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المرحلة الثالثة /فرع الاحياء المجهرية/

Lec (2): Aeromicrobiology

Aerobiology has been defined by many as

- **The study of the aerosolization, aerial transmission, and deposition of biological materials**. Others have defined it more specifically as
- **The study of diseases that may be transmitted via the respiratory route**

.pasteur was able to show that invisible airborne particles were responsible for mysterious fermentative reactions. Despite the variations in definition, this relatively new science is becoming increasingly important in many aspects of such diverse scientific fields as **public health, environmental science, industrial** and **agricultural engineering, biological warfare,** and **space exploration**.

IMPORTANT AIRBORNE PATHOGENS:

Generally, as indicated by the previous definitions of aerobiology, one usually associates airborne microorganisms with disease occurrence in humans, animals, or plants.

1. Numerous plant pathogens are spread by the aeromicrobiological pathway.Up to 70% of all plant diseases are caused by fungi such as **wheat rusts** that can be spread by airborne transmission.
2. There are also numerous airborne pathogenic microorganisms that infect animals . For example, **foot-and-mouth** disease virus is known to be transmitted by the aeromicrobiological pathway.
3. Finally, humans can also be infected by the airborne transmission of many pathogens such as **Legionella pneumophila**, **Mycobacterium tuberculosis** , and newly recognized pathogens such as the S**in Nombre virus (hantavirus).**

Examples of Airborne Plant Pathogens	
Fungal plant disease	**Pathogen**
Dutch Elm disease	*Ceratocystis ulmi*
Potato late blight	*Phytophthora infestans*
Leaf rust	*Puccinia recondite*
Loose smut of wheat	*Ustilago tritici*
Downy mildew	*Pseudoperonospora humuli*
Maize rust	*Puccinia sorghi*
Powdery mildew of barley	*Erysiphe graminis*
Southern corn leaf blight	*Helminthosporium maydis*

Examples of Airborne Animal Pathogens	
Animal Disease	**Pathogen**
Bacterial diseases	
Tuberculosis	*Mycobacterium bovis*
Brucellosis	*Brucella* spp.
Fungal diseases	
Aspergillosis	*Aspergillus* spp.
Coccidioidomycosis	*Coccidioides immitis*
Viral diseases	
Influenza	Influenza virus
Rabies	*Rhabdoviridae*
Foot-and-mouth disease	*Aphthovirus*

Examples of Airborne Human Pathogens	
Human disease	**Pathogens**
Bacterial diseases	
Pulmonary tuberculosis	*Mycobacterium tuberculosis*
Pneumonia	*Klebsiella pneumoniae*
Pulmonary anthrax	*Bacillus anthracis*
Legionellosis	*Legionella* spp.
Whooping cough	*Bordetella pertussis*
Diphtheria	*Corynebacterium diphtheriae*
Fungal diseases	
Aspergillosis	*Aspergillus fumigatus*
Coccidioidomycosis	*Coccidioides immitis*
Viral diseases	
Influenza	Influenza virus
Hantavirus pulmonary syndrome	Hantavirus
Hepatitis	Hepatitis virus
Chicken pox	Herpesvirus
Common cold	Picornavirus
Dengue fever	Flavivirus

IMPORTANT AIRBORNE TOXINS:

1. **Botulinal A toxin: A** toxin from ***Clostridium botulinum*** that is a potential biological warfare agent . Botulinal toxin is a neurotoxin that is normally associated with ingestion of contaminated food . The lethal dose for botulinal toxin by inhalation is 0.3 µ*g* of toxin ,with death expected 12 hours after exposure. Symptoms are caused by inhibition of the production of acetylcholine at nerve ending. Death is due to asphyxiation caused by the paralysis of respiratory muscles.
2. **Staphylococcal Enterotoxin:** Another toxin produced by bacteria is staphylococcus spp. This toxic protein is highly resistant to inactivation in association with the AMB pathway. This toxin can be fatal, with the lethal dose is estimated to be 25 µ*g* by inhalation. The symptoms include cramping, vomiting, and diarrhea, which occur within one hour of exposure by aerosolization.
3. **lipopolysaccharide (LPS)** :Are one of the majer constitutive elements of the outer membrane of gram-negative bacteria. Also referred to as endotoxin. Because gram-negative bacteria are ubiquitous in the environment, LPS is considered to be the most important aerobiological allergens.The dose of LPS required to initiate the toxic effect by inhalation is less than 10 ng.

