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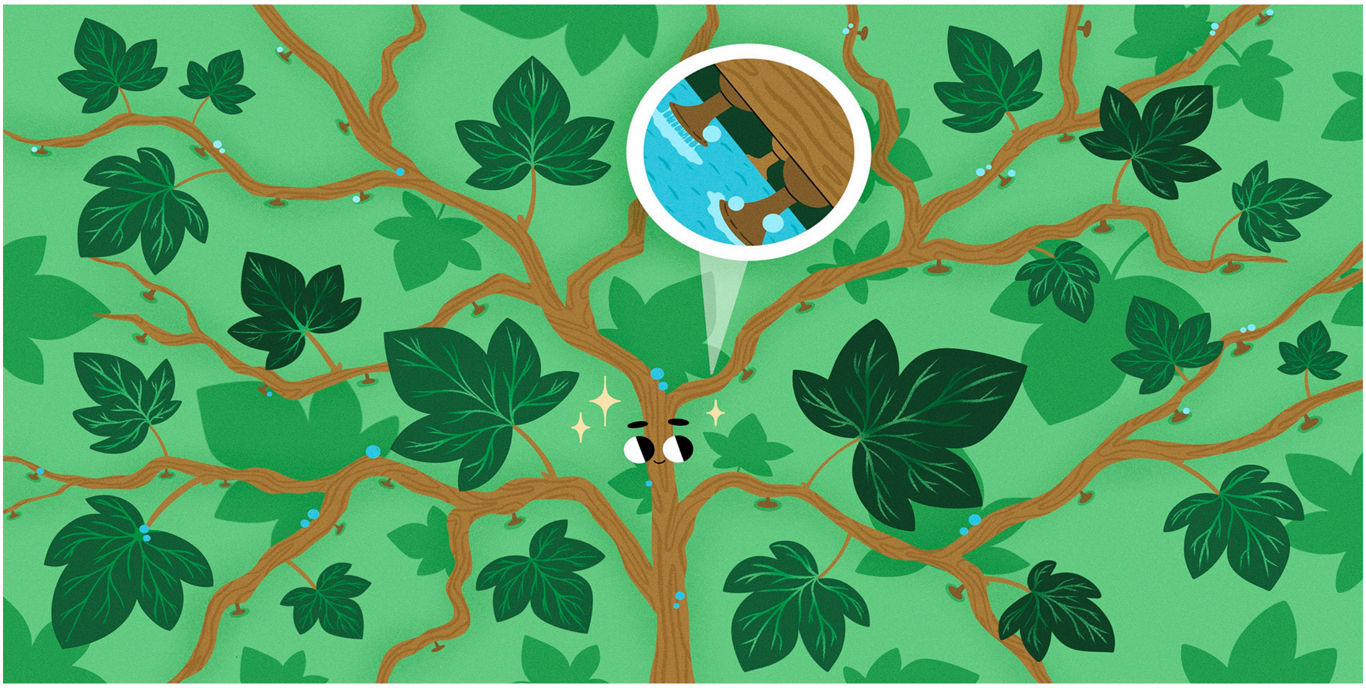

PLANT SLIME: HOW PLANTS USE STICKY SUGARS

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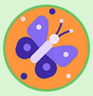

EMMA

AGE: 8

TIBERIUS

AGE: 11

Slime is fun to play with—it is gooey, squishy, slippery, stretchy, and sticks to everything. But did you know that almost all plants make some kind of slime? Similar to how you can make slime at home using glue, plant slime is made of sticky sugars that can act like glue. This slime helps plants in many ways: it protects them from drying out, it helps them take up nutrients from the soil, and it shields plants from toxic materials that could damage them. But plant slime can also help plants climb up walls, stick to other plants, and interact with other organisms in the environment. In this article, we explain how plants use sticky slime to survive in various environments, and even how we can use this slime to make better materials and clean up our environment.

NATURE IS STICKY AND SLIMY

Nature is full of slimy creatures, and there is a good reason for that: slimy mucus protects snails against water loss, helps insects or geckos climb up vertical walls, and allows frogs to catch flies with their tongues. Bacteria produce a glue-like substance that helps them attach to surfaces, which forms a slimy residue called a biofilm. Even algae, mussels, and other organisms that live in water produce sticky substances to glue themselves to rocks and avoid being washed away by waves. Something that may seem even more bizarre is that most plants make slime, too. Since plants cannot move, they have developed a special way to use a slime called **mucilage** to overcome the difficulties of being stuck in one place.

MUCILAGE

A thick, sticky, gel substance produced by plants, composed mainly of polysaccharides.

