M1-Introduction to Microbiology

3 more properties

Learning Objectives

1. Understanding the fundamental knowledge of microbes and pathogens.
    - Some notes related to microbes and pathogens

      Pathogens and microbes are related terms but have distinct meanings:

      1. Microbes: **Microbes, short for microorganisms (microorganism may not be a living organism, e.g.: viruses is not considered as a living organism)**, are microscopic organisms that include bacteria, viruses, fungi, protozoa, and other microscopic life forms. They are found everywhere in the environment, including on and inside the human body. While some microbes can cause diseases, the majority of them are harmless or even beneficial. Microbes play essential roles in various ecological processes and are involved in human health, such as **aiding in digestion and supporting the immune system**.
      2. Pathogens: Pathogens are a specific subset of microbes that have the ability to cause disease in their host organisms. These are the **disease-causing microorganisms**.
2. Recognizing how infectious diseases are transmitted.
3. Understanding the basic concepts of antibiotics, antivirals, and vaccines for infectious diseases.

Simple Classification of microbes

1. Helminths（蛔虫）- Multicellular Organism
    a. Roundworm
    b. Flatworm
    c. Flukes
    - Difference between Helminths and Roundworm

      Helminths are a broad category of parasitic worms, while roundworms are a specific type of helminth. Roundworms are characterized by their long, cylindrical bodies and are typically found in soil or water. Some species of roundworms can cause disease in humans and animals, while others are harmless.
2. Protozoa（原虫）- Eukaryotes
    a. Amoeba
    - Characteristic of Protozoa

      👉 Protozoa are **single-celled organisms** found in soil, water, and the bodies of plants and animals.
        - They are about the same size as a red blood cell.
        - Protozoa move using hair-like structures called **cilia** or **flagella**.
        - Some protozoa can form structures called **cysts** to protect themselves.
        - Protozoa are classified based on their method of movement, such as **amoeboid or ciliary movement.**
        - Belongs to Animal Kingdoms
        - Live by digesting Food
3. Fungi（真菌）- Eukaryotes
    a. Aspergillus (曲霉菌),
    commonly found in soil, decaying plant matter, and other organic materials.
    - Characteristic of Fungi
        - Consist of Mold & Yeast
        - Acquire food by Absorption
4. Bacteria（细菌）- Prokaryotes
    a. Staphylococcus aureus (金黄色葡萄球菌)
    - Characteristics of bacteria

      - Commonly found in various environments, including on the skin and in the nasal passages of humans, as well as in soil, water, and food.
      - Size of Bacteria usually comparable to a mitochondria
      - The genetic materials of Bacteria are usually DNA
5. Viruses（病毒）- Prokaryotes
    a. Influenza A virus
    - Characteristics of Viruses

      - Size of viruses are usually smaller than a mitochondria but larger than an protein. ~100nm
      - Viruses are not considered as a living organism
      - The genetics materials (DNA/RNA) are packed in single-membrane capsules
6. Prions（类病毒颗粒）
    - Some brief introduction to prisons

      💡 Prions are a type of infectious agent (**proteinaceous infectious particles**) that consists solely of protein, which is much smaller than the complex protein and lipid (**<1nm,** which is smaller than C_{60}).

      They are unique in that they do not contain genetic material such as DNA or RNA, even **absence of nucleic acid**. Prions can cause a number of diseases in humans and animals, including **Creutzfeldt-Jakob disease (CJD)** in humans and **bovine spongiform encephalopathy (BSE)**, also known as *mad cow disease*, in cattle. Prion diseases are characterized by the accumulation of abnormal prion proteins in the brain (*大脑中异常朊病蛋白的积累*) , which leads to the **death of nerve cells** and the **development of neurological symptoms**.

⚠️ Do notice that among all the microbes, contains the genetics materials which often exists as DNA or RNA (virus), except prions.

[*Do notice that not all the microbes are eukaryotes, which means they may not have nucleus to keep the genetics materials, for example: virus and bacteria.*]

Comparison between Eukaryotes & Prokaryotes

Eukaryotes	Prokaryotes
More than one chromosomes	Only one, No true chromosome: Plasmids
Usually Multicellular Exception: Protozoa (Amoeba)	Usually Unicellular Exception: Cyanobacteria
Genetic Recombination: Meiosis and Fusion of gametes	Genetic Recombination: Partial, unidirectional transfer DNA
Presence of Lysosomes and peroxisomes	Absence of Lysosomes and peroxisomes
Present of microtubules	Absence of Microtubules

- Plasmids

  In prokaryotes, **plasmids are small, circular pieces of DNA that are separate from the main bacterial chromosome**. They can replicate independently and often carry genes that provide the bacteria with some sort of selective advantage, such as antibiotic resistance or the ability to metabolize certain nutrients. Plasmids can be transferred between bacteria, allowing the genes they carry to spread horizontally within bacterial populations.