AEROSOLS

Particles suspended in air are called aerosols. These pose a threat to human health mainly through respiratory intake and deposition in nasal and bronchial airways. **Bioaerosols:** biological airborne contaminants , which can be ingested or inhaled by humans. include whole entities such as bacterial and viral human pathogens. They also include airborne toxins, which can be parts or components of whole cells.

NATURE OF BIOAEROSOLS :

Bioaerosols vary considerably in size, and composition depends on a variety of factors including

1. the type of microorganism or toxin.
2. the types of particles they are associated with such as mist or dust.
3. the gases in which the bioaerosol is suspended.

Bioaerosols in general range from 0.02 to 100 μm in diameter and are classified on the basis of their size.

1. The smaller particles (< 0.1 μm in diameter) are considered to be in the nuclei mode.
2. those ranging from 0.1 to 2μm are in the accumulation mode.
3. The larger particles are considered to be in the coarse mode.

AEROMICROBIOLOGICAL PATHWAY:

The aeromicrobiological pathway describes: (1) the launching of bioaerosols into the air; (2) the subsequent transport via diffusion and dispersion of these particles; and finally (3) their deposition. An example of this pathway is that of liquid aerosols containing the influenza virus launched into the air through a cough, sneeze, or even through talking. These virus-associated aerosols are dispersed by a cough or sneeze, transported through the air, inhaled, and deposited in the lungs of a nearby person, where they may begin a new infection.

Launching The process whereby particles become suspended within Earth's atmosphere.

Transport: Transport or dispersion is the process by which kinetic energy provided by the movement of air is transferred to airborne particles, with resultant movement from one point to another. coliforms aerosolized from sewage treatment plants have been transported over 1.2 km. Another example is influenza has been shown to spread from east to west around the world.

Deposition: The last step in the AMB pathway is deposition. An airborne bioaerosol will eventually leave the turbulence of the suspending gas and will ultimately be deposited on a surface by one or a combination of interrelated mechanisms.

MICROBIAL SURVIVAL IN THE AIR

The atmosphere is an inhospitable climate for microorganisms mainly because of desiccation stress. This results in a limited time-frame in which microbes can remain biologically active. **Many M.O have specific mechanisms that allow them to be somewhat resistant to the various environmental factors that promote loss of biological activity:**

1. Spore-forming bacteria, molds, fungi, and cyst-forming protozoa ,all have specific mechanisms that protect them from harsh gaseous environments.
2. increasing their ability to survive aerosolization. microbes may be viable but nonculturable .

Many environmental factors have been shown to influence the ability of microorganisms to survive. The most important of these are **1)** relative humidity and **2)** temperature. **3)** Oxygen content, **4)** specific ions, **5)** UV radiation, **6)** various pollutants, and **7)** OAFs (open air factors) are also factors in the loss of biological activity.

*** Relative Humidity**: The major importance in the survival of airborne microorganisms, indicating, that as the relative humidity approaches 100%, the death rate of *Escherichia coli* increases. In general, it has been reported that most gram-negative bacteria associated with aerosols tend to survive for longer periods at low to mid levels of relative humidities .The opposite tends to be true for gram-positive bacteria, which tend to remain viable longer in association with high relative humidities. The ability of a microorganism to remain viable in a bioaerosol is related to the organism's surface biochemistry.

One mechanism that explains loss of viability in association with very low relative humidity is a structural change in the lipid bilayers of the cell membrane. As water is lost from the cell, the cell membrane bilayer changes from the typical crystalline structure to a gel phase. This structural phase transition affects cell surface protein configurations and ultimately results in inactivation of the cell .

Influenza virus was also adversely affected by an increase in relative humidity. **viruses possessing enveloped nucleocapsids (such as the influenza virus) have longer airborne survival when the relative humidity is below 50%,** whereas **viruses with naked nucleocapsids (such as the enteric viruses) are more stable at a relative humidity above 50%.** It should be noted that viruses with enveloped nucleocapsids tend to have better survival in aerosols than those without. Some viruses are also stable in the AMB pathway over large ranges of relative humidity, which makes them very successful airborne pathogens.

*** Temperature**: is a major factor in the inactivation of microorganisms. In general, high temperatures promote inactivation, mainly associated with desiccation and protein denaturation, and lower temperatures promote longer survival times. When temperatures approach freezing, however, some organisms lose viability because of the formation of ice crystals on their surfaces. The effects of temperature are closely linked with many other environmental factors, including relative humidity.

