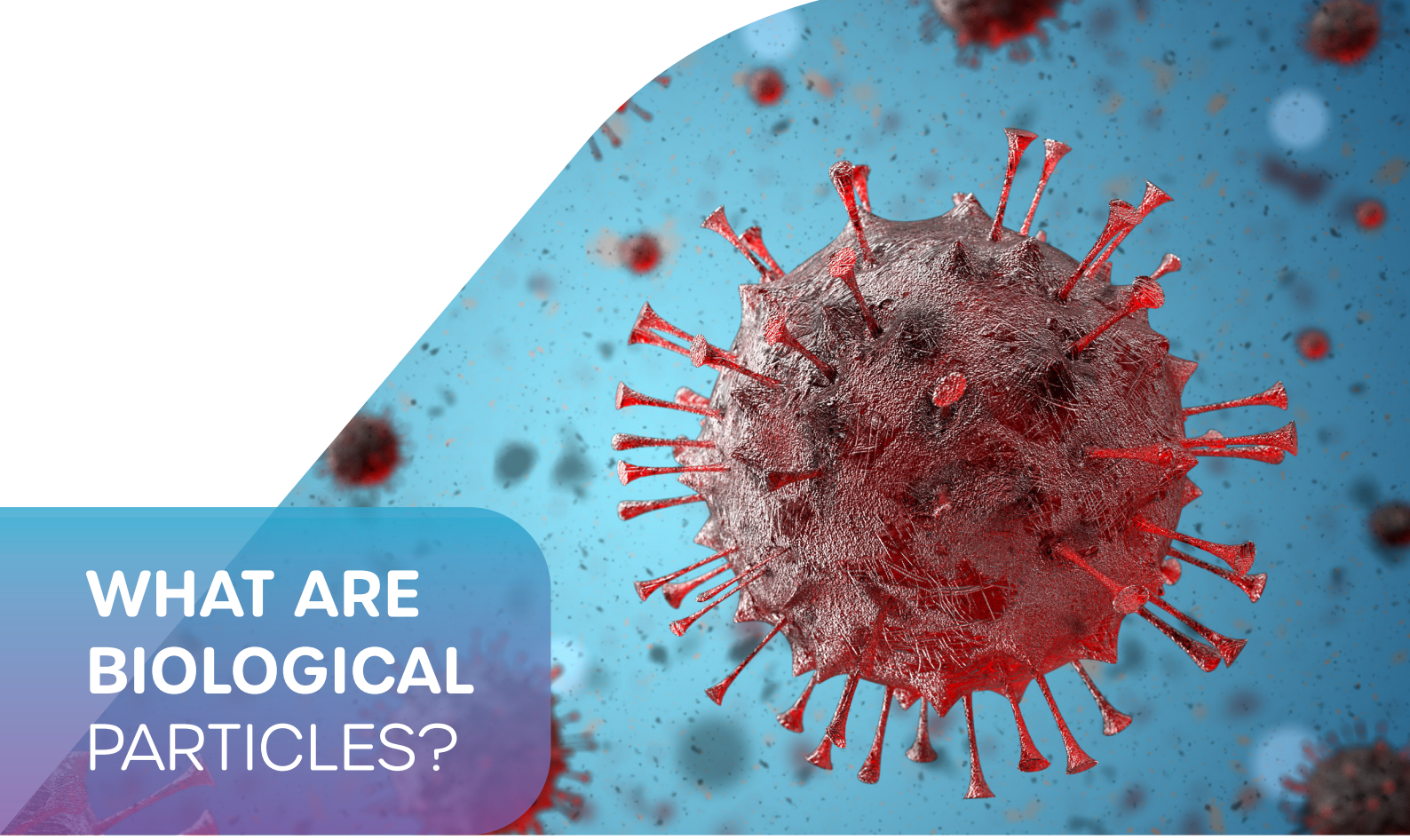

WHAT ARE BIOLOGICAL PARTICLES?

Biological particles are commonly referred to as bioaerosols. Bioaerosols include viruses, bacteria, fungi, algae and organic compounds derived from microorganisms (e.g., endotoxins, metabolites) as well as pollen, plant and animal debris (figure 1).

Bioaerosols are present in both indoor and outdoor air and cover a range of sizes: viruses are the smallest (5 to 300 nanometres (nm)); bacteria and fungal spores can range from around 0.2 µm up to 10 µm; while the largest include pollen, algae and dander (minute particles derived from skin, hair and feathers) that can be tens to hundreds of micrometres in diameter (figure 2).

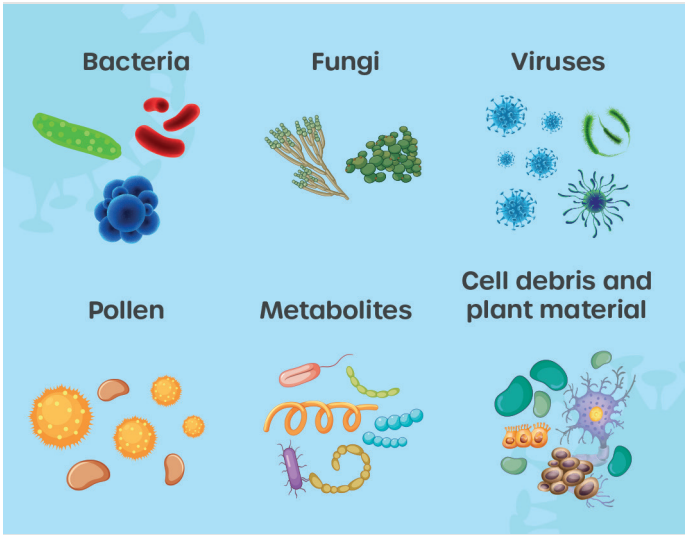

Figure 1. Bioaerosols can consist of live or dead microorganisms (e.g., bacteria, fungi, viruses) and the chemicals they produce (metabolites), as well as pollen and cell debris originating from plants and animals.

