frontiers | Frontiers for Young Minds

BIODIVERSITY
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WHO ARE THE KEEPERS OF MICROBIAL BIODIVERSITY?

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YOUNG REVIEWERS:

GABRIEL
AGE: 15

PETER
AGE: 10

The world is full of an amazing microbial abundance and diversity. Microorganisms are part of all ecosystems and contribute to the activities of nature. Human beings have been studying and harnessing microbial properties for centuries and, nowadays, microorganisms are applied in numerous industrial, agricultural, environmental, and biotechnological processes. But where are the microorganisms used in scientific research or biotechnological processes kept? This article will explain what microbial culture collections are, their importance for the scientific community and society, what they are used for, and their contribution to studies of microbial biodiversity and how to preserve it.

A WORLD OF MICROORGANISMS

Microorganisms have inhabited Earth for more than 3.5 billion years [1], long before the existence of plants and animals. Microorganisms are so small that they cannot be seen by the naked eye. Usually,

objects that measure 0.1 mm (or 100 μm—microns) or larger are visible without a microscope, but microorganisms are much smaller than this. Their small size is the only characteristic that various species of microorganisms have in common—they are otherwise very diverse in terms of their lifestyles, metabolisms, and the functions they play in the environment (Figure 1). Microorganisms can be found everywhere, from the Earth's poles to the equator, from the depths of the oceans to the glaciers of the highest mountains, and even on the surfaces or in the bodies of other living organisms. While we often think of microorganisms in terms of illnesses and infections, most microorganisms have a beneficial impact on the environment and on our daily lives. For instance, did you know that microalgae living in the oceans produce half of the oxygen we breathe [2]? Microorganisms also enrich the soil, which helps plants grow faster and healthier [3]. Some microorganisms are used in food production, to make foods including cheese, wine, bread, and fermented vegetables like cucumbers (pickles).

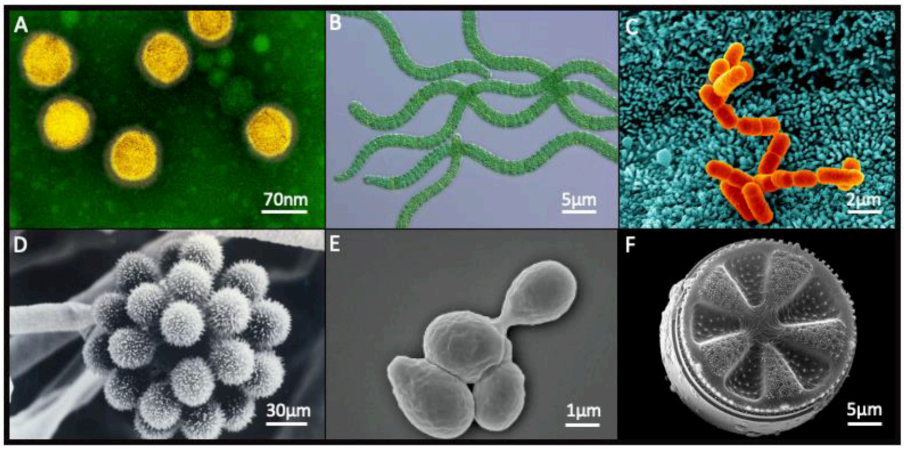

Figure 1

Examples of microorganisms: **(A)** Viruses, **(B)** cyanobacteria, **(C)** bacteria, **(D)** fungi, **(E)** yeasts, and **(F)** microalgae. Scale bars provide information about the organism's size, 1,000 μm are equal to 1 mm.

MICROBIOLOGISTS

Scientists who study microorganisms.

BIODIVERSITY

The variety of different kinds of life on Earth.

MICROBIAL STRAIN

A variant or subtype of a microorganism with minor differences in characteristics (often at the genetic level) that allow it to be distinguished from other members of the same species.

Scientists have recently calculated that Earth is home to 1 trillion microbial species [4]! However, it is believed that 99.999% of those species are still undiscovered. Because of the many beneficial functions that microorganisms perform, **microbiologists** are working on discovering new microorganisms, understanding their roles in their ecosystems, and determining how these organisms can be used to help humans or the planet. To support studies of the microbial world, scientists have created microbial culture collections, which play a critical role in in helping scientists investigate and preserve the **biodiversity** of microorganisms.

