Environmental microbiology

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Introduction

Definition and Scope

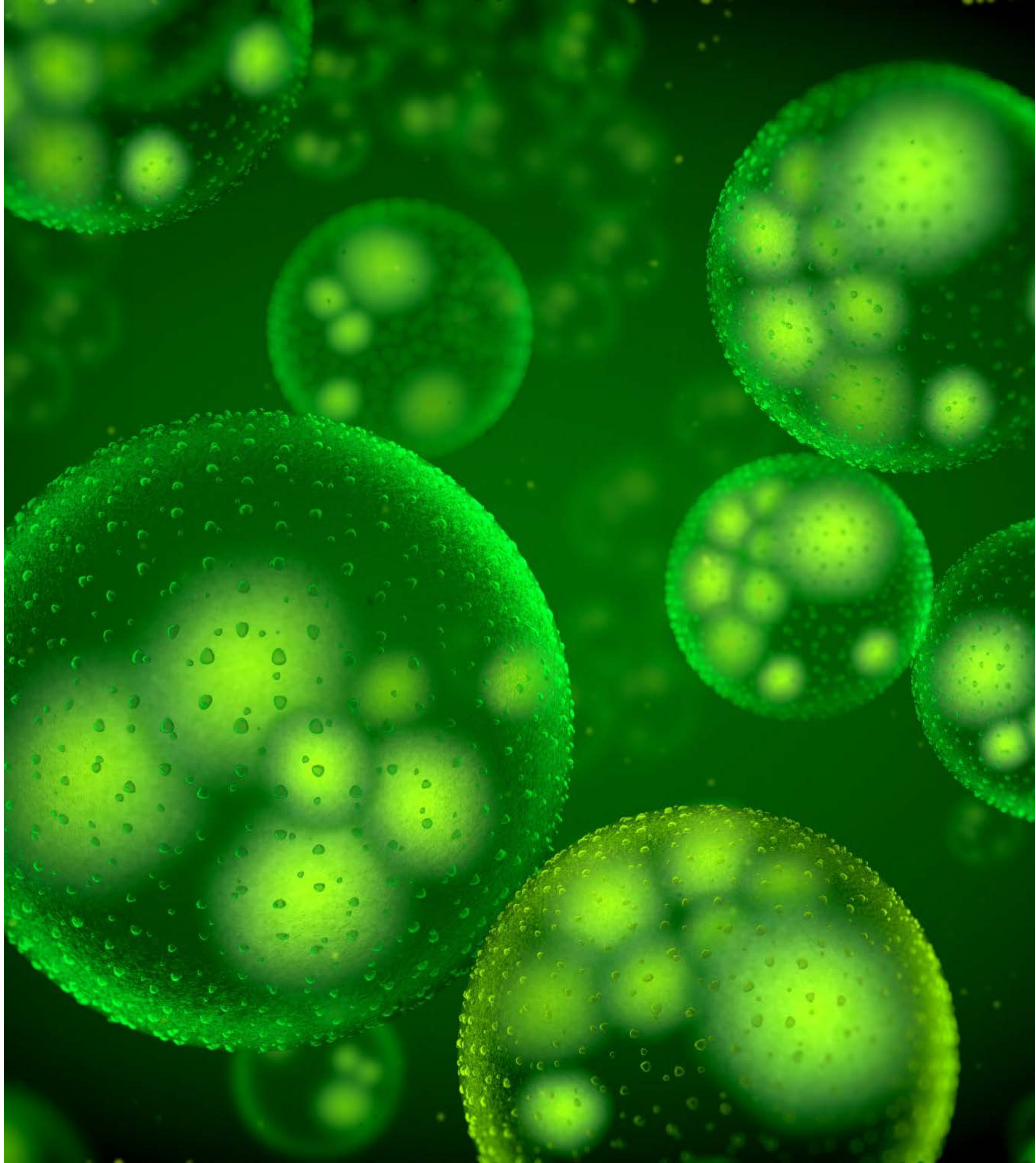
- Environmental microbiology is the branch of microbiology that focuses on the study of microorganisms in their natural habitats and the interactions between microorganisms and the environment. It insist on investigation of microbial communities in various ecosystems such as soil, water bodies, air, sediments, and even extreme environments like hot springs, polar regions, and deep-sea hydrothermal vents

- The scope of environmental microbiology extends beyond the mere identification and characterization of microorganisms to understanding their roles in ecosystem processes, nutrient cycling, biogeochemical transformations and human health

Understanding microbial interactions in the environment is crucial for several reasons:

Ecosystem Functioning: Microorganisms play pivotal roles in driving essential ecosystem processes such as nutrient cycling, organic matter decomposition, and soil formation.

1. **Biogeochemical Cycles:** Microorganisms are key players in biogeochemical cycles, including the carbon, nitrogen, sulfur, and phosphorus cycles. They mediate the transformation and cycling of elements essential for life,
2. **Environmental Health:** Microorganisms can serve as indicators of environmental quality and pollution levels. Monitoring microbial communities in soil, water, and air can provide valuable information about ecosystem health, contamination levels, to human and ecosystem well-being.
3. **Bioremediation and Waste Treatment:** Environmental microbiology contributes to the development of bioremediation strategies for cleaning up polluted environments.
4. **Emerging Infectious Diseases:** Understanding the ecology of pathogenic microorganisms in the environment is essential for predicting and managing disease outbreaks. Environmental microbiology sheds light on the transmission dynamics, reservoirs, and environmental factors influencing the spread of infectious disease



