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BIODIVERSITY
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SEED BANKS: STORING THE WORLD'S PLANTS FOR THE FUTURE

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YOUNG REVIEWERS:

DOROTHY
AGE: 11

SIRI
AGE: 13

Although you may have visited a bank in your lifetime, maybe to deposit or withdraw money, it is likely that you have never been to a seed bank. These buildings do not contain money or gold bars but instead hold something even more precious: the seeds or other materials of plants belonging to over 50,000 species—~12.5% of all known plant species. Human pressures on natural ecosystems threaten many plants, and protecting the vast array of plant life on Earth is critical for assuring that we can grow enough food for everyone on the planet in the years to come. For this reason, scientists have thought of freezing seeds and/or other parts of plants to preserve them and make them available for the future. Seed banks also allow scientists to study the history of certain plants, and these banks can provide them with the resources needed to change some plant traits in helpful ways.

GENETIC EROSION ALERT!

The DNA of each organism contains the information specifying the unique characteristics of that organism. For plants, these characteristics include the fruit's shape, color, and size. Unique combinations of characteristics result in thousands of plant species—a wealth of plant life called plant **biodiversity**. Although we often think of biodiversity in terms of how many species exist in natural systems, like forests or jungles, it is also important for the crop species that serve as our food.

BIODIVERSITY

The variety of life on Earth, which can be measured by the variety that exists within the same species, how many different species exist, and even the variety of biodiversity in an ecosystem.

Like humans, plants have evolved from ancient forms over millions of years through evolutionary processes, including natural changes in their DNA and human choices of which plants to grow or breed together. As they have evolved, plants have acquired new helpful abilities, such as faster growth and increased production of foods, resistance to diseases, or tolerance to environmental stresses like drought.

GENETIC EROSION

Any natural or human-generated process that, over time, results in biodiversity loss in populations of the same species.

ARTIFICIAL SELECTION

A process humans control to modify living things, such as plants and animals, through selective breeding.

Today, Earth's plant biodiversity is threatened by human pressures, including climate change, pollution, habitat loss, and more. Decreased biodiversity also reduces the number of small differences between individuals of the same species, making all the members of a species increasingly similar. This process is called **genetic erosion**, and it can make it more difficult for a species to survive. **Artificial selection** is a process used by farmers to reproduce only plants with desirable characteristics (fast-growing, able to produce more/larger fruits, or able to produce fruits with a longer shelf-life), which has contributed to genetic erosion. To explain this concept, imagine a population of tomatoes with great biodiversity as a deck of 52 playing cards. Each card represents a single tomato variety. Now imagine someone removing certain cards from the deck, one by one. The reduction in the diversity of cards represents what happens to a plant species through the process of artificial selection (Figure 1).

WHAT IS GERMPLASM, AND WHY DO WE NEED TO PRESERVE IT?

GERMPLASM

The set of living genetic resources that can act as carriers of inheritance.

SEED BANK

A special facility where seeds are stored in controlled conditions of temperature, humidity, and light to preserve the genetic diversity of plants for the future.

Germplasm refers to the materials or tissues that store DNA and pass it on through the generations. In plants, germplasm consists of any tissue capable of regrowing an entire plant, such as seeds, bulbs, tubers, roots, cuttings, and seedlings. Germplasm collections are also known as **seed banks**, as they represent all the collected variants of a plant species (Figure 2). Plants are critical for Earth's other life forms, including humans, as they provide oxygen, food, medicines, and many other important products for our daily lives. For this reason, protecting plant biodiversity through germplasm conservation is essential because plant biodiversity is declining at an alarming rate. This means that many plant species are disappearing, and their unique

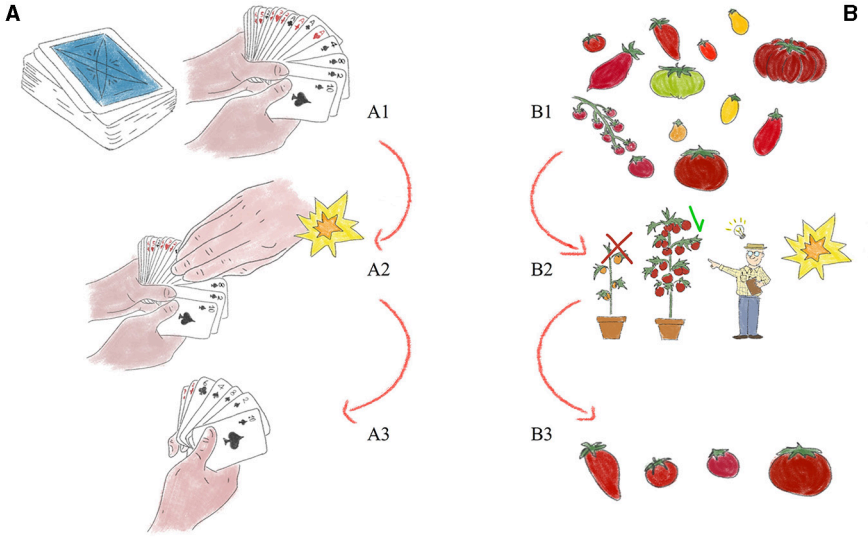

Figure 1

Genetic erosion within a plant population. **(A)** Imagine a deck of 52 unique cards. Removing some cards from the deck reduces the diversity in the remaining cards. **(B)** Similarly, the natural tomato population contains many varieties, but if farmers decide to grow or breed only a few types, the overall biodiversity of the tomato population will be reduced.

and essential properties are disappearing with them. Decreasing plant biodiversity also has consequences for **food security**, which is the availability and accessibility of food for everyone in the world.