CULTURE COLLECTIONS: A TREASURE OF MICROORGANISMS

What are culture collections? As the name implies, they are actual collections of **microbial strains**. In fact, a strain of each microbial

species ever **isolated** is maintained in at least two different collections worldwide. Culture collections are for microorganisms what public libraries are for books. These collections serve three main purposes. First, by isolating and describing new microbial strains, these collections help scientists to understand and explore the biodiversity of microorganisms. Second, collections preserve the microbial strains that scientists have isolated and described over many years of study. Third, scientists who wish to study or use a certain microbial strain can obtain it from one of the collections.

Collections of microorganisms have existed ever since microbiologists were first able to isolate and cultivate these organisms. The isolation and cultivation of the first microbial strain is attributed to Robert Koch, in the 1870's. A few years later, the first culture collections were established in Europe, with the purpose of preserving and distributing microorganisms for future study. Back then, the isolation of microbial strains was a very challenging process, so isolated strains were considered very precious resources that needed to be preserved for future scientific investigation. Today, thanks to important technological developments, culture collection activities including sample collection, isolation, identification, and preservation (Figure 2) have become "routine" processes for some microorganisms. However, these activities still require a lot of time and can be difficult for groups of microorganisms that remain undiscovered.

ISOLATION

In microbiology, the procedure performed to separate a single microorganism (a strain) from the sample in which it is found and from other microorganisms in the sample.

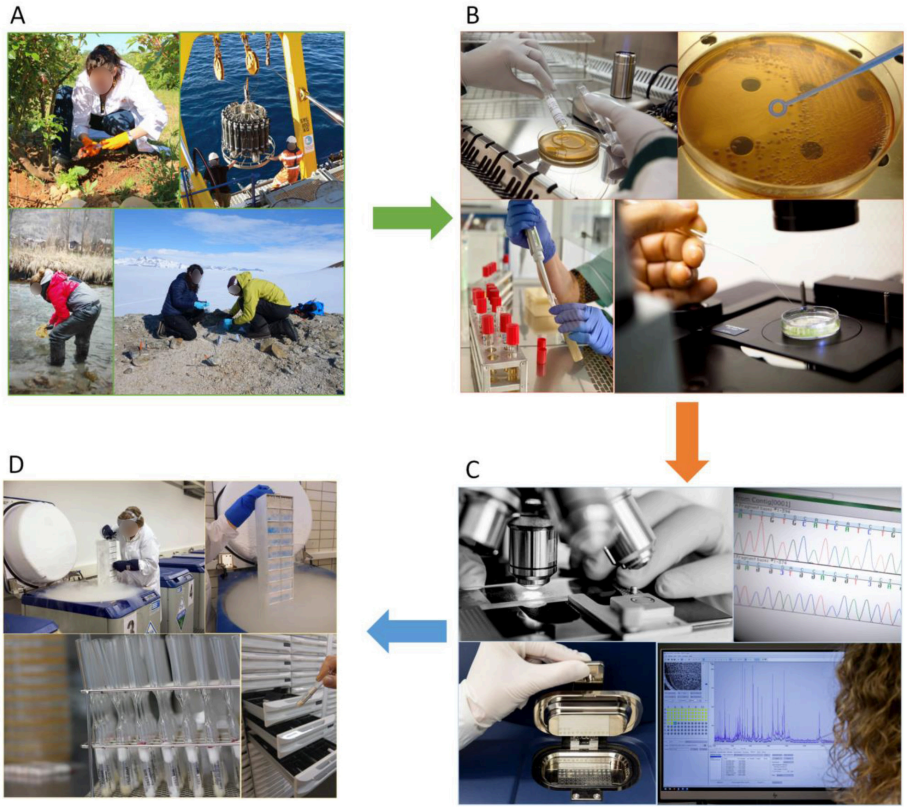

Figure 2

(A) Microorganisms are collected from the natural environment along with a sample of the habitat they live in. **(B)** In the laboratory, microbiologists isolate microorganisms from the sample by giving the microorganisms the necessary nutrients and growth conditions that they need. **(C)** Isolated microorganisms are characterized to discover which species they belong to. **(D)** To conserve microorganisms, they can be dehydrated (like a packet of instant soup) or stored at very low temperatures in freezers (−80°C) or liquid nitrogen (−172°C).

