electric kettle, etc. It does not need to be boiling, just warm.
2. Stretch out the balloon by blowing it up repeatedly, and then lay it aside.
3. Pour the yeast packet, sugar, and warm water into one bottle and stir/swirl. Then cover the neck of the bottle with the balloon.
4. Then pour a yeast packet and warm water into the other bottle and cover the neck of the bottle with a balloon.
5. Give the experiment a few minutes. You should start seeing bubbles form in the one with sugar over the next several minutes, the balloon should inflate. Compare the differences between the two bottles. The one without sugar should not inflate and have much less bubbling. Talk about how yeast makes dough rise in baking while that is happening or even move to the next activity and then come back to see the changes. As the yeast feeds on the sugar, it produces carbon dioxide. With no place to go but up, this gas slowly fills the balloon. A very similar process happens as bread rises. Carbon dioxide from yeast fills thousands of balloon like bubbles in the dough. Once the bread has baked, this is what gives the loaf its airy texture.
6. Rinse them out thoroughly and do again with one having warm water and one room temperature/cold water. Compare and contrast again. Yeast is a living organism and needs to feed on the sugars in the right environment to produce carbon dioxide.

We just fed and grew yeast, a group of real fungus cells! Scientists today are experimenting with how we can grow all kinds of cells and even have those cells grow into things like organs, tissue,

or skin. Cells are kind of like using LEGOs to create a house or a tool. They are commonly used as the foundational building block to produce, maintain, and remodel the tissue matrix being grown into something to help someone and can be considered a key contributor to the healing and growth properties of a Tissue-Engineered Medical Product or TEMP. That could be a heart that we grew to give someone who had a heart attack, skin for someone who had a bad burn, anything like that. We aren't there yet, but scientists are working on making this a reality in the near future. Living cells are a critical component required in most TEMP processes.

Automation in BioFabrication/TEMP Processes Curriculum

Materials:

- ability to play videos
- basic art supplies (crayons, colored pencils, markers, and paper)
- robotics supplies if possible

Ask the girls what they think of when they hear the word “robot.” What do robots do? What do they look like? Do they have any robots in their house or that they interact with in their lives?

Robots are machines that we build to perform specific tasks. They have a computer inside of them that allows them to take in information, store it, process it, and then do a certain action based on that information. Robotics combines mechanical engineering and computer engineering to help us with a number of problems both in our daily lives and on a much bigger scale.

Robots often do jobs that may be dangerous for a human, like NASA’s robots that are exploring the solar system for us. They may also help us with jobs that we find dull, boring, or repetitive, such as building a car on an assembly line. Play this video from SciShow Kids (bit.ly/3dxnWb9) and/or this one from Science Trek (bit.ly/32w9ObC) to give a good overview of how robots do these jobs for us. Discuss with the girls what they learned. What are some of the jobs the video(s) discussed? Why would a human not want to do these jobs? What are the benefits of robots doing these jobs instead of humans? Are there reasons why a human would be better at this job (i.e. what would be the benefit of having a human do it instead of a robot)? These are the questions that scientists and companies are asking right now and as they look toward the future.

Scientists are looking at how to automate, or use robots instead of humans, to solve a number of different problems, even problems of the future. Our health is something that has always been and will always be an area to help people in new and innovative ways. Scientists are looking at growing cells, tissues, even organs to help people who may need replacement parts. We call these “replacement parts” Tissue-Engineered Medical Products. Scientists are also looking at how robots can help with this process to do it quicker, cleaner, and more efficiently.

Use this video from the ASME American Society of Mechanical Engineers about 3D Bioprinting at the Children's National Health System (bit.ly/2P326mp) to talk about using machines to grow cells, tissues, and organs to help people. Then, start a discussion at their age level to further understand it. Ask questions about what problems bioprinting is solving, how robots are helping, and ways they think this could be used in the future. Remind them of an automated assembly line, even bringing up video of it if you want, and have them think about how that might work in a place that is growing cells.

Have them use an assembly line to make SWAPs, a snack, a picture, LEGO model, etc. Have them draw an assembly line using robots or a single robot doing a step on an assembly line. Then, if possible, have them build and program a robot to do something simple that could be a step in an assembly line such as a robot arm picking something up.