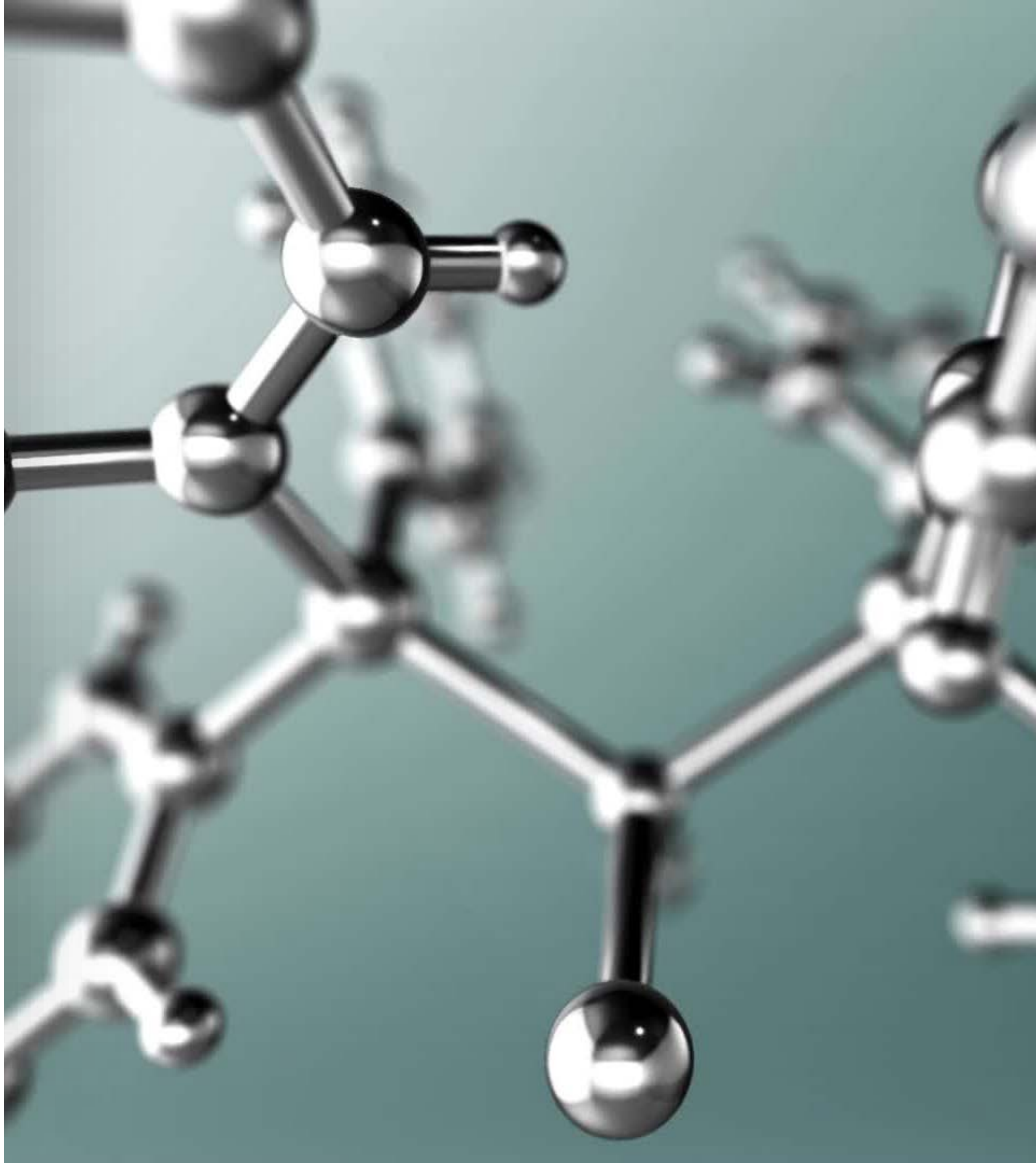
Overview of Microbial Communities

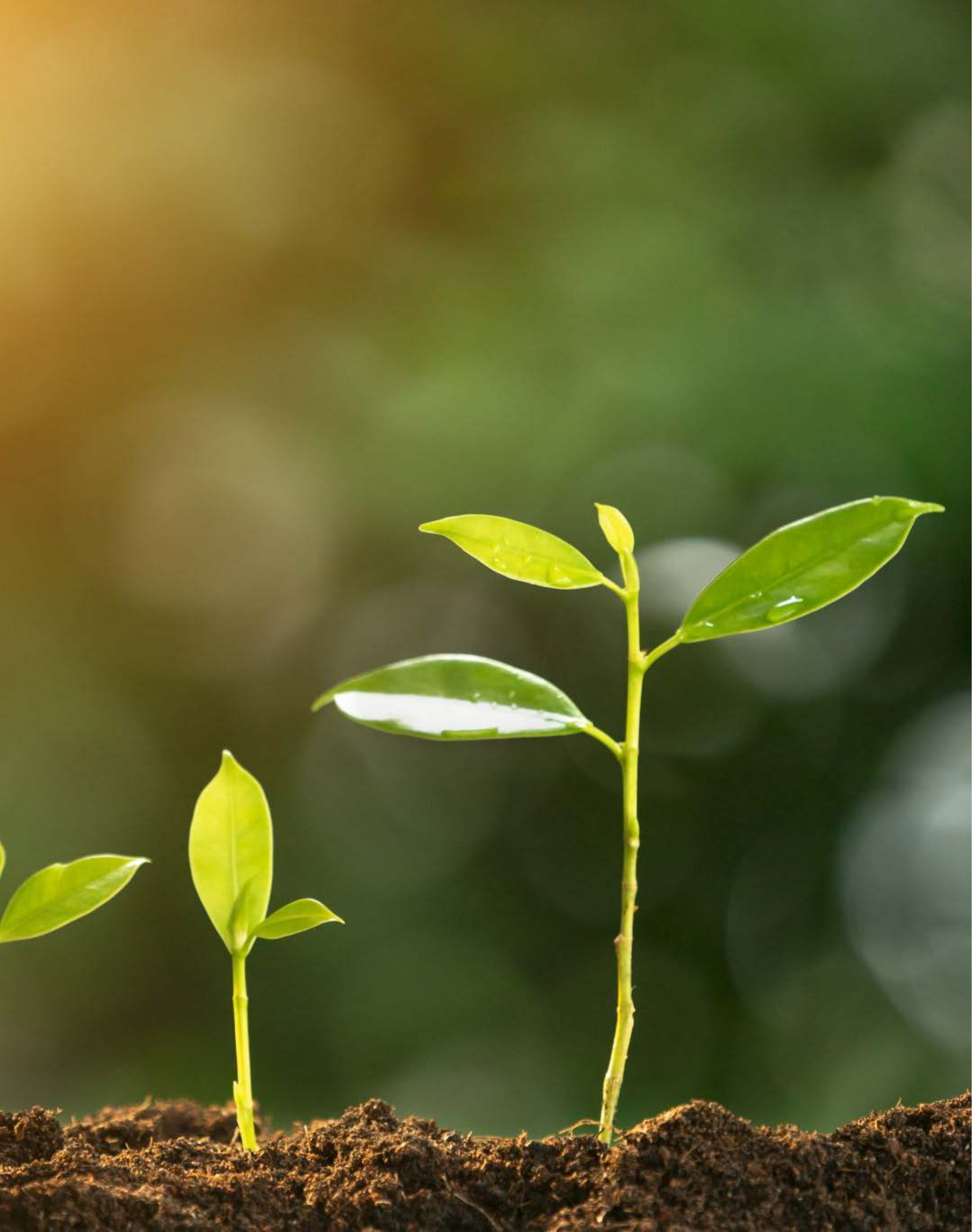
1. **Bacteria:** Bacteria are diversity in terms of morphology, physiology, and metabolic capabilities. They play essential roles in nutrient cycling, organic matter decomposition, nitrogen fixation, and symbiotic interactions with plants and animals.
2. **Archaea:** Archaea represent a distinct domain of microorganismse in extreme environments such as hot springs, salt flats, and deep-sea hydrothermal vents. They contributing to biogeochemical cycles and ecosystem stability in harsh conditions. Archaea play key roles in methane production, sulfur cycling, and nitrogen metabolism.
3. **Fungi:** Fungi are essential components ofaquatic ecosystems, participating in nutrient cycling, decomposition of organic matter, and symbiotic relationships with plants (mycorrhizae) and animals. Fungal diversitys a wide range of taxa including yeasts, molds, and mushrooms.
4. **Viruses:** Viruses are abundant in the environment, infecting a variety of microbial, plant, and animal hosts. Environmental virus play crucial roles in regulating microbial populations, nutrient cycling, and genetic exchange among microorganisms.

