The Tech Interactive

Biotinkering Programs for Science Centers

Algae String

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
SUPPORTED BY THE NATIONAL INSTITUTES OF HEALTH

Stanford MEDICINE | Department of Genetics

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Algae String Overview

Science Center Experience

Large brown algae such as kelp contain alginate, which is a long molecular chain, or polymer, similar to the polymers in plastic but biodegradable. In this activity, visitors create strings using polymers harvested from seaweed and a dash of chemistry. They are empowered to choose from a variety of ingredients as they design and mix a custom algae gel. Then, they extrude gel made by a previous visitor into a calcium bath to explore how a chemical reaction can shape the squishy gel into a solid string. Fresh algae string is wet and can be used right away to create quirky crafts or taken home to be dried out, which will reveal more of its unique ingredient properties.

Subject
Biodesign

Ages
10+

Duration
20-30 min

Key Concepts
Algae, polymers, chemical reaction, extrusion

Activity Goals

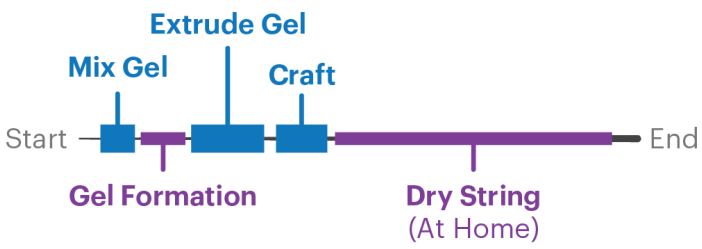
- Enable visitors to design and create colorful strings using biological building blocks harvested from seaweed.
- Provide opportunities for tactile stimulation and real-time iteration during experimentation with biological products.
- Demonstrate that biology can be used to make environmentally-friendly products with both practical and creative applications.

Operational Considerations

Base Biology	Format Complexity	Lab Requirements	Cycle Length	Cost
Algae Polymers (Sodium Alginate)	Medium: Biological Product	Sink	2-3 days	$$$

Cycle Details

A full *Algae String* cycle takes a minimum of several days to complete due to mandatory wait times for chemical processes and string drying (shown in purple). Using an assembly line approach, however, the visitor-facing activity can be consolidated into a single ~30 min experience (shown in blue).



Background Information

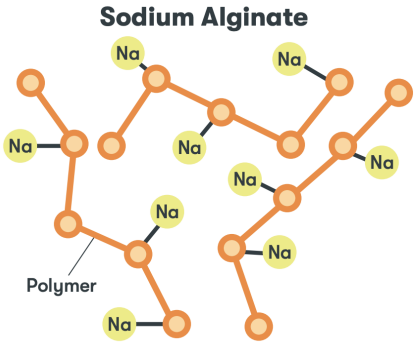
Algae Polymers

Algae is an informal term for a large and very diverse group of organisms that use photosynthesis to harvest energy from the sun. They are considered plant-like organisms, but are not plants because they lack many of the structures that characterize land plants. Algae can be found almost everywhere on the planet and vary in size from tiny single-celled things to larger multicellular ones.

The material at the core of this activity, alginate, is derived from large brown algae such as kelp, a type of seaweed that can grow to over 100 ft long in the ocean. Alginates are produced in the cell walls of brown algae, where they help provide structural strength and flexibility. They are polymers, meaning they are long molecules made of smaller subunits that repeat over and over and are linked together by chemical bonds. A process called polymerization happens inside the algae cells, linking the individual subunits together to form long molecular chains.

Polymers can be either natural or synthetic. Humans have used natural polymers such as cellulose, natural rubber, starch, and wool for thousands of years. Today, the manufacturing of synthetic polymers has become commonplace, and products made from these new polymers can be found all around us, They are present in items such as plastic bags, Styrofoam cups, nylon or polyester clothing, epoxy glue, and Teflon-coated cookware. Alginates, however, are natural biopolymers because they are produced by the cells of a living thing.

Harvesting alginate from brown algae is a complex chemical process with many sequential steps. The end result is isolated and purified alginate polymer chains that are associated with sodium (Na) ions. Called sodium alginate, this compound is readily available to consumers in powdered form. One of the main reasons for this is its frequent use in food preparation and cooking, where it is valued as a gelling agent and used for advanced techniques such as the spherification of liquids.