PLANT SLIME IS BUILT FROM SUGAR

Plant mucilage is released by cells to form a slimy layer or sticky droplets around them (Figure 1). We cannot always see mucilage because it is often microscopic, which means it is not visible to the naked eye. But some plants produce slime in amounts that we can see. Nearly all plants produce mucilage on at least one plant part, like the stems, leaves, flower buds, or seeds. Even the roots underground wrap themselves in a layer of mucilage.

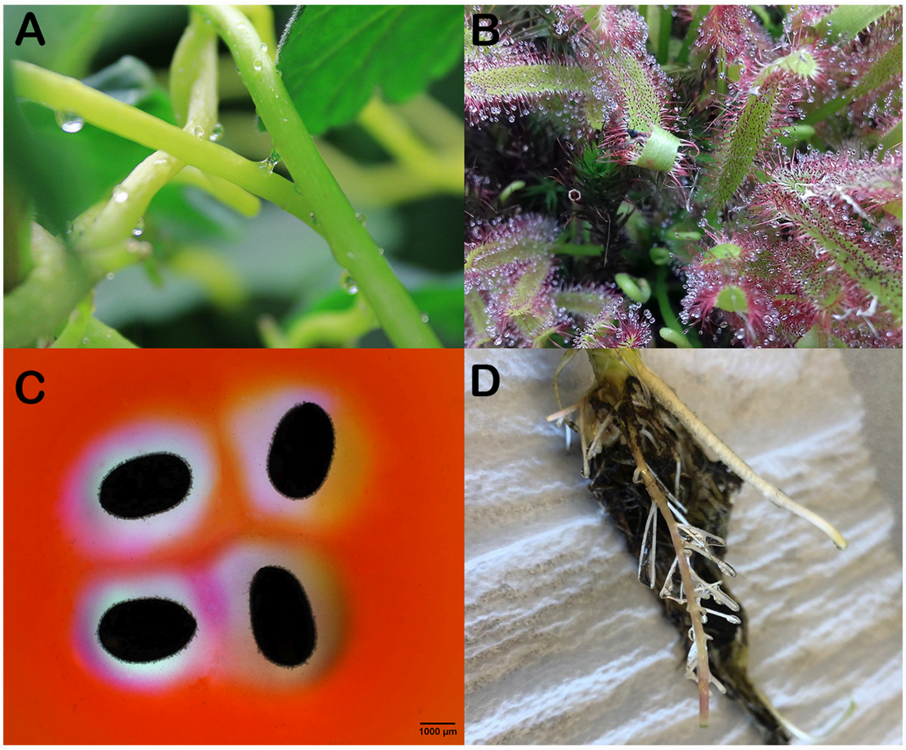

Figure 1

Figure 1

Mucilage on plants. **(A)** Sticky droplets on a parasitic dodder plant. **(B)** Sundew plant with sticky mucilage stalks to trap insects. **(C)** Chia seed mucilage (white) after soaking the seeds (black) in water (background dyed red for contrast). **(D)** Slimy mucilage on grass roots after removal from soil.

POLYSACCHARIDES

Long chains of sugar molecules.

Mucilage is mostly made of **polysaccharides**, which are long chains of sugars. There are many types of sugars, with funky names like glucose, galactose, and xylose. These long sugar chains are what make mucilage sticky. How sticky depends on the composition of the sugar units and how they are linked together. You can think of it like building with Lego blocks: you have a few types of blocks (the individual sugars) but depending on how you put them together, you get unique forms (Figure 2). In this way, thousands of distinct polysaccharides can be made with just a few types of sugars. Mucilage can also include other compounds—like proteins, which can break down the polysaccharide chains into their sugar units; fats, which help hold water; and minerals that can interact with other minerals in the surroundings. There is a lot of variation in mucilage polysaccharide mixtures between different plants, which helps the plants perform unique functions.