Robots Do Jobs Humans Find Boring!

Robots help us solve problems big and small. They do jobs that might be dangerous for humans or even jobs that we find boring. The earliest robots were made to build objects like cars on an assembly line because people found it boring to do one job over and over again.

Image Credit: Smithsonian Magazine

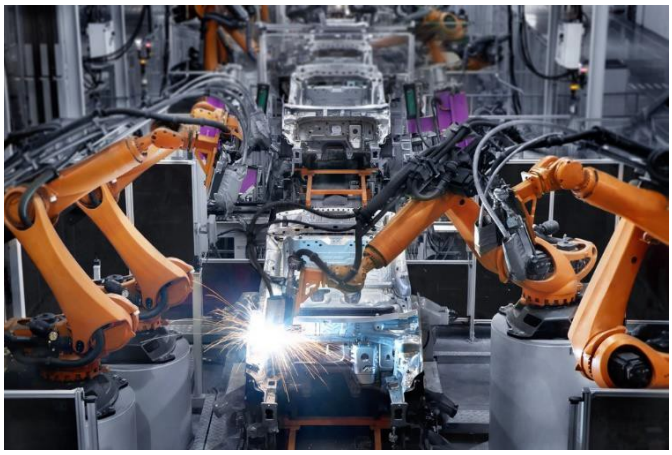


Image Credit: Alliance for American Manufacturing

Let's Try It Out!

1. Create an assembly line to make a SWAP, snack, picture, LEGO model, or anything else you can come up with! Instead of having one person do all the steps, each person does one step and then passes it on to the next person to do their step and on and on until the job is completed.
2. Think about how a robot would do this step. Would it need an arm? Fingers? How does it know where to stop or start? All of these are questions robot designers have to think about!
3. Draw a picture of an assembly line with robots or a robot doing a step in an assembly line.
4. If possible, build a robot to do a very simple step, i.e. picking something up.

Extra Resources:

Check out this video from SciShow Kids (bit.ly/3dxnWb9) and/or this one from Science Trek (bit.ly/32w9ObC) to learn more about the jobs robots help us with! Check out this video (bit.ly/2P326mp) to learn more about how robots can help keep us healthy and maybe even live longer with bioprinting!

ARMI/BioFab USA Biofabrication Patch Order Form

To help us improve our patch program and gather feedback from our girls, please complete this survey.

Troop Number: _____

# of Girl Scouts completing the Biofabrication Patch Program:

Daisy		Cadette	
Brownie		Senior	
Junior		Ambassador	

After talking with the girls about their experiences earning this patch, please answer these questions:

1. What was the girls' favorite thing about earning this patch?

2. What did the girls learn while earning this patch?

3. What would make this patch program better?

4. I don't give up when things are hard:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

5. Even if I am afraid of making mistakes, I still try new things:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

6. Girls like me can do important things:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

7. Girls like me can be good at many different things:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

8. I understand what biofabrication is:

ARMI/BioFab USA Biofabrication Patch Order Form

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

9. I know how scientists develop tissue in a lab to make products:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

10. I know about careers in biofabrication and tissue manufacturing:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

11. I know how biofabrication and tissue manufacturing helps people and the community:

	Exactly like me	A lot like me	Kind of like me	A Little like Me	Not at all like me	Don't know
Number of girls responding						

12. Did you work with someone in the biofabrication field to help you/your girls earn the Biofabrication patch?

- ❑ Yes
- ❑ No

BIOFABRICATION

Please return your Biofabrication patch order form AND evaluation forms together!

Patches can also be ordered at bit.ly/biofabpatchorder.

Troop Age Level(s): Daisy _____ Brownie _____ Junior _____
Cadette _____ Senior _____ Ambassador _____

Troop Leader: _____

Street: _____ City: _____ State: _____ Zip Code: _____

Day Phone #: _____ Night Phone: _____ Cell: _____

_____ # of patches

If you have any questions, please contact Customer Care at 1-888-474-9686. You may also email Customer Care at customercare@girlscoutsgwm.org.

Please mail this order form **AND** your evaluation to:

The Mountain Top Shop
Girl Scouts of the Green and White Mountains
1 Commerce Drive
Bedford, NH 03110