Role of Microorganisms in Ecosystem Functioning

- Microorganisms are integral to ecosystem functioning and provide essential services that sustain life on Earth:

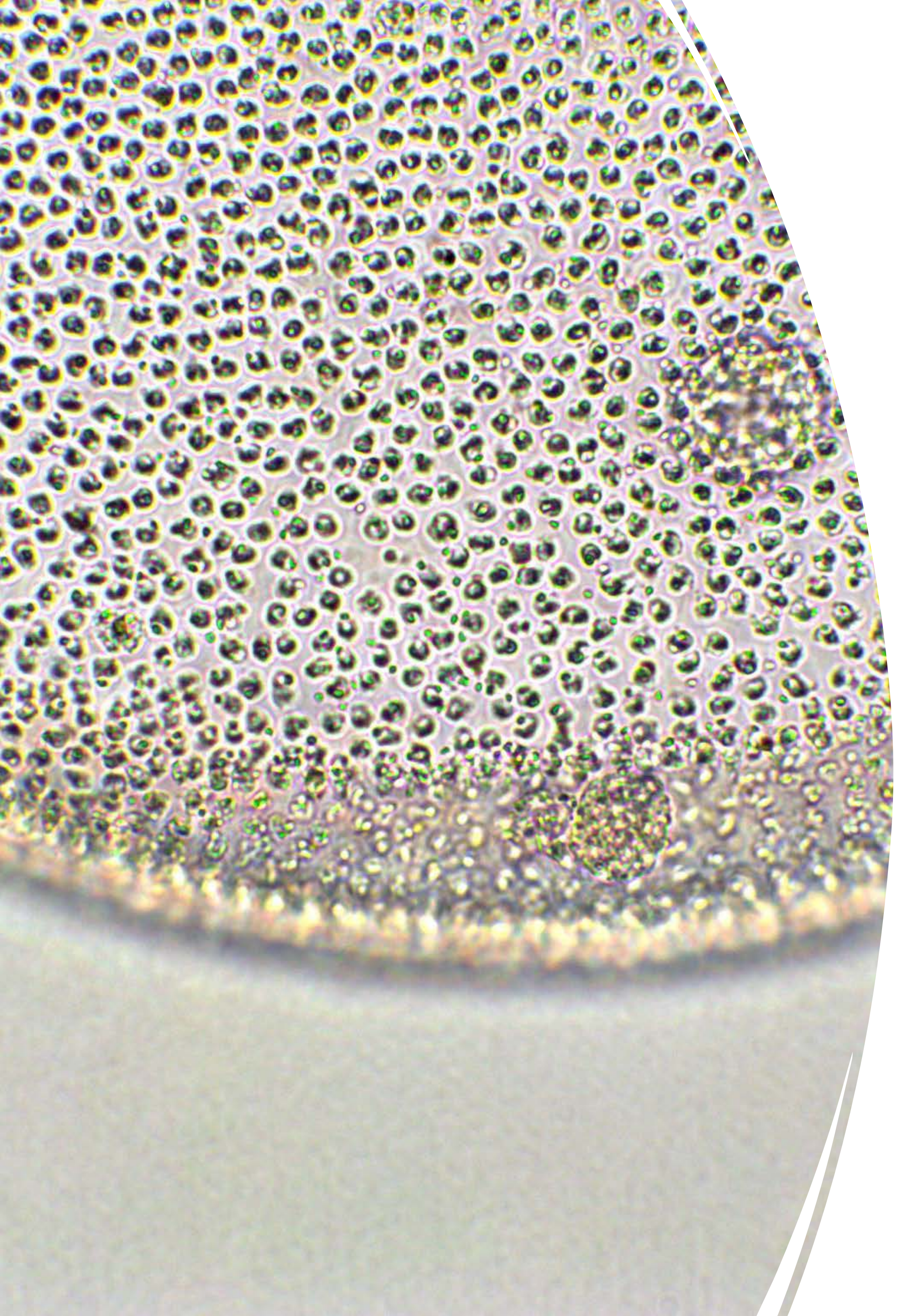
1. **Nutrient Cycling:** Microorganisms y mediating the transformation and cycling of nutrients such as carbon, nitrogen, phosphorus, and sulfur. They decompose organic matter, and recycling of essential elements between living organisms and the environment.
2. **Energy Flow:** Microorganisms participate in energy flow within ecosystems through processes such as photosynthesis, respiration, and chemosynthesis. They convert solar energy into organic matter.
3. **Bioremediation:** Microorganisms possess remarkable metabolic capabilities that enable them to degrade pollutants, detoxify contaminated environments. Bioremediation strategies harness microbial activities for the cleanup of oil spills, industrial waste.
4. **Symbiotic Interactions:** Microorganisms engage in symbiotic relationships with plants, animals. Examples include nitrogen-fixing bacteria in legume root nodules, mycorrhizal fungi enhancing plant nutrient uptake,





Microbial Habitats: Soil, Water, Air, and Sediments

1. **Soil:** Soil crucial for nutrient cycling, organic matter decomposition, and plant growth. Microorganisms in soil play roles in nitrogen fixation, mineralization, and soil aggregation, influencing soil fertility and structure.
2. **Water:** Aquatic environments, including freshwater, marine. Microorganisms in water ecosystems participate in nutrient cycling, primary production, and food web dynamics, influencing water quality and ecosystem health.
3. **Air:** The atmosphere contains airborne microorganisms dispersed by wind, aerosols, and atmospheric processes. Airborne microbes include bacteria, fungi, and viruses adapted to atmospheric conditions.
4. **Sediments:** Sedimentary environments such as riverbeds, lake bottoms, and ocean floors support microbial communities involved in organic matter decomposition, nutrient cycling, and sediment diagenesis.