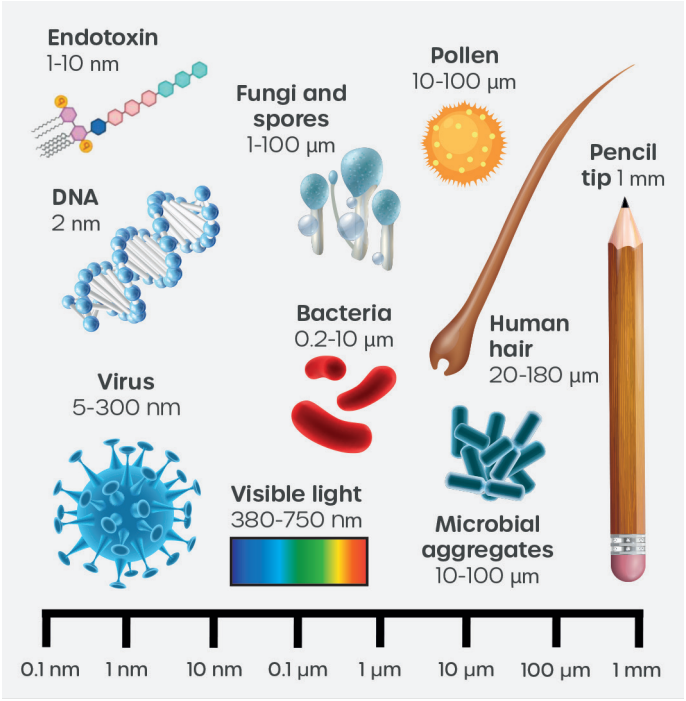

Figure 2. Typical size ranges of various bioaerosols (pictures not to scale).

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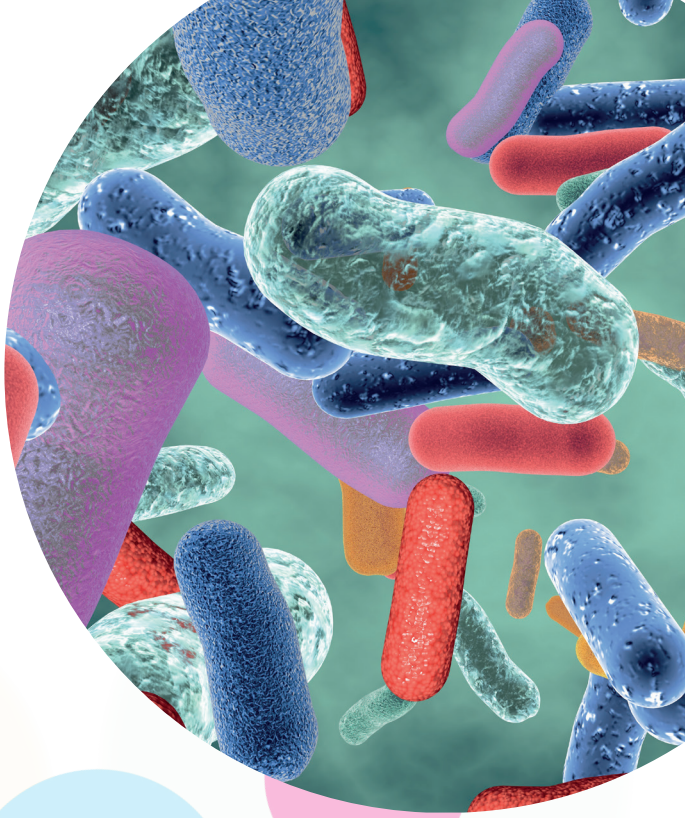

WATCH THIS YOUTUBE VIDEO:

Pasteur's Swan Necked Flask Experiments:
www.youtube.com/watch?v=_ZzJ6NcmiKU

The earliest efforts to describe the distribution of airborne microbes were carried out by Louis Pasteur, over 125 years ago. However, in ancient Egypt, people used wild airborne yeasts to improve bread by leaving a mixture of grain and liquids near an open window. Airborne yeasts have also been used in the making of wines and beers for many centuries.

WATCH THIS YOUTUBE VIDEO:

Are clouds full of bacteria?
www.youtube.com/watch?v=46_0SQDh9Sk

In 1832, Charles Darwin collected some airborne dust close to the Cape Verde islands in the Atlantic Ocean. The samples were stored in a museum in Berlin and, in 2007, were chemically and microbiologically examined using modern techniques. Analysis revealed the presence of many viable microbes attached to sand grains. This shows that microbes can adhere to Saharan dust and easily survive transport across the Atlantic.

It is now well known that the long-range transport of microorganisms is ubiquitous. We know that bioaerosols can also reach the clouds and contribute to rainfall.

Globally, natural sources of bioaerosols outweigh those generated by humans. Plants and soil are the main sources in terrestrial environments. For example, the combined surface area of leaves across the globe has been estimated to be around four times the ground surface area ($\approx 6.4 \times 10^8$ km^2 and $\approx 1.5 \times 10^8$ km^2, respectively)!

Rainfall can also increase the release of bioaerosols from soil and plant surfaces, when water droplets hit them and initiate the projection of microbes into the air. The annual global budgets of bacteria, fungi, and pollen are approximately 28.1, 186, and 84 teragrams/year, respectively.

Water bodies such as rivers, lakes, and oceans are rich in various microorganisms. The action of the wind and waves, along with bubble bursting, can result in bioaerosols entering the atmosphere. There are around 10^{19} (10 quintillion) bubbles created every second in Earth's oceans and seas.