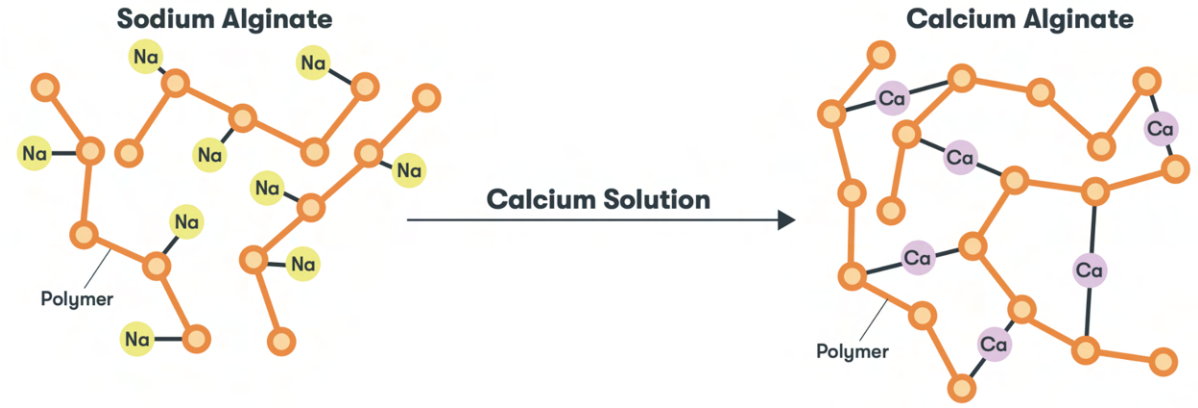
String Formation Process

Solidifying the Gel

When powdered sodium alginate is dissolved in water, it creates a squishy gel-like substance. This soft gel is transformed into a solid string using chemistry. The core chemical reaction involved is called ionic cross-linking, and it results in the formation of chemical bonds that connect one polymer chain to another. Cross-linked polymer networks have more structural stability than individual, unconnected polymers do, which is why cross-linking reactions can turn liquid substances into more solid materials

For sodium alginate, the cross-linking chemical reaction is initiated by the presence of a lot of calcium ions. The sodiums that were originally associated with the alginate polymers are replaced by calcium. Since calcium ions have two positive charges (sodium has just one) they can bond to two polymers at once. This means that they form bridges between different polymer chains. As the bonds form, the once

free-floating alginate polymers get linked together in many places, creating an overall net-like structure (diagram below). The new substance formed in this chemical reaction is called calcium alginate. It is a more structured material than the sodium alginate gel and forms the foundation of the algae string.



Adding the gooey algae gel to a concentrated calcium solution starts the chemical reaction described above. To shape the gel into a string, we use a technique called extrusion, or squeezing the gel out of a small hole. Extruding over a calcium bath makes the gel cylinder-shaped when it hits the liquid surface and the chemical reaction is initiated. The cross-linking reaction starts at the outside of a newly extruded string and moves toward the interior as the calcium slowly diffuses in from the bath. This is why algae strings get more solid over time if left in a calcium bath.

Properties of Dried String

Algae string starts out wet and noodle-like because lots of water is trapped inside the calcium alginate net. Over time, as the string dries out, the water evaporates and the string becomes stiffer and more strong. Calcium alginate on its own typically creates a string that is very brittle and breaks easily once dry. This can be remedied, however, by the addition of various additives to the algae gel mixture.

Humectants are materials that stay moist by absorbing water vapor from the air. They can keep dried algae strings flexible and workable for a very long time. They are not involved in the chemical reaction, but their presence is important for helping keep the dried string flexible. Different humectants will result in slightly different string texture, look, and feel, depending on which ones and how much is added, so they can be used to customize algae string. For example, humectants with high sugar content will be sticky but add a slight sparkle to the dried string, while other humectants may make the string smooth, lumpy, oily, or stretchy.

Real-World Connections

Environmental Impacts

Most plastic products that we see everyday are made from synthetic polymers. These materials have a serious environmental downside because they are not biodegradable and are frequently synthesized from petroleum products. A need to live more sustainably on earth has motivated recent scientific and industry research into how we might leverage natural polymers instead. Algae string is a great example of a product made from a natural polymer that could one day replace the synthetic fibers in many

textiles that harm the environment by introducing microplastics into our ecosystems. Designing with new materials like algae string can be part of a circular design approach to manufacturing that reimagines waste streams and minimizes linear product life cycles.

Applications and Companies

Both startups and more established companies are currently exploring alginate polymer technology as the basis for new materials and products. For example, Keel Labs is a startup focused on developing algae polymers into more sustainable fibers for the fashion and textile industries. The company grew out of an undergraduate Biodesign Challenge project from 2016.