Nutrient Cycling and Biogeochemical Processes

1. **Carbon Cycle:** Microorganisms mediate carbon cycling through processes such as photosynthesis, respiration, and decomposition. Autotrophic and heterotrophic microorganisms transform organic and inorganic carbon compounds
2. **Nitrogen Cycle:** Nitrogen cycling involves microbial processes such as nitrogen fixation, nitrification, denitrification, and ammonification. Nitrogen-fixing bacteria and archaea convert atmospheric nitrogen into ammonia, while other microorganisms catalyze nitrogen transformations essential for plant growth and ecosystem functioning.
3. **Sulfur Cycle:** Sulfur cycling encompasses microbial-mediated transformations of sulfur compounds including sulfide, sulfate, and elemental sulfur. Sulfate-reducing bacteria, sulfur-oxidizing bacteria, and archaea play key roles in sulfur metabolism,
4. **Phosphorus Cycle:** Microorganisms participate in phosphorus cycling through processes such as mineral weathering, organic phosphorus mineralization

Environmental Microbiology and Human Health

Waterborne Pathogens and Water Quality

1. **Waterborne Pathogens:** Waterborne pathogens are microorganisms that contaminate water sources and pose risks to human health when ingested or contacted. Examples include bacteria (e.g., Escherichia coli, Salmonella spp.), viruses (e.g., norovirus, hepatitis A virus), protozoa (e.g., Giardia lamblia, Cryptosporidium spp.), and helminths (e.g., Schistosoma spp.). These pathogens can cause diseases such as gastroenteritis, diarrhea, hepatitis, and parasitic infections.

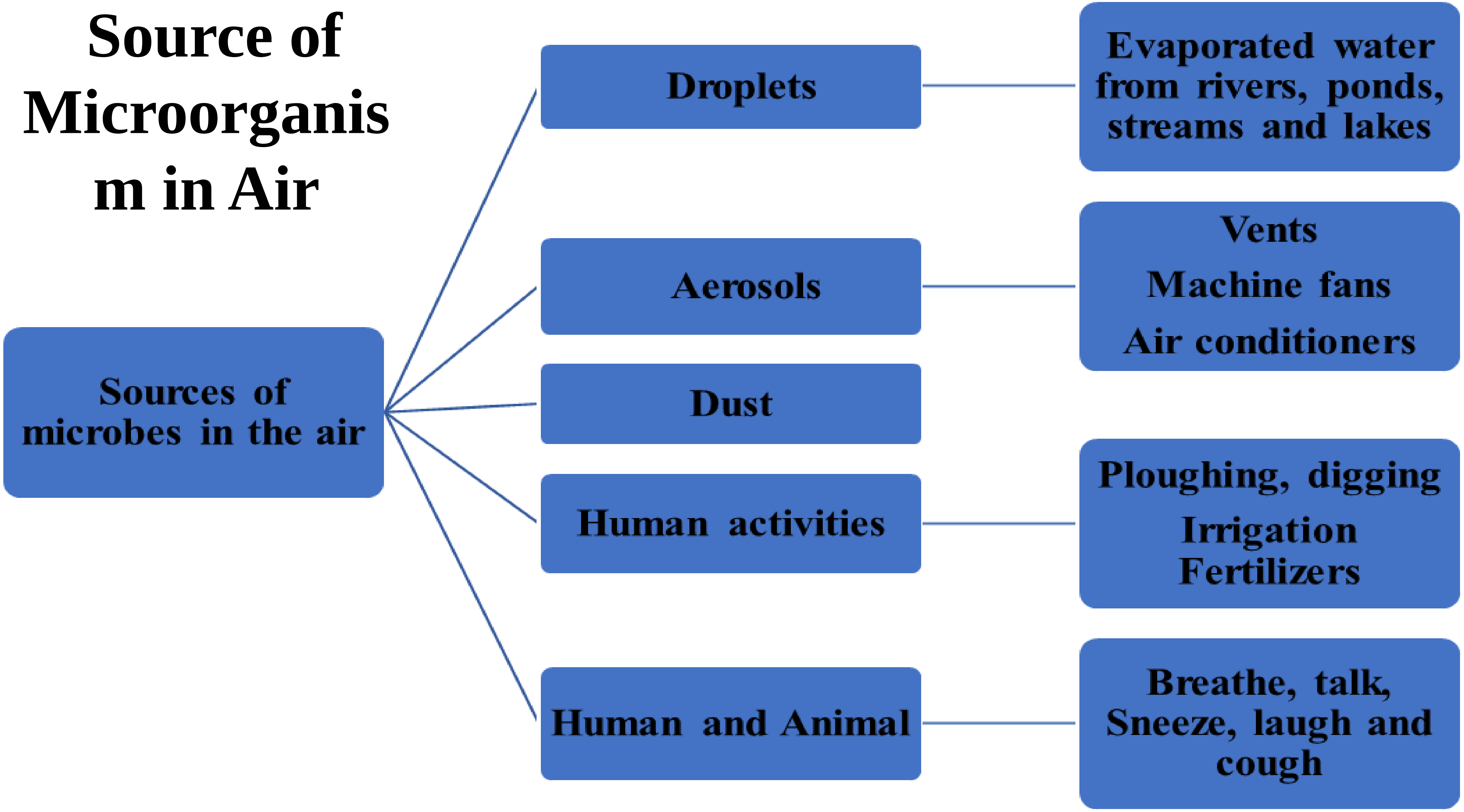
2. **Water Quality Monitoring:** Environmental microbiologists monitor water quality by assessing microbial indicators of fecal contamination and pathogens in water sources. Techniques include culture-based methods, molecular assays (e.g., polymerase chain reaction), and immunological assays to detect and quantify microbial contaminants. Monitoring ensures compliance with regulatory standards and protects public health by preventing waterborne disease outbreaks.

Airborne Microorganisms and Respiratory Health

1. **Airborne Microorganisms:** Airborne microorganisms include bacteria, fungi, viruses, and allergens dispersed in the atmosphere through aerosols, dust particles, and respiratory droplets. Common airborne pathogens include respiratory viruses (e.g., influenza virus, respiratory syncytial virus), bacteria (e.g., Mycobacterium tuberculosis, Legionella pneumophila), and fungal spores (e.g., Aspergillus spp., Penicillium spp.).