*** Radiation** : The main sources of radiation damage to microorganisms including bacteria, viruses, fungi, and protozoa are the shorter UV wavelengths, and ionizing radiation such as X-rays. The main target of UV irradiation damage is the nucleotides that make up DNA. Ionizing radiation or X-rays cause several types of DNA damage, including

1. single strand breaks,
2. double strand breaks, and
3. alterations in the structure of nucleic acid bases.

UV radiation causes damage mainly in the form of intrastrand dimerization, with the DNA helix becoming distorted as thymidines are pulled toward one another . This in turn causes inhibition of biological activity such as replication of the genome, transcription, and translation. Several mechanisms have been shown to protect organisms from radiation damage. These include

1. association of microbes with larger airborne particles,
2. possession of pigments or carotenoids,
3. high relative humidity, and
4. cloud cover, all of which tend to absorb or shield bioaerosols from radiation.

Many types of organisms also have mechanisms for repair of the DNA damage caused by UV radiation. An example of an organism that has a radiation resistance mechanism is *Dienococcus radiodurans*, a soil bacterium that is considered the most highly radiation-resistant organism that has yet been isolated. An important component of its radiation resistance is the ability to enzymatically repair damage to chromosomal DNA. The repair mechanism used by these bacteria is so highly efficient that much of the metabolic energy of the cell is dedicated exclusively to this function.

* **Oxygen, open air factors (OAFs), and Ions:** In general, these three factors combine to inactivate many species of airborne microbes. **Oxygen toxicity** is not related to the dimolecular form of oxygen (O_2) , but is instead important in the inactivation of microorganisms when O_2 is converted to more reactive forms. These include **<u>superoxide radicals</u>**, **<u>hydrogen peroxide</u>**, and **<u>hydroxyl radicals</u>**.

These radicals arise naturally in the environment from

1) the action of lightning . **2)** UV radiation, and **3)** pollution, etc . Such reactive forms of oxygen cause damage to DNA by producing mutations, which can accumulate over time.

* **The open air factor (OAF)** : It is closely linked to oxygen toxicity and has come to be defined as a mixture of factors produced when ozone and hydrocarbons (generally related to ethylene) react. For example, high levels of hydrocarbons and ozone can cause increased inactivation rates for many organisms, probably because of damaging effects on enzymes and nucleic acids. Therefore, OAFs have been strongly linked to microbial survival in the air.

***The formation of other ions**, such as those containing chlorine, nitrogen, or sulfur, occurs naturally as the result of many processes. These include

- the action of lightning,
- shearing of water,
- the action of various forms of radiation that displace electrons from gas molecules, creating a wide variety of anions and cations not related to the oxygen radicals.

These ions have a wide range of biological activity.

1) **Positive ions** cause only physical decay of microorganisms (e.g., inactivation of cell surface proteins).

2) **negative ions** exhibit both physical and biological effects such as internal damage to DNA.

Aeromicrobiology involves various aspects of **intramural (indoor)** and **extramural (outdoor)** aerobiology as they relate to the airborne transmission of environmentally relevant microorganisms, including viruses, bacteria, fungi, yeasts, and protozoans.

EXTRAMURAL AEROMICROBIOLOGY (OUTDOOR): is the study of microorganisms associated with outdoor environments. In the extramural environment.The two controlling factors in the movement of bioaerosols are

1. **The expanse of space** and
2. **The presence of air turbulence.**

Extramural environment includes

(A)The spread of **agricultural** pathogens

(B)The spread of airborne pathogens associated with **waste** environments.

INTRAMURAL AEROMICROBIOLOGY (INDOOR):

The home and workplace are environments in which airborne microorganisms create major public health concerns. In comparison with the extramural environment, intramural environments have limited circulation of external air and much less UV radiation exposure. Indoor environments also have controlled temperature and relative humidity, which are generally in the ranges that allow extended microbial survival. Thus, these conditions are suitable for the accumulation and survival of microorganisms within many enclosed environments, including office buildings, hospitals and laboratories.

BIOAEROSOL CONTROL

The control of airborne microorganisms can be handled in a variety of ways. The mechanisms used to control bioaerosols include

1. Ventilation
2. Filtration
3. UV treatment
4. Biocidal agents
5. Physical isolation.