On the other hand, some alginate-based products have been on the market for a long time. Wound dressings made from dried alginates are currently in widespread use to treat wounds on the skin that produce a lot of fluids, like ulcers. These bandages are made from calcium alginate (the product in our algae string chemical reaction). The gel formed when dry alginates absorb fluids helps the wound heal faster by forming an easy-to-change barrier that lets in air and keeps bacteria out. Another common real-world use of calcium alginate is in science and technical professions, including dental molds and cell tissue culture.

Useful Vocabulary

Term	Definition
Algae	A diverse group of aquatic organisms that have the ability to photosynthesize. Seaweed is a type of algae.
Alginate	A natural polymer produced in the cell walls of brown algae.
Biopolymer	A natural polymer produced by the cells of a living thing.
Cell	The smallest functional unit of life. Complex organisms are made of many cells.
Chemical bond	A link formed between two or more atoms or ions.
Chemical reaction	A process that breaks an existing set of chemical bonds to form new ones.
Extrusion	The shaping of a substance by forcing or pushing it out, especially through a small opening.
Humectant	A substance that retains moisture by absorbing water vapor from the air.
Ion	An atom with a net positive or negative charge.
Ionic cross-linking	The formation of covalent bonds that hold portions of several polymer chains together
Kelp	A large brown seaweed that typically has a long, tough stalk with a broad frond divided into strips.

Photosynthesis	The process of converting sunlight into chemical energy in the form of sugars.
Polymer	A large molecule composed of many repeating subunits.

Visitor Experience

Operational Summary

Context

Algae String uses a visitor-supported assembly line approach to consolidate a 2-3 day chemical and physical process into a single 20-30 minute experience for visitors. This activity was originally designed to run on a daily basis. While daily operations are not required, this schedule does allow for supply chain efficiency, as the materials made by past visitors can be used to support future visitors in a reliable and consistent fashion.

This activity was created as a semi-facilitated experience organized around three hands-on engagement stations: mixing, extrusion, and creative exploration. Each station is designed to be largely self-guided, with the facilitator providing initial onboarding and support as needed to answer questions and encourage creativity and confidence. A facilitator-led introduction and individual supply distribution can happen at any time and location between when visitors enter and receive their challenge at the first station, depending on what works best for a given space and staffing model. The remainder of the experience can be fairly self-paced, with visitors progressing between stations when ready.

Activity Outline

1. Visitor Prep and Introduction
    - Visitors put on gloves.
    - Facilitator gives an overview of the activity.
    - Facilitator briefly introduces algae, polymers, alginate, and biodegradable materials.
2. Algae Gel Mixing Station
    - Facilitator explains the goal: design an algae gel to use for making string.
    - Visitors get individual supplies: mixing containers and sodium alginate powder.
    - Visitors explore the available shared ingredients and effects they have on dried string.
    - Visitors experiment with mixing different ingredients together to form a custom algae gel.
3. String Extrusion Station
    - Visitors exchange their algae gel for one prepared on a previous day.
    - Facilitator introduces how the chemical reaction works.
    - Visitors explore different methods to extrude strings of various shapes and sizes.
    - *Optional:* Visitors may choose to return to the Mixing Station to restart the experiment.
4. Crafting Station
    - Visitors use their wet string to make fiber-based creations or take it home to dry.

Visitor Prep and Introduction

Overview

Provide a brief overview of the activity to orient visitors to the nature of the experience and have all participants put on gloves. The facilitator should introduce visitors to algae, kelp, polymers, and biodegradable materials. Tailor the focus and depth of the background information shared to the target audience and local community being served.

Essential Materials	Individual ● Gloves (all sizes) *Optional:* physical examples to support the introduction (e.g., images of kelp, dried algae string)
Example Setup	 

Engagement Strategies

Cultivate Confidence and Agency

- Successfully putting on gloves can be challenging and frustrating. Supports such as a hand measuring diagram can help young visitors navigate this step more independently.

Algae Gel Mixing Station

Overview

Visitors create an algae gel by combining sodium alginate with water and use additives to customize it. To provide authentic choice, offer a variety of additives, including a range of colors and humectants. Pre-portioning alginate powder into mixing pouches with clearly defined final volumes can help manage the mess and ensure that appropriate alginate concentrations for string making are achieved by all visitors. It takes quite a long time for alginate to fully dissolve, so visitors are encouraged to get the process off to a good start by making sure that their ingredients are thoroughly mixed. Once visitors are happy with their algae gel, they can move to the String Extrusion Station.