FOOD SECURITY

The idea that everyone has easy access to affordable quality food they need to survive and thrive.

Figure 2

Plant germplasm kept at the Mediterranean Germplasm Database. **(A)** Kernels of various cereal grains. **(B)** Ears of several types of wheat. **(C)** Seeds of legumes. **(D)** Seeds are cataloged and stored on shelves placed in a controlled environment.

NIKOLAI VAVILOV, THE HERO DAD OF GERMPLASM BANKS

Since prehistoric times, our ancestors have always stored the seeds of plants to ensure a future harvest. The idea of creating germplasm banks only came about in the twentieth century. Nikolai Vavilov, born in Russia in 1887, was a botanist and geneticist who understood the importance of protecting plant biodiversity for agriculture and beyond. He dedicated his life to traveling the world to collect seeds and samples of wild and cultivated species [1]. In 1921, Vavilov founded the Institute of Plant Industry in St. Petersburg, and his collection of seeds and plants was the largest in the world. For the most important species for human nutrition (such as wheat, beans, and cickpeas), he recovered the seeds from the locations where each species first appeared on Earth. For example, cereal seeds originated 1,000's of years ago in the Fertile Crescent in the Middle East.

Vavilov's work was complicated due to the policies of the Soviet government at the time, which did not support scientific research. Vavilov argued that plant biodiversity was crucial for long-term food security, which he believed to be a human right. He was imprisoned until his death for his ideas. His precious and heroic work inspired later research and the birth of many of today's germplasm banks.

HOW DO GERMPLASM BANKS WORK?

Conservation of plants can take place in collections, botanical gardens, and seed banks. Seed banks are buildings, usually located far from where many of the plant species exist. Seed banks can be either small sections of research centers, or buildings used only for the conservation of germplasm.

To best preserve seeds, they are placed in closed containers protected from light and humidity. Seeds must be labeled so they can be easily identified (Figure 2D). Then, seeds are treated with chemicals to prevent microorganisms from growing on them. Specialized workers do all these tasks, including botanists, laboratory technicians, and curators. The conditions inside seed banks are extremely important. The temperature must be maintained around 2°C to keep plant materials from breaking down. For long-term conservation, **cryopreservation** can be used, which means keeping the germplasm in very cold freezers (−80°C) or in liquid nitrogen (−196°C) [2].

CRYOPRESERVATION

The process of cooling and storing seeds, tissues, and other biological material at freezing temperatures to preserve them for future use.

Currently, the largest and most technologically advanced seed bank is the Svalbard Global Seed Vault, located on an island in the Arctic Ocean. This bank is a maximum-security shelter capable of surviving catastrophes such as floods, earthquakes, fires, and even nuclear explosions (Figure 3). This facility was built with the support of the Food and Agriculture Organization of the United Nations. It offers

secure, free, and long-term storage of seeds, and it works like a real bank. The deposited germplasm remains the exclusive property of the depositors, who can take back the deposited material at any time.

Figure 3

Svalbard Global Seed Vault. This is the entrance to the underground seed bank (photo credit: Svalbard Global Seed Vault; photo by Riccardo Gangale).

Figure 3

Estimating the number of seed banks worldwide is a difficult task. A recent survey states that there are over 7 million samples belonging to ~50,000 species archived in more than 1,700 seed banks worldwide, all different in structure, size and focus [3]. Seed banks are generally funded by government agencies, research institutions, and conservation organizations. They are established as a service to the global community because they offer "insurance" against the pressures of the climate crisis and because they may hold our future food and nutrition security.

WHAT IS NEW IN THE TWENTY-FIRST CENTURY?

Managing all the samples in seed banks is challenging. One major challenge is choosing the best individuals to preserve and build collections that represent most of the total genetic variation on Earth without a lot of identical samples. Luckily, a fairly new laboratory technique called next-generation sequencing technologies (you can read more about it in this Frontiers for Young Minds article) and the use of **bioinformatics** (you can read more about it in this Frontiers for Young Minds article) tools make it possible to compare DNA sequences of many plants to identify patterns of DNA variation—kind of like a barcode that uniquely identifies each product.

BIOINFORMATICS

Scientific field that combines biology, computer science, and statistics to analyze large amounts of biological data.

Indeed, DNA barcoding allows a rapid and comprehensive assessment of plant biodiversity. We have learned that variety within or between

the same plant species is fundamental to ensuring humanity's food security. However, biodiversity protects against climate change, helps fight diseases, supports communities by preserving cultures and lifestyles, and produces economic benefits. All these reasons should push us to preserve biodiversity. This is a global challenge that affects everyone, everywhere.

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YOUNG REVIEWERS

DOROTHY, AGE: 11

I love all kinds of science, but especially space sciences. I love reading fantasy and science fiction especially about space travel. I want to contribute to the mission to Mars. I like playing Minecraft and Roblox with my little brother. I also love soccer, mountain biking, and taekwondo. I currently live in Temple Terrace, Florida.

SIRI, AGE: 13

My name is Siri. I am in the 8th grade. Some things that I enjoy doing are reading, soccer, science, computer science, cooking, and baking. I like to read novels, non-fiction, and scientific novels. I love animals and have two dogs two cats, and 10 chickens. I love learning more about animals and plants.

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