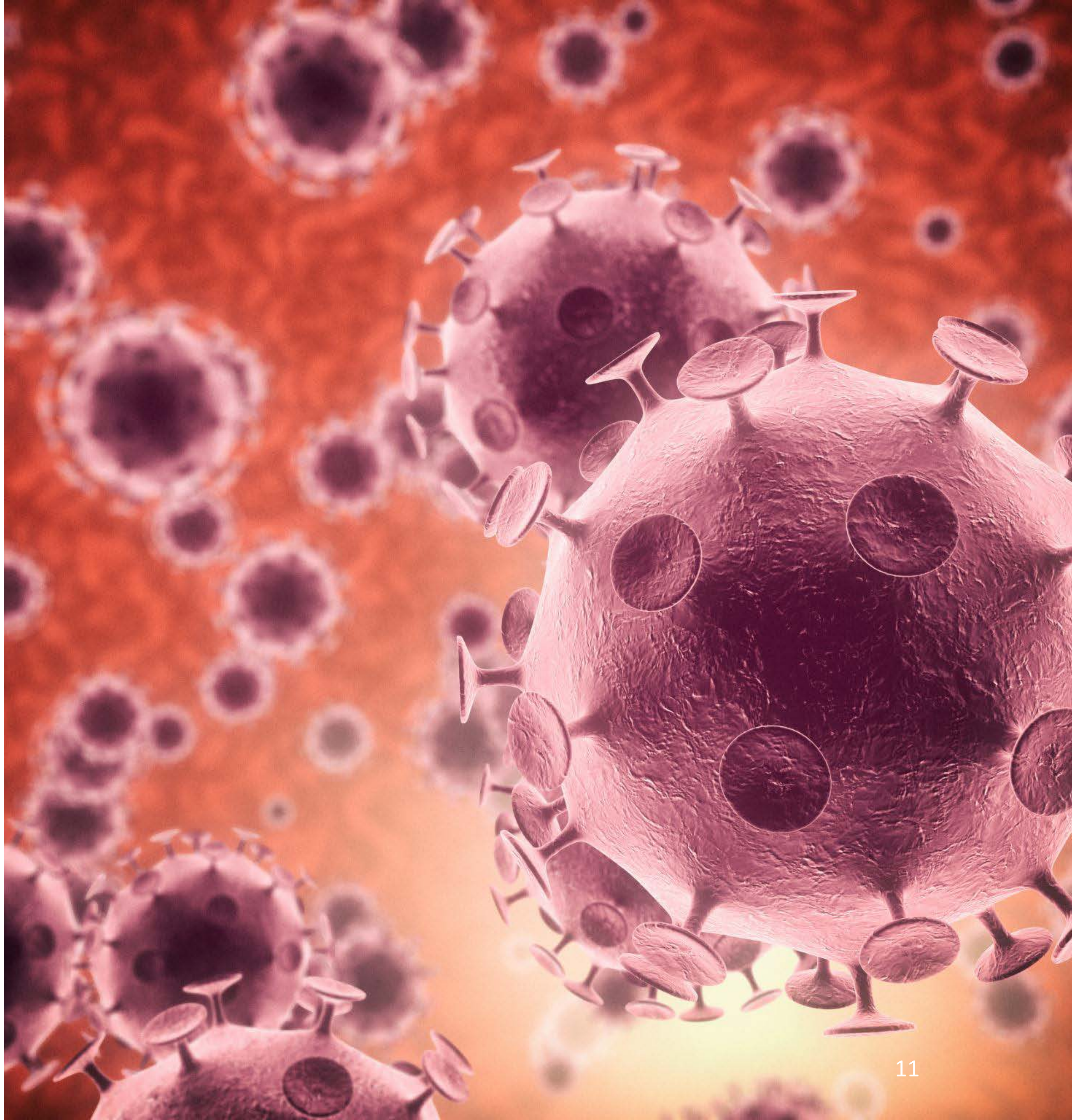
2. **Respiratory Health Impacts:** Airborne microorganisms can cause respiratory infections, allergic reactions, and exacerbate pre-existing respiratory conditions such as asthma and chronic obstructive pulmonary disease (COPD). Inhalation of airborne pathogens can lead to pneumonia, bronchitis, sinusitis, and allergic rhinitis, particularly in susceptible individuals with compromised immune or respiratory systems.

Source of Microorganism in Air



Air borne diseases

- **Bacterial origin-**
- Diphtheria
- Tubeculosis
- Meningitis
- **Air borne Viral Diseases**
- Small Pox
- Measles
- Influelza



Air Borne Fungal Diseases

- Sytemic Mycosis
- Histoplasmosis
- Cryptococcosis

Airborne infection

- Transmission of infection produced by respiratory droplets less than 5 micro meter

Droplet infection

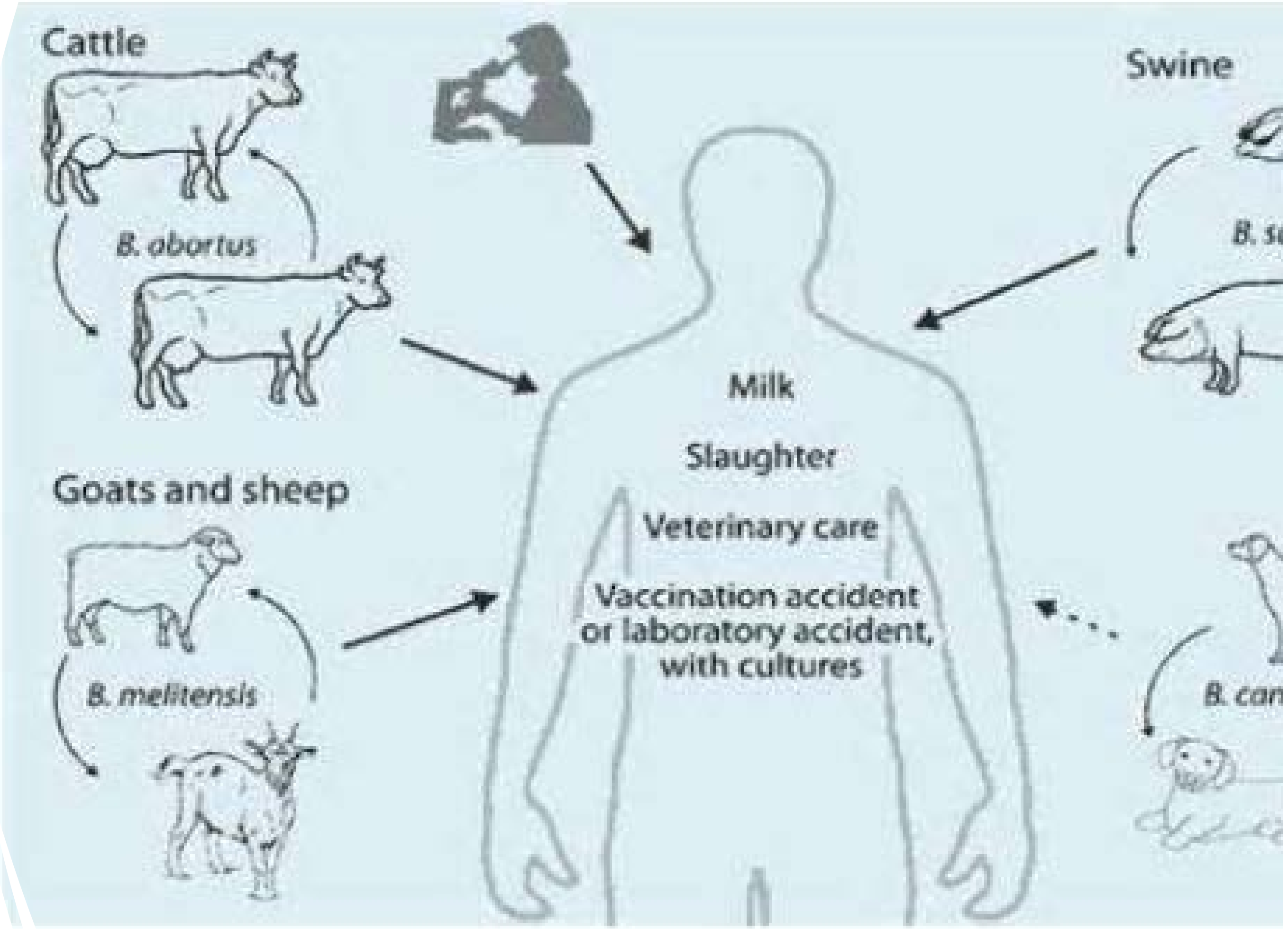
- Transmission of infection produced by respiratory droplets larger than 5 micro meter in size
- Note: Adult man inhales about 15 m3 of air per 24 hours and baby about 1 m3 /24 hours

