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MICROORGANISMS FLOATING THROUGH THE AIR

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COLLÈGE JOLIOT-CURIE VIVONNE

AGES: 14–15

Would you believe us if we told you that, when you breathe in, you inhale thousands of microorganisms with every breath. Although this might sound scary, be assured that they are safe for your health. These airborne microorganisms, too small to see with the naked eye, consist of many different species. Who are they? Where do they come from? What do they do in the air? These are some of the questions that we answer in this article, although many questions about airborne microorganisms remain to be explored.

WHAT ARE AIRBORNE MICROORGANISMS?

Microorganisms are tiny—around 1 µm, which is one thousand times smaller than 1 mm. Each individual microorganism is made of a single cell. These cells do not come together to create a larger multicellular organism, like human and animal cells do. Microorganisms are found in every environment on Earth, including soils, oceans, ice, and air (Figure 1). The microorganisms that are found in the air are called airborne

MICROORGANISMS

Microscopic organisms including bacteria, fungi, and algae.

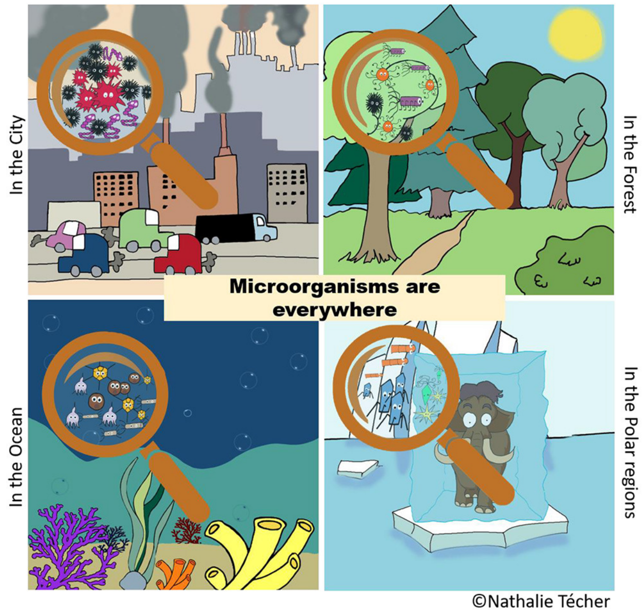

Figure 1

Figure 1

Although we cannot see them without the help of a microscope, microorganisms are found in every environment on Earth, including the oceans, soils, forests, glaciers, and in the air we all breathe. The number and diversity of airborne microorganisms depend on where you are located on the planet. For example, you would breathe in fewer airborne microorganisms while standing on a glacier in the Arctic than you would if you were standing in the middle of a city.

microorganisms, and they travel either on their own or attached to dust particles. Dust particles can come from things like car exhaust and industrial pollution. Airborne microorganisms have various shapes (round, rod-shaped, or string-shaped) and can include many different species of bacteria, fungi, and algae. Consider all the different species of birds, their various sizes, shapes, and ways of living—then imagine that the same is true for airborne microorganisms. Each day, you inhale up to 15,000 l of air, containing millions of airborne microorganisms belonging to thousands of different species.

WHERE DO AIRBORNE MICROORGANISMS COME FROM?

The tiny size of microorganisms makes them extremely light and susceptible to every gust of wind. The airborne microorganisms floating around you are in constant motion, which is affected by the weather conditions. During extreme weather, such as cyclones or sandstorms, airborne microorganisms can be transported thousands of kilometers in just a few days (for example, from the African desert to Central America) [1]. At some point, the microorganisms that have been swept up into the air fall back down to the Earth's surface, due to gravity. However, unlike a ball that is thrown up in the air, microorganisms fall at a relatively slow speed and can stay suspended in the air for quite some time. Airborne microorganisms are constantly falling to the Earth's surface and being replaced by new organisms that arrive in the air (Figure 2). These new microorganisms come from the soil, the sea, and the plants on Earth's surface. A microorganism living in the sea can become airborne through a process called