Essential Materials	<u>Individual</u> ● Sodium alginate powder ● Sealable mixing pouch (travel pouch, plastic baggie, etc.) <u>Shared</u> ● Water in a dispenser (bottled or filtered) ● Variety of dyes (red, yellow, blue, etc) ● Variety of humectants (glycerin, syrup, etc.) *Optional: Record-keeping materials to log gel ingredients*
Example Setup	  
Key Visitor Steps	1. Put sodium alginate powder in a mixing pouch (can also be prepared by staff). 2. Add water, colors, and humectants of choice. ○ A final concentration of about ⅔ tsp sodium alginate per 100 ml of liquid produces a good-consistency gel for string-making. 3. Seal pouch and agitate to start dissolving the alginate. *Optional: Label pouch with ingredients added.*

Engagement Strategies

Cultivate Confidence and Agency

- Give encouragement and validate ideas to help visitors embrace the personally-motivated design process, as many are uncomfortable with doing “science” without a recipe or protocol. Ask questions and offer suggestions to help visitors work through this discomfort.
- Streamlining complex steps with user-friendly equipment like a bottle top set-volume liquid dispenser can make a step that involves measuring a precise volume of water easily accessible and empowering to all ages and experience levels. These types of equipment also feel very “sciency” to visitors, and successful interactions with them can build confidence in a lab setting.
- A symbol-based system for labeling ingredient bottles and recording visitors' ingredient choices can help remove language barriers at this step.

Emphasize Science as a Creative Process

- Enable visitors to make informed decisions about their ingredient choices by exploring dried strings with specific ingredients. A touch board or other method of “research” into the effects of the ingredients on hand can help visitors imagine what they might want to create with science and why, which can provide a sense of purpose and creative direction for their experimentation.

Make Community-Relevant Connections

- Providing ingredient options, such as specific varieties of humectants, that are familiar to the populations you serve can allow additional points of cultural connection to the activity.

String Extrusion Station

Overview

Visitors make algae string by extruding algae gel into a calcium bath. Because of the time needed for sodium alginate to fully dissolve into a gel, they trade the gel that they just mixed for one created by a previous visitor and use that one instead. Encourage visitors to start experimenting with extrusion by making a short tester string to get familiar with extrusion and the chemical reaction. They should wait for approximately one minute after extruding the gel before removing it from the bath to give time for the cross-linking reaction to solidify their new string. After visitors have a basic understanding of the process, they can be turned loose to explore different extrusion techniques and experiment with trying to create strings of different sizes, shapes, and colors. Once visitors are finished experimenting and satisfied with their strings, they have two options for proceeding through the experience: they can choose to return to the Algae Gel Mixing Station to create another algae gel or they can move to the Crafting Station.

Essential Materials	Individual ● Calcium bath (see Backend Preparations for details) ● Fully dissolved algae gel, mixed by previous visitors ● Extrusion tool (mix pouch with a squeeze-top cap, cut plastic bag, etc.) *Optional:* Timers
Example Setup	 
Key Visitor Steps	1. Extrude algae gel into a calcium bath. 2. Leave the new string in for approximately a minute (minimum). 3. Remove the wet string to see what it looks like. 4. Repeat trying different extrusion techniques.

Engagement Strategies

Cultivate Confidence and Agency

- A record-keeping method, such as stickers, at the Algae Gel Mixing Station lets visitors document what ingredients they used and allows them to make a more meaningful choice about which pouch they want to select at this station.
- To help visitors of all ages independently track how long their strings have been in the bath, consider providing simple devices like 1-minute sand timers.
- Encourage young visitors to repeat the mixing step when they are done extruding. This provides the opportunity for them to assume the role of an expert since they have done it already and can guide other members of their group who did not initially participate through the process.

Encourage Experimentation and Open-Ended Exploration

- Highlight the varied approaches and opportunities for iteration that exist when extruding gel into the calcium bath. Expand those opportunities by providing additional tools for gel extrusion.
- Encourage collaboration between visitors through gel swapping at the extrusion station to increase the number of string colors that an individual visitor can produce.

Foster Scientific Curiosity

- The phenomenon of turning something soft into something solid is exciting and inspiring to many visitors. Encourage those who are intrigued to learn more about the underlying chemistry of alginates and polymer cross linking by providing supplemental video or graphic content or knowledgeable facilitators.