Disease caused by air borne microbes

Brucellosis

- Bacterial diseases –

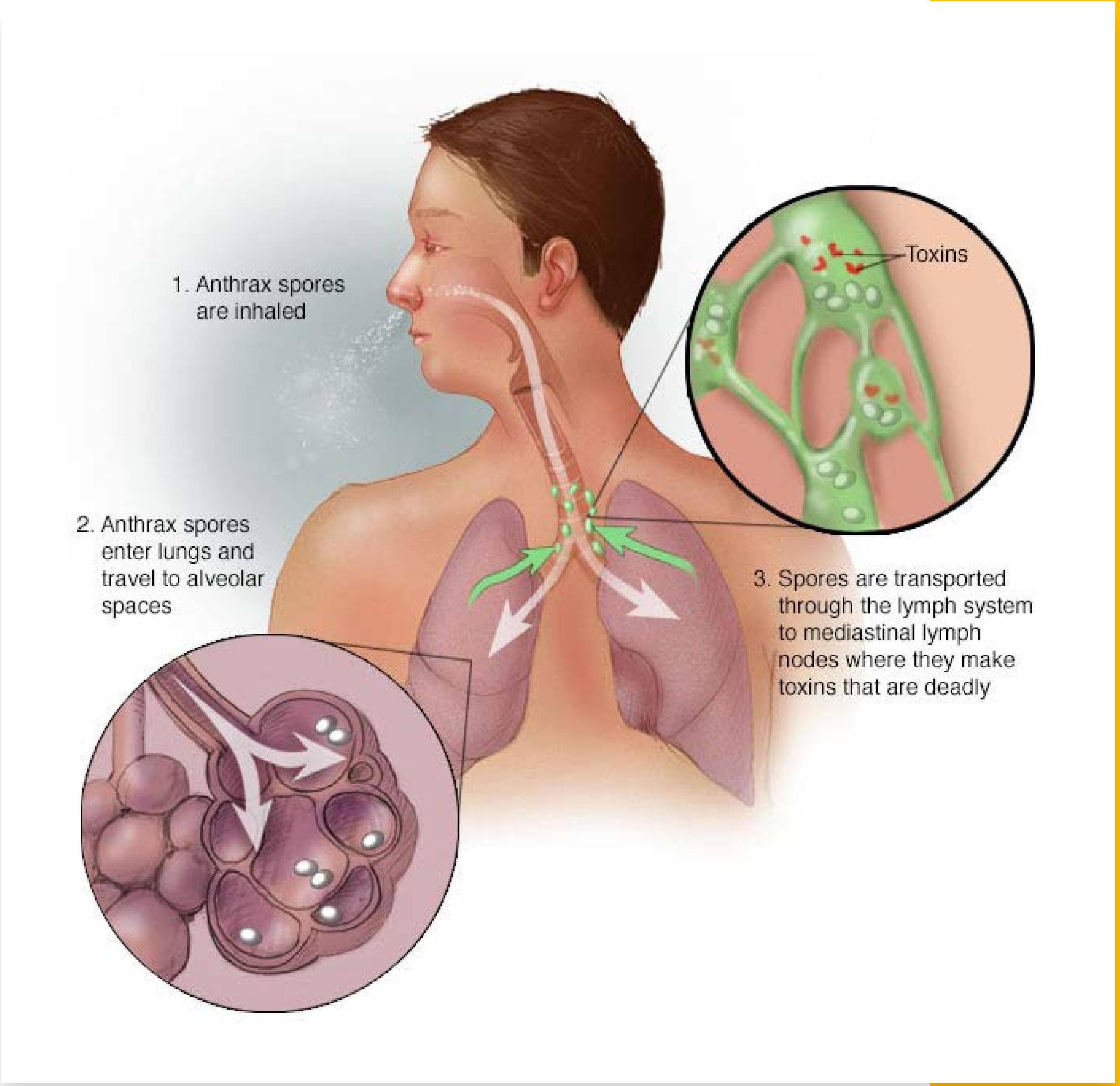
- **Brucellosis:**
- Brucella-suis it is mainly an occupational disease among veterinarian, butcher and slaughter house workers.



• Pulmonary Anthrax:

- Anthrax is caused by a spore-forming bacterium.

- It mainly affects animals. Humans can become infected through contact with an infected animal or by inhaling spores.