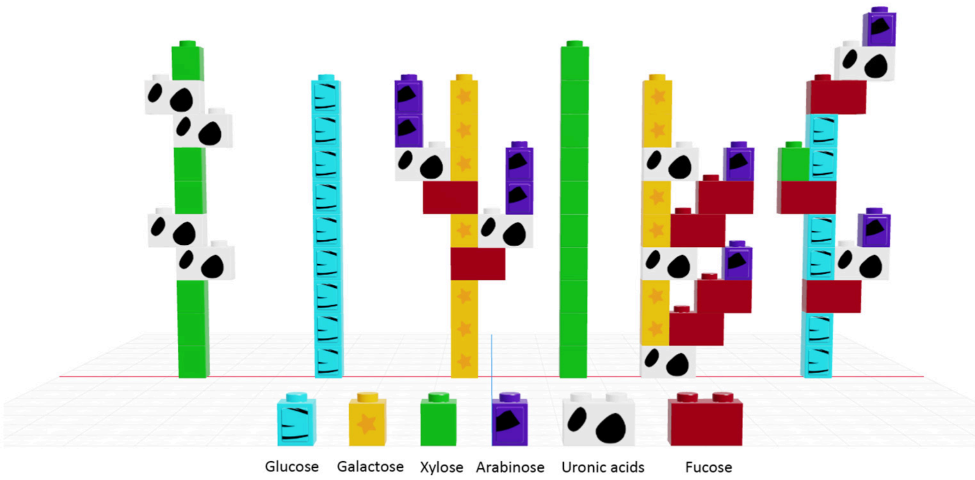

Figure 2

Figure 2

Slime polysaccharides built with Lego blocks. Unique sugar chains can be made by linking together different types of sugars (the specific Lego blocks) in various patterns (figure was generated using Mecabricks.com).

DIFFERENT SLIMES FOR DIFFERENT TIMES

Some plants develop a layer of mucilage from their very beginnings as seeds, which you can see after soaking seeds in water (Figure 1C). This slime layer protects new seeds from drying out and helps them stick in the soil, so they can germinate and grow into plants. When seeds germinate, they send out roots to look for water. The new roots are sometimes covered in a thin, protective layer of mucilage that can help them push through hard soil and stay hydrated (Figure 1D). Mucilage can absorb 25–600 times its weight in water [1].

Most of the nutrients plants need are taken up from soil, by the roots. But sometimes the nutrients are out of reach, trapped in soil particles, or surrounded by toxic elements (like aluminum and other metals that are harmful to plants). To deal with this, plants can use mucilage as a tool to transform the environment around them and get to the nutrients. Mucilage can make soil particles stick together, changing the way nutrients and water move through the environment. Mucilage can bind to toxic elements in the soil to prevent them from damaging the roots [2]. It can also be used to send signals to microscopic "friends" like bacteria living in the soil. These microscopic friends, called **microorganisms**, can give nutrients to plants or help protect roots from harmful organisms. To recruit these beneficial microorganisms and get them to share some of the nutrients plants need, plants put a tasty blend of slimy polysaccharides into the soil. Different plants provide their own distinct slime "smoothies," which they can change depending on the environment and the nutrients needed. Because of this, unique communities of soil microorganisms are often found living close to different types of plant roots. The microorganisms can then eat the sugars from the polysaccharides—a win-win situation for all.

MICROORGANISM

Living things that are too small to be seen with the naked eye so they must be viewed under a microscope. Some examples are bacteria, molds, and viruses.

IS SLIME LIKE A SUPERPOWER?

Some plants have developed extra-special ways to use slime. Plants like cacti, aloe, and other succulents are filled with mucilage cells that help them store water [3]. Water storage helps them grow in dry environments like the desert, where water is very limited. Climbing plants use a small layer of slime as glue, to help them stick to almost any surface (Figure 3). Sticky disks at the end of special roots or small vines usually produce this glue. Some plants have developed a way to steal resources from other plants. These are called **parasitic plants** because they do not make their own energy. Some parasitic plants can wrap around other plants' stems and secrete sticky droplets to help them stick tightly to their hosts, like the parasitic dodder plant. Then they push small, fang-shaped organs into the host plant to suck out its nutrients.

PARASITIC PLANT

A plant that lives in or on another plant (the host) and gets some or all of its nutrients and energy from the host.

Other plants secrete a slime feast along their stems to attract friendly insects, like ants and wasps, that protect the plants from predators that would eat them. This slime is similar to the sugar-rich nectar found in flowers, which attracts pollinators like bees, butterflies, and even some birds. Some plants also use slime to eat insects. They make a sticky, sweet trap and then digest the insects that get caught in it. These plants are called **carnivorous plants** because they eat animals to supplement their photosynthetic diet. All these mechanisms have evolved to help plants survive in their individual environments.

CARNIVOROUS PLANT

A plant that gets nutrients from trapping and consuming other organisms like insects, but still generates some energy from photosynthesis.

MUCILAGE: TO INFINITY AND BEYOND

Scientists are continually investigating ways to improve our use of natural resources. We have learned that plants use mucilage in a variety of ways, but mucilage might also help us reduce or repair damage to the environment. The slime released by roots has **bioadhesive** properties [4]. Bioadhesives are natural substances with

BIOADHESIVE

Natural substances that can be used as sticky adhesives or glues.