Crafting Station

Overview

Visitors can use their still-wet string to create crafts of their own, such as bracelets, keychains, or knots. They can also take their fresh string and creations home in baggies. Consider using compostable baggies to reduce plastic waste from the activity. At home, wet algae string can be dried out to become a sturdy and long-lasting string material. It is more suitable for new and different crafts in this form.

Essential Materials	<u>Shared</u> ● Take-home baggies ● Crafting supplies with different functions: ○ Fiber arts (crochet hooks, etc.) ○ 3D assembly (craft sticks, brads, etc.) ○ Attachments (string, yarn, keychains, etc.)
Example Setup	

Engagement Strategies

Make Community-Relevant Connections

- Consider providing information and materials to support fiber arts techniques that are common among the cultures and audiences served.

Common Visitor Questions

Visitors often ask unpredictable or incredibly specific questions about the content or process of an activity while they are participating in the experience. Every audience will have different interests or prior knowledge that they bring to the experience. Below are examples of the most common questions we hear from visitors and the types of answers we aim to provide.

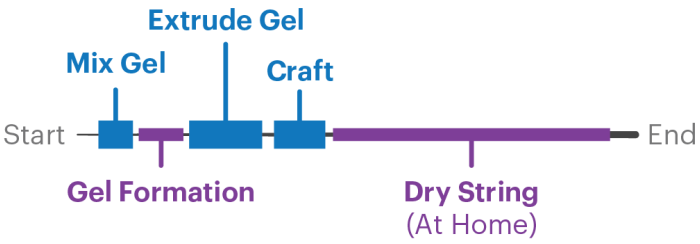
Question	Information
Can I eat this?	*No! You should never eat anything you make in a lab.* Think about it — a *lot* of people have touched these materials. Gross.
How much of each ingredient should I add?	*It's up to you to decide!* You're the designer, so you get to pick what qualities the string will have once it's made. If you're not sure where to start, check the information about the effects each ingredient will have on the dried string to help you make a decision.
Will I get to take my algae string home?	*Yes, but not strings made from the algae gel you designed.* It takes time for the sodium alginate powder to fully dissolve, so the algae gel you just mixed won't be ready in time. A future visitor will finish that experiment. You get to make strings to take home from a gel created by a previous visitor.
I'm squeezing my pouch, why isn't anything coming out?	*Your gel likely has some thicker sections or clumps that need to be mixed better.* Sometimes the ingredients aren't mixed very evenly in the pouch to start, so that means that some parts of the resulting gel are really thin while others are really thick and goopy. These extra-dense clumps can't fit through the hole in the cap, so it gets clogged. You can fix this issue by pushing the clump back down into the pouch and squishing the pouch a little to help distribute things better.
Why is the calcium bath colored? Will it impact my string?	*The coloring in the gel can leak out of the newly-formed string.* If the dye being used in the algae gel is smaller than the openings in the calcium alginate net formed during cross-linking, it can diffuse out and escape from the freshly-made algae string. This is the case with food coloring. If a string is left in the bath for a very long time (several days), eventually most of the color will leave it. Diluted color in a previously-used calcium bath won't significantly impact the color of freshly extruded strings because the chemical reaction happens as the gel hits the liquid.
Plastic bags for biodegradable string, really?	*Don't worry, we use compostable baggies!* That means that these bags will break down naturally in a compost environment. It usually takes around 90 days for the materials to break down completely.
What happens if dried string gets wet?	*It will just get soggy and slippery again (like it is now).* When added to water, your dried string would just rehydrate into wet noodles like when they were first made.
How long will my dried string last?	*Very long, if stored properly.* Dried string is stable and can be incredibly long-lasting. In fact, algae strings made by The Tech have held up for more than three years (and counting!).

Is this how Orbeez are made?	*No. While they look similar, they are made very differently.* Water beads, like the children's toy Orbeez, resemble the fresh algae string but are made of a different polymer (sodium polyacrylate). Orbeez are sold in their dried form, with the polymers already cross-linked together. Both Orbeez and our string form something called a hydrogel when they come into contact with water. While the overall process is roughly the same, the underlying chemical reactions are different because the polymers are different.

Backend Preparations

Overview of Components

The biological base of *Algae String* is sodium alginate, a polymer harvested from large brown algae, so minimal ongoing support is needed to operate this activity. A full activity cycle, from start to finish, usually takes several days due to mandatory wait times (shown in purple) for chemical processes and string drying after visitors leave the institution. Shortening the length of the overall cycle is possible, but it requires dedicated effort at several steps to hurry things along.