Samples can be taken from easily accessible environments, such as the skin of a person's hand, but also from extreme environments, such as the Antarctic Ocean floor. Isolation can be very difficult, especially if microbiologists are trying to isolate a specific type of microorganism among thousands of others present in the same sample. Did you know that one gram of soil can contain anywhere from 100 to 1,000,000 different species of bacteria [5]? Growing microorganisms is also a complex task. Many types of microorganisms need unique nutrients and growth conditions. Even today, microbiologists can only grow a very small fraction of the microorganisms that exist on Earth. It is estimated that 60–99% of microorganisms cannot be grown in the lab [1]. The ability to grow new species of microorganisms is one of the greatest challenges for microbiologists today! Finally, the identification of a novel microorganism requires a great deal of experience, in-depth knowledge of microorganisms, and an understanding of how to classify microorganisms (called taxonomy). Once a novel microorganism has been described, it is given a Latin name and it is stored in at least two culture collections, where it can be preserved and distributed to other scientists who wish to study it.

Today, more than 800 culture collections exist worldwide, and together they preserve and distribute more than 2,350,000 strains! If we consider that the first microorganisms were isolated $<$150 years ago, we realize that microbiologists and culture collections have been working like busy bees to isolate, characterize, and preserve microbial biodiversity. Some culture collections are very large institutes, with tens of thousands of strains, while some are small organizations. Collections may preserve common, well-characterized strains or very rare species, such as those isolated from extreme environments. However, all culture collections are equally important because they contribute to the investigation and preservation of microbial biodiversity.

All of society ultimately benefits from the strains and information generated by public culture collections. The users of these collections are usually research scientists in universities or hospitals. School teachers or individuals can acquire microbial strains for educational purposes if they have access to a laboratory equipped with the required instrumentation and materials. Microorganisms can be obtained only if they are not disease-causing or toxic. Dangerous microbial strains are stored in specific places and are accessible only by experts who are authorized to handle them. Microbial strains are not free! Culture collections require funds to support their research, so when users purchase microbial strains, they support future collection activities.

CULTURE COLLECTIONS IN THE TWENTY-FIRST CENTURY

How have culture collections evolved since they began? In the past, culture collections existed as a way to explore, preserve, and distribute microbial biodiversity. Today, an additional goal of culture collections is to increase the benefits to society that the knowledge and use of microorganisms can provide. These modern-day culture collections are called microbiological resource centers (mBRCs). This complicated name highlights the idea that microorganisms should be considered resources, since they are assets for the natural environment and for the sustainable development of our society.

mBRCs perform some very important additional tasks (Figure 3). These centers provide services to support research and development, thereby helping to facilitate new discoveries. They are responsible for data management and data sharing through organizing, storing, and exchanging information related to microbial strains in the collection. They also provide education and training activities, to teach others how to preserve and use microbial biodiversity; and finally, they help with the creation of rules for using microbial biodiversity.

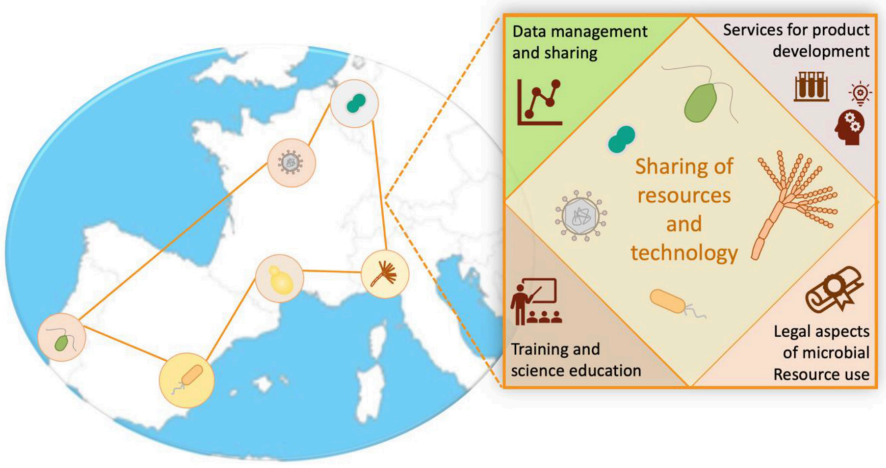

Figure 3

Figure 3

Culture collections and microbBiological Resource Centers (mBRCs) around the world develop collaborative networks to help with the use, preservation, and enrichment of microbial biodiversity. Each mBRC is specialized in specific microorganisms, such as yeast, fungi, or bacteria. Tasks performed at each mBRC (box on right), which are strengthened by the collaborative networks, provide the support and facilities for microbial biodiversity preservation and sustainable use.