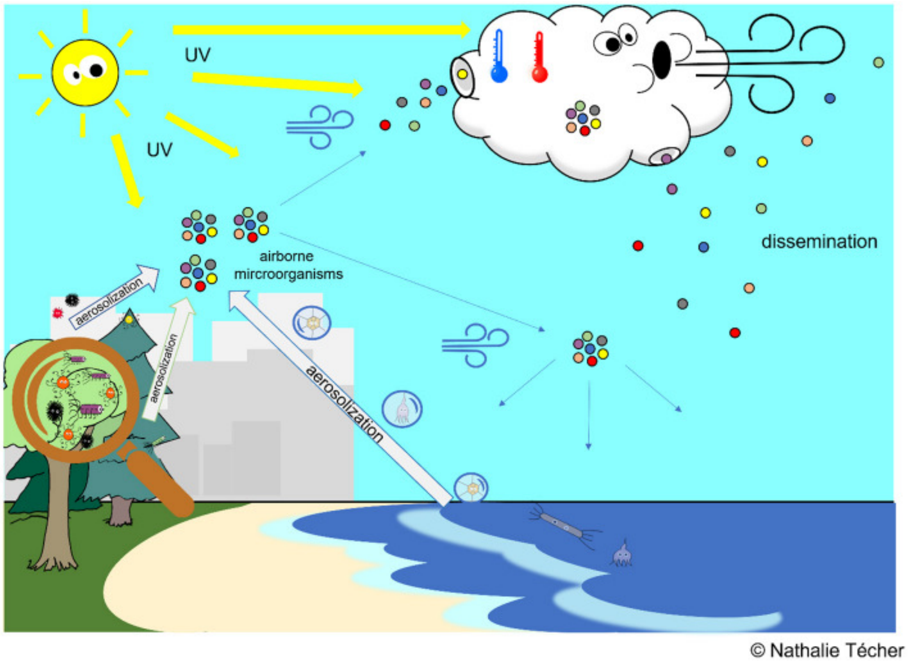

Figure 2

Figure 2

Airborne microorganisms originate from different environments on the Earth's surface, such as the ocean and the soil. Once they become airborne, wind can spread airborne microorganisms around the world in a process called dissemination, and eventually they fall back to the Earth's surface. While they are suspended in the air (and in clouds), airborne microorganisms face harsh conditions, including UV radiation from the sun and extreme temperatures. While airborne, microorganisms could affect the weather and the Earth's atmosphere.

AEROSOLIZATION

The process by which particles on the ground or in the water become suspended in the air.

aerosolization. Aerosolization occurs when solid particles become suspended in the air and, in the sea, this can happen when air bubbles in the water are released into the air. These microorganisms cannot fly on their own—like a floating feather, they are held aloft and transported by the air.

The number and diversity of airborne microorganisms depend on the geographical location [2, 3]. Thus, depending on where you are located on the planet, you might inhale different numbers and kinds of microorganisms (Figure 1). The concentration of airborne microorganisms depends on both human activity and the number of microorganisms in the environment. If you live in a big city where there is a lot of human activity (lots of cars and industries, for example), the air will be filled with a high number of airborne microorganisms that come from dust and soil. However, if you live in the frozen region of Greenland, you will probably inhale many fewer microorganisms, since the snow and ice that surround you contain fewer microorganisms than do soils, farms, or cities.

WHAT DO AIRBORNE MICROORGANISMS DO?

We still know little about what airborne microorganisms do. Each species has its own lifestyle. It has been suggested that some species help in the formation of clouds and rain [4]. Airborne microorganisms might transform the chemical compounds around them and thus change the air quality. The air is composed of gases (oxygen, carbon dioxide, nitrogen), airborne microorganisms, and dust, but it also

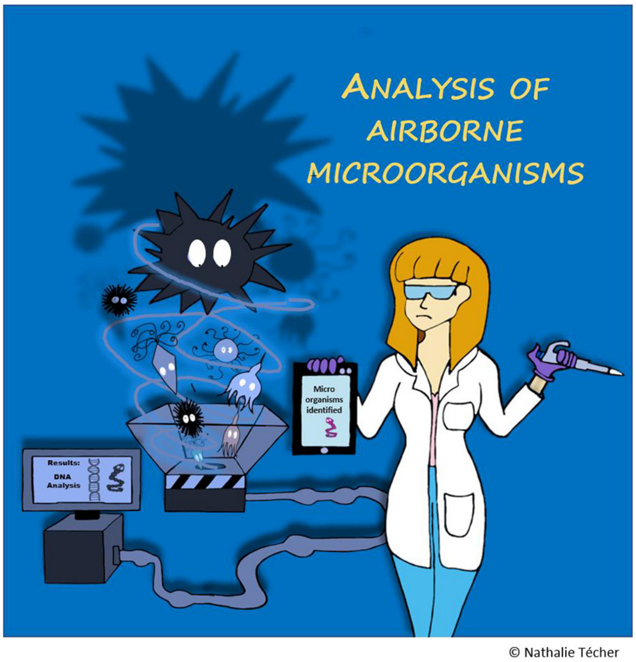

Figure 3

Figure 3

Special methods are used to catch and study airborne microorganisms. First, airborne microorganisms must be sucked into a container and concentrated. In the lab, the DNA of the trapped microorganisms can be analyzed to identify which species they belong to, as well as to investigate their functions in the air.

contains a multitude of very tiny chemical compounds that are like floating food for airborne microorganisms. Like every animal, microorganisms consume food and produce wastes, and these activities can change the chemical composition of the air. While we suspect that airborne microorganisms can eat while they are in the air, we do not know if they reproduce in the air. The air is a stressful environment, with harsh chemical and physical conditions. For example, high levels of solar **UV radiation** and extremely cold or hot temperatures are generally not good for living organisms, including most microorganisms (Figure 2). However, microorganisms are much more resistant to extreme environmental conditions than humans are, and they have tools to protect themselves. For example, the cell membranes of some microorganisms contain pigments called carotenoids, which act like a shield against UV radiation–similar to the pigment called melanin found in human skin. Other microorganisms have antifreeze proteins that can protect them from extremely cold temperatures. Under harsh conditions, some microorganisms can become dormant (go into hibernation) and wait for better conditions. Despite these protective measures, it is not clear how active microorganisms really are in the air.