A visitor-supported assembly line approach can be used to consolidate the visitor-facing activity into a single floor experience (shown in blue). To achieve this, allow sufficient time between each phase of the activity for slow processes to complete on their own. The visitor-supported phase of the cycle should be maintained on a consistent and ongoing basis to ensure that materials (fully dissolved algae gel) are available at the next step of the activity. To stabilize the assembly line approach against supply chain disruptions and visitor number variability, staff can make supplemental algae gel pouches when needed. This strategy can also be used to support operational formats other than daily programming, if desired.

Backend preparations for this activity include:

1. Selecting and Preparing String Ingredients
2. Preparing Calcium Baths
3. Storing Algae Gel
4. Making Supplemental Algae Gel Pouches

Starting Up: Getting the Visitor Assembly Line Going

The first time this activity is run with visitors, staff will need to prepare algae gel pouches one day in advance to have supplies ready for each step of the activity. After that, the visitor-supported assembly line approach can be leveraged in an ongoing fashion to sustain supplies.

Selecting and Preparing String Ingredients

These ingredients are used by visitors at the Algae Gel Mixing Station. The goal is to provide an array of options that allows visitors to make personalized choices about what properties, such as texture, look, feel, and color, that they want the final dried string to have.

Technical Tip: Avoid Tap Water

Hard tap water can contain calcium, so it should be avoided in all preparation steps prior to the string extrusion step, otherwise cross-linking can be triggered prematurely in the algae gel.

Materials

Reusable Equipment	
Item	**Notes**
Water dispenser	A pump that can deliver a pre-measured volume is ideal
Ingredient bottles	Squeeze or pump top bottles work well

Consumable Supplies	
Item	**Notes**
Sodium alginate powder	Can be purchased from various online sources
Water	Bottled or filtered
Dyes or colorants	Provide several options - food colorings works well
Humectants	Provide several options - syrups, aloe vera, and glycerine all work well

Procedures

1. Select ingredients for the visitor-facing activity.
    - Purchase sodium alginate that was derived from kelp.
        - Use a powdered variety that is considered a food thickening agent.
        - Avoid dental alginate as it contains ingredients that initiate cross-linking too early.
    - Procure water to dissolve the sodium alginate in.
        - Use bottled or filtered water only.
    - Choose a minimal set of dyes or colorants which visitors can use and combine creatively to change the color of algae gel.
        - Standard food coloring and gel food colorants both work well, but feel free to explore other options.
        - Avoid mineral pigments, as they also might initiate cross-linking too early.
    - Choose several humectants with distinct properties which visitors can use to alter the flexibility and texture of dried algae string.
        - Easy-to-acquire options include syrups (e.g., pancake, agave, sugar, honey), aloe vera, or glycerin, but feel free to explore others.
        - Avoid syrups with lots of calcium, such as molasses or real maple syrup.

2. Prepare ingredients for visitors to use.
    - Dilute selected dyes (if needed).
        - More concentrated dyes (e.g., gel food colorants) should be diluted before visitor use to avoid staining hands and supplies. Use bottled or filtered water only.
    - Put the bottled or filtered water into a dispenser.

Equipment Highlight: Pre-Measured Volume Pumps

Using a water dispenser that delivers pre-measured volumes not only improves the visitor experience and simplifies facilitation for staff, but it also streamlines backend operations. This tool can help ensure that each visitor-made algae gel gets the appropriate volume of water added at the Algae Gel Mixing Station. Stabilizing this variable helps to ensure that all gels achieve a final sodium alginate concentration that enables good string making, which is key for achieving a relatively self-supporting and low-maintenance visitor-supported assembly line.

Preparing Calcium Baths

These calcium baths are used by visitors at the String Extrusion Station. Each bath may be reused for 5-7 activity sessions before the calcium level becomes too depleted to support a speedy chemical reaction. Replace the solution at this point to ensure a successful string-making experience for visitors.

Materials

Reusable Equipment	
Item	**Notes**
Large container	Sized to calcium bath volume needed
Measuring cup	Plastic is best as calcium chloride will cause metal to corrode

Consumable Supplies	
Item	**Notes**
Water	Tap water is okay
Calcium chloride	Can be found online or at home brewing supply stores

Procedures

1. Make a stock of calcium bath solution.
    - Add ⅓ cup calcium chloride ($CaCl_2$) to 3L of water, scale as needed.
        - Any type of water can be used, as the presence of calcium is not an issue.
    - Wait for the $CaCl_2$ to fully dissolve.
        - Stirring can speed up this process.
    - This solution is stable for long periods of time and can be used on an as-needed basis.
2. Prepare individual calcium baths for visitor use.
    - Distribute at least 2 cups of calcium solution into smaller bath containers for visitor use.