Figure 3

Figure 3

An ivy plant climbing up a wall using tiny, thread-like tendrils and a glue-like mucilage.

sticky properties that can act like glue. In a period of drought when rain is scarce, grasses release more mucilage to help water stick in the soil around them [5]. Maybe we can plant grasses to help rebuild ecosystems that have been destroyed through mining or deforestation, for example, by using them to establish healthy soils in which other plants and organisms can flourish.

Some mucilage has antibacterial properties, which means it can stop growth of bacteria. Cactus mucilage can remove bacteria from water in an affordable, renewable, easy-to-use way [6]. To purify water, mucilage is separated from the plant by boiling or chemical processes, then mixed with contaminated water in filter tubes. The mucilage sticks to mud particles and bacteria in the water and makes them settle to the bottom, separating them from the water. This could help developing countries dramatically, by giving people access to clean water—one of our most valuable resources.

Glues are used in a wide variety of things, such as construction, in the medical field, and in food packaging. Especially for food and medical uses, we need clean and sterile materials, so we often use single-use plastics which are bad for the environment. The bioadhesive and antibacterial properties of mucilage might offer natural alternatives to these issues. To make mucilage-based products, the sticky compounds in the mucilage can be removed by a chemical process in a laboratory, and then combined in various ways to create new materials. To replace plastics, mucilage compounds can be combined to create a durable, water-resistant, and lightweight materials. When combined with substances that we know work well with the human body, these materials can help heal broken bones and wounds by providing a structure for new cells to attach to, or by helping the body absorb medicines [7].

By replacing synthetic materials with natural mucilage-based products, we can use renewable materials that are kinder to the environment, improve human health, and reduce the amount of plastic waste. On top of all that, some plant slime is edible. This is why it can be used safely for medicine and food packaging or directly to make food products. For example, mucilage is used to stabilize milk products such as ice cream and yogurt. It also improves the texture of fruit fillings, jams, and desserts. Fun fact: marshmallows were originally made from root mucilage collected from the marshmallow plant. It is important to note, however, that not all mucilage is edible. Some plants may also contain toxic chemicals that they use to protect themselves.

PLANT SLIME FOR THE FUTURE

In summary, slime is everywhere on Earth and provides many important functions. By understanding the unique principles used in nature to produce sticky, glue-like, and antibacterial substances, scientists can develop better ways to heal wounds, reduce the need for synthetic glues, purify water, help the environment rebuild itself, and so much more. Who knew plant slime could be used for so many cool things? We still have a lot to learn about the specific compounds in plant mucilage, but from what scientists have discovered so far, plant slime may be able to make the world a better, cleaner place.

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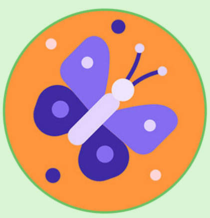

EMMA, AGE: 8

I love to learn about nature and the world around us. I enjoy being outside, hiking with my family and discovering new places we have not visited before. I think I am a very active person and my favorite sports are rhythmic gymnastics and skiing. I am also very fond of rollerblading, but I just started, and I have a lot to learn and practice.

TIBERIUS, AGE: 11

My name is Tiberius and I am 11 years old. I live in a household that speaks three languages. I compete on a swim team in the summer. I enjoy playing video games, reading fantasy novels and playing in chess tournaments at school with my friends. I play the piano and guitar. I really like science, especially microbiology. I find it interesting how such small organisms can affect our lives so much and how we could not live without them.

AUTHORS

CORINE FAEHN

I am a second-year Ph.D. student at the University of Tromsø in Norway. I am studying how different plant species contribute to stabilizing their surrounding ecosystems through the use of root mucilage (slime). Studying plants in the Arctic gives me a unique opportunity to look at adaptations in extreme environments, which can hopefully be used to contribute to ecosystem restoration or agricultural improvement. In my spare time, I like to tend to my plants at home, read books, or just enjoy nature (preferably during summer). *corine.a.faehn@uit.no

ANDREW GALLOWAY

I am a consultant plant biologist, and I write various articles about how cool plants are. During my time at University, I examined how plant roots interact with the soil *via* slimy root mucilage. I found that this mucilage could clump soil together and keep it stuck tightly to the root's surface. This means that plants could maintain water uptake during periods of drought. When I am not working, I like to read sci-fi stories, hit the gym, and look after my over 100 houseplants.

KIRSTEN KRAUSE

I am a university professor of plant molecular biology at the Arctic University of Norway. I am enthusiastic about learning how minute molecules can regulate something as complex as a plant. My current passion is parasitic plants that use sticky mucilage to “capture” their host plants and hold them close. I like working with other like-minded people to explore some of the cool stuff nature has invented. We use a mix of microscopy, biochemistry, and molecular biology for our investigations.