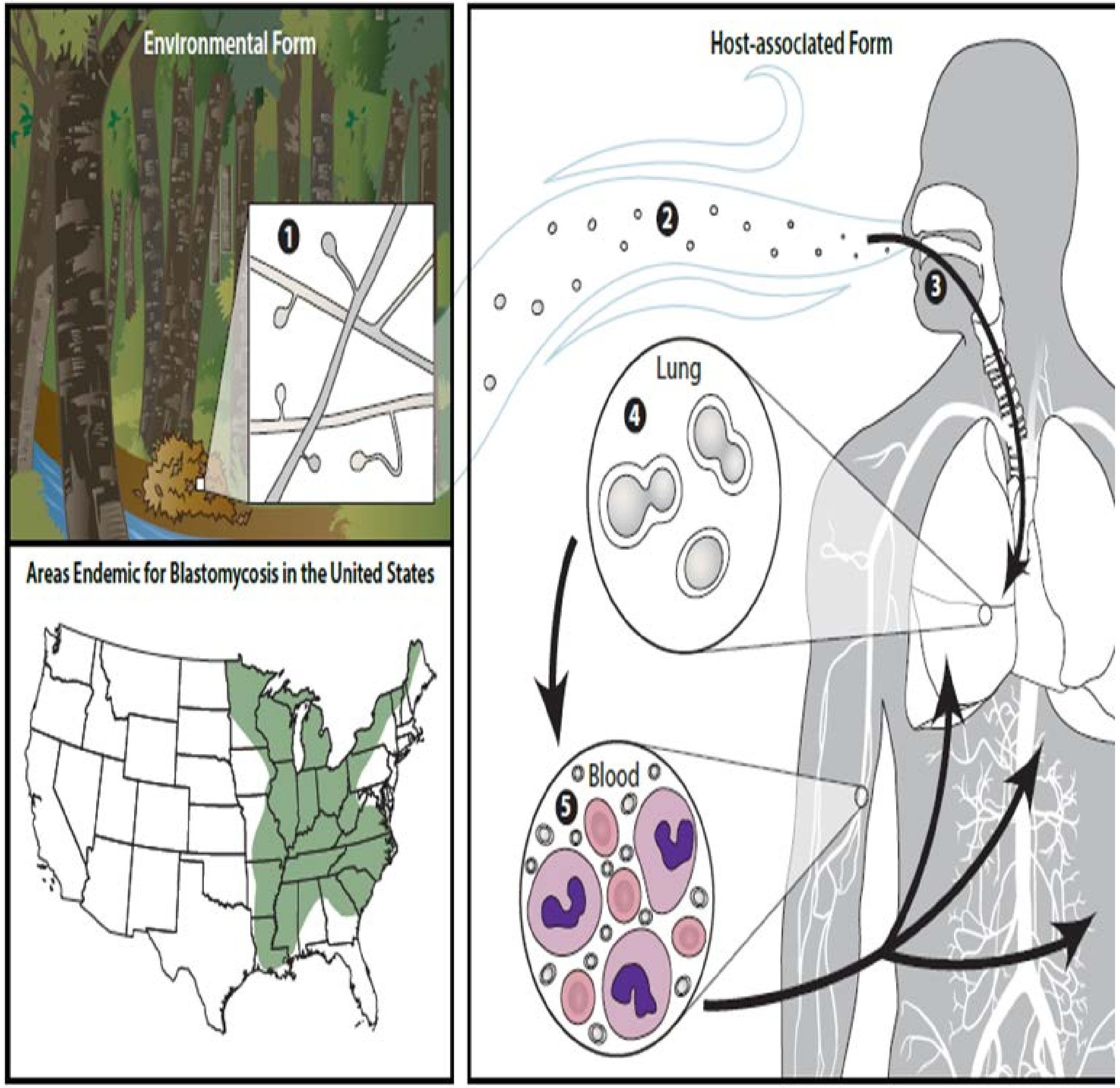


- Air Borne Fungal Diseases

  - **Blastomycosis:**

- Blastomycosis is an infection caused by the fungus *Blastomyces*.

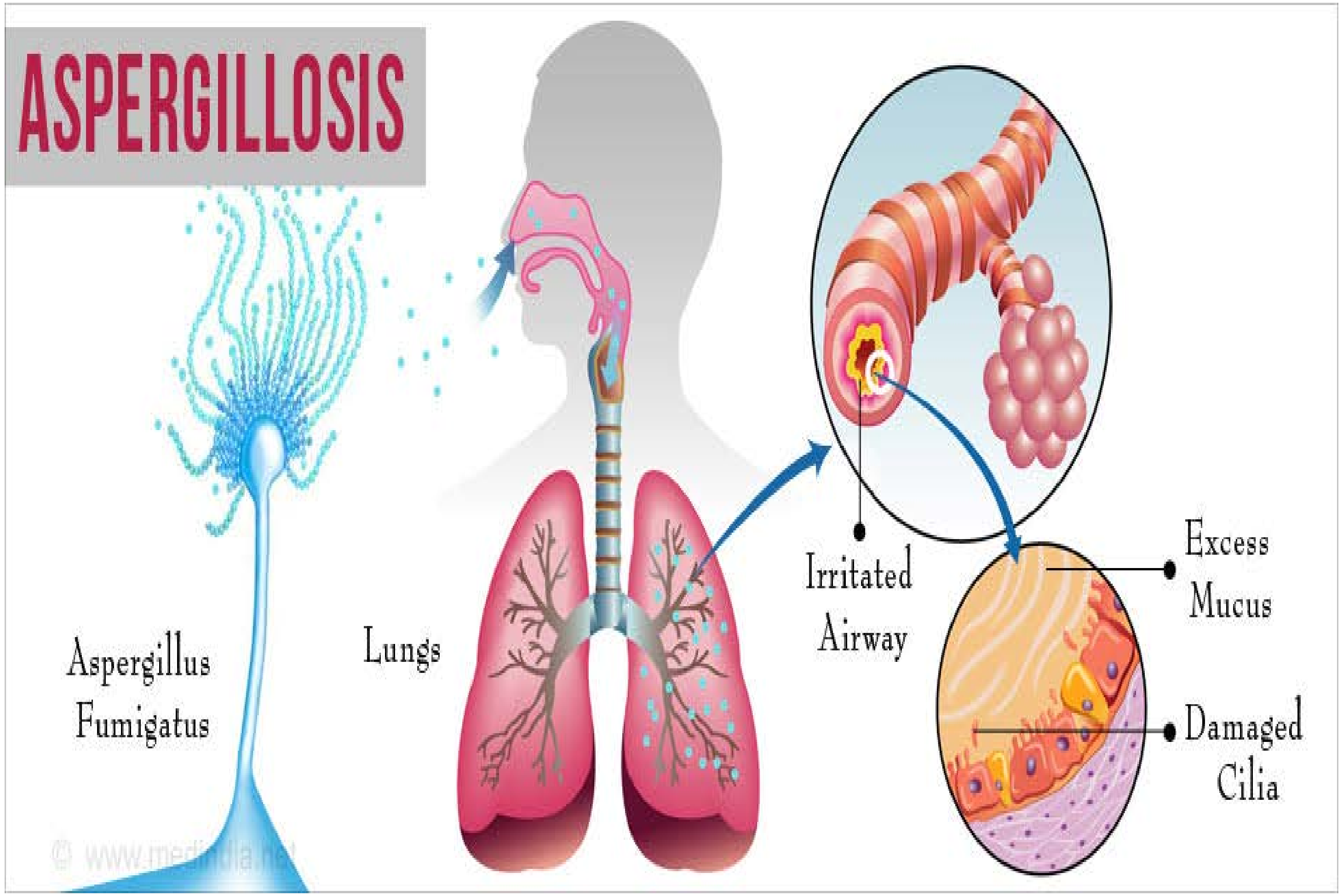
- The fungus lives in the environment, particularly in moist soil and in decomposing organic matter such as wood and leaves.