GENETIC RESOURCE

Any material from plants, animals, microorganisms, or other organisms containing genetic material (DNA or RNA) with current or potential value.

Because microorganisms are valuable resources, rules have been created to prevent their exploitation. Microbiologists must follow these rules if they want to use strains isolated from the natural environment for research or commercial purposes. For instance, scientists must ask for a special permit before collecting microbial resources from the natural environment in most countries! In fact, since October 12, 2014, there are specific rules set by an international agreement known as the Nagoya Protocol on Access and Benefit Sharing. This agreement aims to protect the use of **genetic resources** and it obliges scientists to share the benefits of these resources in a fair and equitable way. These rules are very important for

BIOPIRACY

Using or exploiting genetic resources or indigenous knowledge without consent or without providing fair compensation to the local communities.

combatting **biopiracy** and they also help to conserve the biodiversity of Earth's microorganisms.

Have you ever heard the expression "together we can do great things?" Microbiologists at culture collections and mBRCs certainly have! Culture collections and mBRCs are developing collaborative networks to share expertise, instrumentation, data, and resources. They work together at the national and international level to increase our knowledge of the microbial world and to promote the use of microbial strains in fields like medical sciences, biotechnology, agriculture, environmental sciences, and biodiversity. Moreover, in collaboration, they have recently started developing even wider networks that provide innovative and high-quality services, such as the European Microbial Resource Research Infrastructure, which brings together the microbial resources and expertise of more than 50 European culture collections and mBRCs. Large or small, modern or old-fashioned, alone or in teams, culture collections and mBRCs all over the world are continuously working to promote the biodiversity and sustainable use of microorganisms.

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CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

YOUNG REVIEWERS

GABRIEL, AGE: 15
I like exercising and coding simple games. I also like fantasy and science fiction novels and cooking sweet treats.

PETER, AGE: 10
I am Peter, and I love to golf with my family. In my spare time, I like to play other sports, read, write, and draw. My favorite subject in school is art, but I also enjoy doing math. Every once in a while, my family goes camping, and my mom and I hike a mountain.

AUTHORS

MARWA ZAAROUR

I am a young researcher eager to understand and discover microorganisms, and find new applications. I obtained a Ph.D. in Synthetic Biology to investigate new ways in making good uses of microorganisms and especially bacteria. Since I was a kid, I was always curious to know how living organisms function, so as I grew up, I decided to study Biology and then to specialize in Microbiology. I like to spread knowledge, and I aim in my research journey to contribute in innovative solutions and discoveries that feed a better world.

JEAN-LUC LEGRAS

Since I was a teenager, I always wanted to become a microbiologist. Now I am in charge of the CIRM-Levures yeast collection. During my career, I have been working with bacteria, molds and yeast isolated from food or natural environments. I am fascinated by the amazing ability of yeast species to occupy and adapt to multiple ecological niches and provide us bread, kefir or cheese. I enjoy hiking, gardening, listening to music, taking photos, and preparing homemade bread using my own sourdough.

MICHEL-YVES MISTOU

As a researcher in microbiology, I worked on different aspects of the metabolism and cellular organization of bacteria. I focused my work on different bacterial species, some of which are considered good, such as lactic acid bacteria that participate in fermentation processes like those used in the manufacture of yogurts or cheeses. While at Anses or Pasteur Institute, I worked on pathogenic bacteria responsible for different types of diseases in humans and animals. At present I coordinate the CIRM, a network of microbiological resources centers dedicated to the conservation and valorization of microorganisms of environmental, veterinary, biotech, and agronomical values.

GIULIA CHELONI

I started my scientific path working on a project aimed at investigate microalgal biodiversity in aquatic environments and isolate strains to establish a microalgal culture collection (I have isolated more than 600 microalgal strains). After spending hours at the microscope, diving into the tremendous microalgal diversity of natural samples, I decided to become a microalgal ecophysiologist and focus my research on the impact that pollutants might have on microalgae. I investigate pollutants toxicity to microalgal species and the possible consequences for natural environments. I profoundly believe that microalgal biodiversity is a key element for the health of our planet. *giulia.cheloni@cnrs.fr