UV RADIATION

Ultraviolet (UV) radiation is a form of non-ionizing radiation that is emitted by the sun.

HOW DO WE STUDY AIRBORNE ORGANISMS?

Evaluating the number and diversity of microorganisms floating in the air requires specific tools. First, we need to catch airborne microorganisms and lock them up in a container that will be brought back to the laboratory (Figure 3). To collect lots of microorganisms in a container, we use a machine that works like a vacuum cleaner, sucking in the air and catching airborne microorganisms on a filter or in a tube [5]. This is similar to vacuuming your house: you suck up the dust and it is collected in a container found inside the vacuum. Once this container is brought to the laboratory, equipment is used to extract and read the **DNA** of the microorganisms. The DNA is like an identity card that allows us to count how many airborne microorganisms there are and identify the species they belong to. To identify them, the DNA from airborne microorganisms are compared to a library of DNA from known microorganisms.

DNA

The genetic material found in each cell that is passed on to offspring from their parents and determines an organism's characteristics.

WHAT ABOUT CORONAVIRUS?

Airborne microorganisms have always existed, and you have been inhaling these tiny living things since you were born. Even though airborne microorganisms consist of bacteria, fungi, and algae, most of the time they do not make us sick. Airborne microorganisms are mostly safe for humans. You might be thinking, "But the SARS-CoV-2 corona virus that causes COVID-19 is found in the air, and it can cause disease in humans, cannot it?" You are right, the coronavirus can be found in the air, as can many other viruses. Viruses are not made of cells, so they are generally not considered to be microorganisms. While recent studies confirmed the potential transmission of the coronavirus through the air, scientists believe that the coronavirus is mostly transmitted between humans through tiny droplets of saliva that are projected into the air when infected people talk or sneeze. These saliva microdroplets disappear rapidly from the air, especially outdoors.

CONCLUSION

No matter where you are in the world, from the North Pole to the South Pole, there are millions of microorganisms in the air, which we breathe in with every breath. While invisible, they are alive and in constant movement, due to wind and air. Airborne microorganisms consist of thousands of different species, most of which remain largely unknown. They could perform many functions in the air, but we still do not understand these functions. Airborne microorganisms require further studies, and these studies promise to be extremely interesting, since there are many things we still do not understand. The exploration of airborne microorganisms has only just begun, and it is likely to lead to exciting discoveries in the areas of meteorology, air chemistry and human health!

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YOUNG REVIEWERS

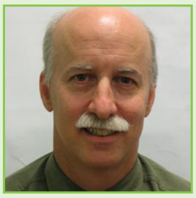
COLLÈGE JOLIOT-CURIE VIVONNE, AGES: 14–15

In our class (troisième 3), we are 25 students of 14–15 years old from the Joliot-Curie de Vivonne middle school. We are obviously calm, serious, hard-working and attentive pupils. Well, let us face it. We are also a little talkative, sometimes naughty and not always at our maximum. But we overflow with energy, creativity, and good mood!

AUTHORS

ROMIE TIGNAT-PERRIER
Romie Tignat-Perrier is a microbiologist working on environmental microorganisms. She is interested in understanding the roles microorganisms play in different under-explored ecosystems such as the air. She worked on the INHALE project that led to a large-scale sampling of airborne microorganisms at different locations around the world (Greenland, United States of America, Bolivia, Amsterdam Island, France, South Africa, etc.) and provided a better understanding of airborne microorganisms. *rom26.p@hotmail.fr

NATHALIE TÉCHER
Nathalie Técher is a biologist with a passion for the marine environment. She investigates how climate change can impact the physiology of intriguing marine animals like corals and their associated microorganisms. She loves to turn science into art with a sense of humor to help "young minds" understand the world that surrounds them.



TIMOTHY M. VOGEL
Timothy M. Vogel is a Professor at the University of Lyon in France with extensive experience in the field of microbial ecology. He has developed a network of collaborations with first-rate universities and research centers from all over the world. His research aims to explore bacterial adaptation and evolution using the very latest sequencing technologies (metagenomics approaches).

CATHERINE LAROSE
Catherine Larose is a microbiologist interested in understanding how microorganisms interact with their environment and with each other. She is a specialist of extreme environments such as the Arctic soil, sea-ice, terrestrial snowpacks, and the air. She loves working in the field and she lead numerous scientific missions in the Arctic.

AURÉLIEN DOMMERGUE
Aurélien Dommergue is the Director of the Institute of Environmental Geosciences and Professor at the University Grenoble Alpes in France. He is known for his research on atmospheric chemistry and the mercury cycle, especially in remote regions such as the polar regions and high altitude sites. He is the coordinator of the INHALE project that led to a large-scale sampling of airborne microorganisms at different locations around the world.