Aspergillosis:

- Aspergillosis is an infection caused by Aspergillus, a common mold (a type of fungus) that lives indoors and outdoors.

- Infection occurs through inhalation of spores. Most people breathe in Aspergillus spores every day without getting sick.



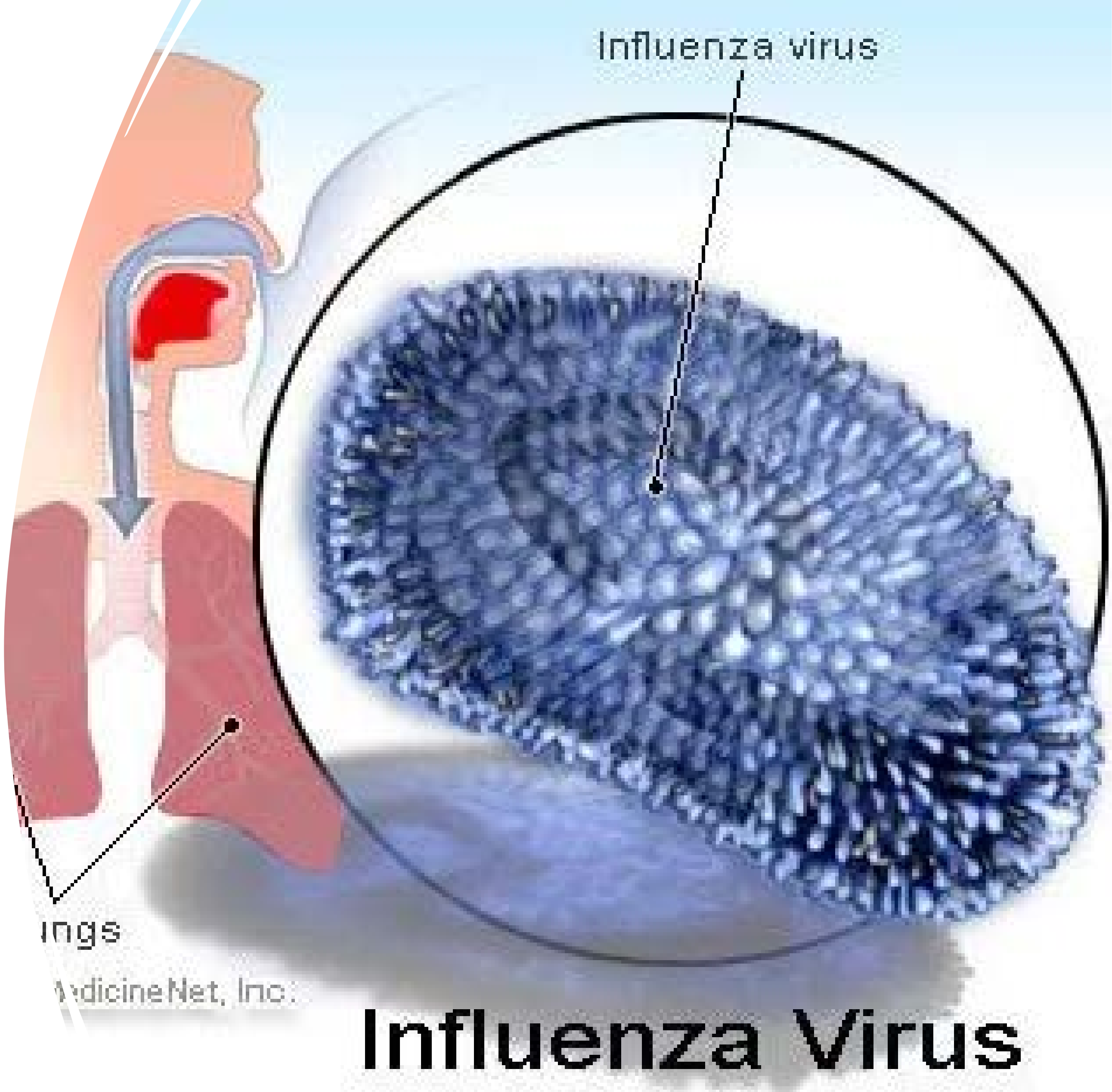
Air Borne Viral Diseases

Common Cold:

- Most people get colds in the winter and spring, but it is possible to get a cold any time of the year.
- Symptoms usually include sore throat, runny nose, coughing, sneezing, watery eyes, headaches and body aches. Most people recover within about 7-10 days.

Influenza:

- Symptoms of influenza are nasal discharge, head ache, muscle pains, sore throat and general weakness. Causative agents are *orthomyxovirus.*



- **Factors affecting microbial survival in air**

Atmospheric humidity:

- The relative as well as the absolute humidity content of the air play a major role in the survival of the air borne microorganism.

Temperature:

- Temperature is the major factor in the inactivation of microbes. High temperature promotes inactivation, mainly associated with desiccation and protein denaturation and lower temperature promotes longer survival times.

Soil Microbes and Agricultural Productivity

1. **Soil Microbial Communities:** Soil microbes play essential roles in nutrient cycling, organic matter decomposition, and plant-microbe interactions crucial for soil fertility and agricultural productivity. Beneficial soil microbes include nitrogen-fixing bacteria (e.g., Rhizobium spp., Azotobacter spp.), mycorrhizal fungi, and plant growth-promoting rhizobacteria (PGPR) that enhance nutrient uptake, disease resistance, and crop yields.

2. **Soilborne Pathogens:** Soilborne pathogens such as fungal pathogens (e.g., Fusarium spp., Phytophthora spp.) and nematodes can cause plant diseases and reduce crop productivity. Environmental microbiologists study soil microbial communities to understand disease dynamics, develop sustainable pest management strategies, and promote soil health in agriculture.

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