Storing Algae Gel

Store visitor-made algae gel produced at the Algae Gel Mixing Station for long enough to allow the sodium alginate powder to fully dissolve. This typically takes at least six hours. Algae gel can also be stored for longer periods, if needed, to help buffer the supply chain against variations in numbers of visitors.

Materials

Reusable Equipment	
Item	**Notes**
Refrigerator	If storing gel long-term

Procedures

1. Make sure the individual algae gel pouches are sealed.
    - If storing for several days:
        - Room temperature is usually fine, but refrigerated is also an option.
    - If storing for a week or more:
        - Refrigerate the gel to minimize contamination growth.
2. Check algae gel for contamination before use if stored for a longer period of time.

Technical Tip: What Does Contamination Look Like?

If properly sealed and used within a quick time frame, unwanted microbial growth in algae gel mixtures is rarely an issue. The most common form of contamination is usually mold, like you see on food accidently left out in a kitchen. In algae gel, this often looks like floating black or white spheres. A visual inspection should quickly identify any gel mixtures that have unwanted microbial growth. Dispose of these and clean all tools thoroughly before reuse.

Making Supplemental Algae Gel Pouches

The first time this activity is run with visitors, staff will need to prepare algae gel pouches a day in advance to have supplies ready for each step of the activity. Once the activity is up and running, it should not be necessary for staff to pre-make supplemental pouches, but it is always an option.

Materials

Reusable Equipment	
Item	**Notes**
Mixing pouch	Something flexible and sealable, such as a plastic pouch or baggie, is ideal
Measuring spoons	

Consumable Supplies	
Item	**Notes**
Sodium alginate powder	Can be purchased from various online sources
Water	Bottled or filtered
Dyes or colorants	As desired
Humectants	As desired

Procedures

1. Combine bottled or filtered water, sodium alginate powder, and desired dyes or flexibility ingredients in a mixing pouch.
    - Sodium alginate should be at a final concentration of about ⅔ tsp per 100 ml of liquid. Scale amounts as needed.
2. Agitate so that all ingredients are equally distributed to help promote the formation of a consistent algae gel.
3. Leave the mixture for at least 6 hours or overnight to allow the alginate to fully dissolve.
    - If the alginate has not been absorbed into the gel by the next day, break up any clumps and redistribute throughout the liquid to encourage further combining.
    - In an emergency, it is possible to use sustained and vigorous mixing to shorten the gel-formation time window to closer to one hour.
4. Seal the pouch and store algae gel until needed.

Common Backend Questions

Standard operating procedures for this activity will vary based on the unique context of a given institution. Factors such as physical spaces, programming frequency, equipment availability, staffing models, and audience characteristics will introduce constraints and preferences that the general procedures above can be adapted to accommodate. Below are answers to the most common operational questions and insights from our experience running the activity in the Biotinkering Lab.

Question	Information
What makes a good algae gel mixing pouch?	*Ideally, something flexible that will stay sealed while the gel is mixed.* Zip-lock baggies can work, but mixing by hand (squishing) must be done carefully to avoid explosions. We've found that plastic pouches marketed for packing liquids during travel work well because they are flexible but sturdy and

	can be sealed tightly. Mixing by squishing is one of the most effective ways to combine chunky sodium alginate gel and easier for young visitors to do. Also, it is much less messy than open containers! The pouches our visitors use have a similar form factor to applesauce pouches and include squeeze-top caps. While not a requirement, this pouch format allows the gel to be made and mixed in the same container that is used for extrusion.
What type of pre-measured volume water dispensers work best?	*Ones that are durable and have a press-down dispensing mechanism.* Measuring volumes accurately with beakers or graduated cylinders is difficult for many visitors, especially young ones. It also requires additional instruction and facilitator support, so we recommend streamlining this step by providing a simple and intuitive measuring device. We use BrandTech seripettor® Bottletop Dispensers, which can dispense pre-measured volumes up to 25mL.
What are some good starter humectants?	*We choose to offer visitors aloe vera, vegetable glycerin, and agave syrup.* These three ingredients provide a range of different but fairly predictable effects on dried strings, so they make a nice trio of options for visitors. Agave syrup gives strings a sparkle, but these strings are sometimes also a little bit sticky. Strings made with aloe vera tend to be a bit stretchier, but often dry with lumps and a noticeably different texture. Vegetable glycerin produces smoother strings without impacting the final color, but they have a slightly oily residue. We provided this info to visitors to help them make informed decisions while mixing algae gel.
What is the strategy for maintaining a perpetual supply of algae gel?	*Have visitors create a new algae gel mixture for each one they extrude.* We don't limit visitors to extruding only one gel mixture, but we do have a strict replacement policy to ensure that our stock is constantly being replenished. To be able to make string from a new gel mixture, visitors must first repeat the mixing station to create a bonus pouch. To further supplement supplies, facilitators can also mix algae gel along with visitors during low-key sessions.
There are clumps of alginate powder in pouches left overnight, what now?	*Mush up the clumps and let the pouch sit until the next day before use.* If the algae gel ingredients aren't mixed together well enough by visitors, remaining larger clumps of alginate powder will form little pockets that won't hydrate easily on their own to become a gel. This is why we encourage visitors to mix for as long as they want before moving on to the extrusion station.
Oops, the algae gel turned solid right away, what happened?	*That just means calcium got into the algae gel before it was shaped into string.* Algae gel will start to solidify as soon as it encounters calcium ions, and it takes whatever shape it is in when this chemical reaction starts. So, when calcium gets into the algae gel before it is extruded, a solid mass will form in the container. This is why we avoid water sources with calcium and ingredients like dental alginate that might prematurely initiate a cross-linking reaction.

Supplemental Resources

Full Materials List and Recommendations from The Tech

Reusable Equipment		
Item	**Notes**	**Specific Recommendations**
Refrigerator	If storing gel long-term	
Water dispenser	A pump that can deliver a pre-measured volume is ideal	We use BrandTech seripettor® Bottletop Dispensers, which can dispense pre-measured volumes up to 25mL.
Ingredient bottles	Squeeze or pump top bottles work well	We use pump top ones for humectants and squeeze ones for dyes.
Large container	Sized to calcium chloride bath volume needed	We use a large glass jug with a magnetic stir bar on a stir plate as a low-effort way to prepare calcium chloride for the next day.
Measuring cup	Plastic is best as calcium chloride will corrode metal	We use a cup that holds 2 cups of liquid to simplify individual calcium bath preparation.
Measuring Spoons	To measure sodium alginate powder	We use adjustable ones to achieve intermediate measurements in one scoop.
Mixing pouch	Something flexible and sealable, such as a plastic pouch or baggie, is ideal	We use 100mL clear, refillable travel pouches. These are durable and have a defined volume that can be used to limit visitor additions to an amount that is most appropriate for the sodium alginate powder we provide.
Extrusion tools	Use the same pouch as the gel was mixed in to eliminate the need to transfer sticky gel to a new container. Could also opt for other tools like syringes, piping bags, etc.	Our mixing pouches have caps with squeeze-tops to allow for direct use of these containers as visitor extrusion tools. This works very well.
Calcium bath container	Should hold a minimum of about 2 cups of liquid	We use a 50 oz plastic container with a basket (designed for berries). The basket provides a useful tool for visitors to pull their string from the bath as well as streamlines cleanup and reuse of baths between sessions.
Timers	Optional but recommended	We use 1-minute sand timers to cut down on auditory overload.
Scissors	Optional but recommended if there is string at the craft station	

Consumable Supplies		
Item	**Notes**	**Specific Recommendations**
Gloves	All sizes	
Sodium alginate powder	Can be purchased from various online sources	We use a variety that is sold as a food thickening agent.
Water	Bottled or filtered is required for any step prior to string extrusion but tap water is okay for calcium baths	
Dyes or colorants	Provide several options - food colorings works well	We use the primary colors (red, yellow, blue) to support color wheel exploration.
Humectants	Provide several options - syrups, aloe vera, and glycerine all work well	We use aloe vera, vegetable glycerin, and agave syrup.
Calcium chloride	Can be found online or at home brewing supply stores	We use food-grade calcium chloride for an extra visitor-safety layer.
Record-keeping materials	Optional but recommended as it allows visitors to log their algae gel ingredients so that future visitors can make an informed choice at the extrusion station	We use icons to denote different humectants and provide them to visitors printed on custom-designed dissolvable rice paper stickers. Labeling is achieved by adding stickers to pouch exteriors and cleaning is streamlined because stickers just dissolve in the dishwasher.
Crafting supplies	Provide a variety of supplies that support fiber arts, 3D assembly, and attaching	We use craft sticks with holes, brads, string, yarn, and keychains.
Sealable baggies	To take wet string home	We use compostable ones.