- Multicellular & Unicellular

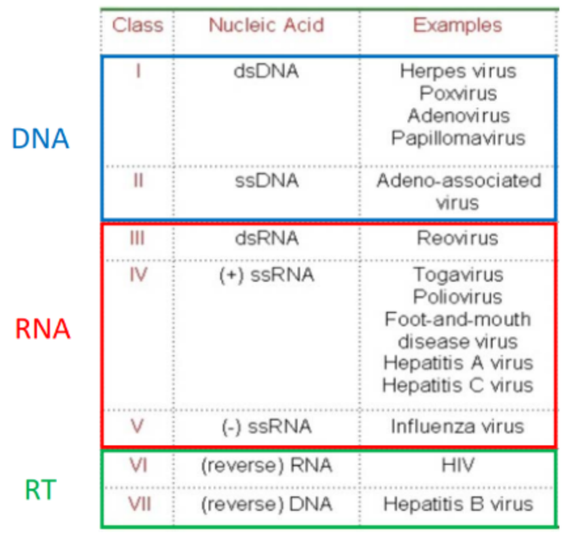
  Multicellular refers to organisms that are made up of multiple cells, while unicellular refers to organisms that are made up of only one cell.

  - More about Cyanobacteria
    - Cyanobacteria are a type of bacteria that obtain their energy through photosynthesis.
    - They are often referred to as blue-green algae due to their blue-green coloration and their ability to form large mats in bodies of water.
    - Some species of cyanobacteria can produce toxins that are harmful to humans and animals.

- Introduction to Lysosomes, peroxisomes and microtubules
  - Lysosomes are involved in the breakdown of cellular waste and the recycling of cellular components.
  - Peroxisomes are involved in the breakdown of fatty acids and the detoxification of harmful substances.
  - Microtubules are structural components of the cytoskeleton, which are involved in cellular movement and transport.

Introduction to Viruses

Classification of Viruses



Class	Nucleic Acid	Examples
I	dsDNA	Herpes virus Poxvirus Adenovirus Papillomavirus
II	ssDNA	Adeno-associated virus
III	dsRNA	Reovirus
IV	(+) ssRNA	Togavirus Poliovirus Foot-and-mouth disease virus Hepatitis A virus Hepatitis C virus
V	(-) ssRNA	Influenza virus
VI	(reverse) RNA	HIV
VII	(reverse) DNA	Hepatitis B virus

1. DNA viruses:
   - Have DNA as their genetic material.
   - Class I # dsDNA:
     - Herpes virus (疱疹病毒)
     - Adenovirus (腺病毒)
     - Papillomavirus (乳头状瘤病毒) ~ HPV
   - Class II # ssDNA:
     - Adeno-associated virus (腺相关病毒)
2. RNA viruses:
   - Have RNA as their genetic material.
   - Class III # dsRNA:
     - Reovirus
       (嵌合病毒: associated with respiratory and enteric infection [*呼吸道和肠道感染*])
   - Class IV # (+) ssRNA:
     - Hepatitis A/C virus
     - Foot-and-mouth disease virus
     - Togavirus（病毒属）[*拓扑病毒*]
     - Poliovirus（脊髓灰质炎病毒）[*Polio-小儿麻痹症病毒*]
3. Retroviruses:
   - Contain RNA as their genetic material, but use a unique enzyme called reverse transcriptase to convert their RNA into DNA, which can then be integrated into the host cell's genome.
   - Class VI # (reverse RNA):
     - HIV ~ AIDs
   - Class VII # (reverse DNA):
     - Hepatitis B Virus

Viruses and Disease

Rhinovirus; Coronavirus (HKU1, 229E)	Common cold 傷風
Poliovirus	Polio 小兒麻痹症
Varicella-zoster virus (VZV)	Chickenpox 水痘
Hepatitis B virus (HBV)	Hepatitis 肝炎
Mumps virus	Mumps 腮腺炎
Human immunodeficiency virus (HIV)	AIDS 愛滋病
Influenza A virus (IAV)	Influenza 感冒

- Influenza and Common cold

Microbes and humans

Vast majority of microbes are harmless. There are 3 symbiotic relationship between microbes and human:

- Commensalism relationship (共栖关系)
- Mutualism relationship (互利共生关系)
  - E. Coli @ Large Intestine:

- Produce Bacteriocins → Inhibit the Growth of other Microbes
- Synthesize Vitamin K & B

- Parasitism relationship (寄生关系)

> ⚠️ Do notice that Presence of microbes (Colonization) ≠ Disease (Infection)
> They can communicate with our body, including immune system, even our brain

Normal (endogenous) flora of Humans

- Normal flora of humans refers to the microorganisms that naturally inhabit various parts of the human body, including the skin, mouth, gut, and urinary tract.

- Skin, Groin, Perineum, Feet, Scalp:
  - Staphylococcus epidermis
  - Staphylococcus aureus
  - Diphtheroid (白喉)
  - Streptococci
  - Pseudomonas (First Bacteria observed under microscope)
  - Aeruginosa (綠濃桿菌)
  - Anaerobes Candida (白色念珠菌)
  - Torulopsis (釀酒酵母菌)
  - Pityrosporum (癬菌)
- Nose, Urethra, Vagina:
  - Staphylococcus epidermis
  - Staphylococcus aureus
  - Diphtheroids
  - Streptococci
- Teeth
  - Streptococcus mutans
  - Fusobacterium
  - Actinomyces
  - Streptococci
- Throat
  - Streptococcus Viridans
  - Streptococcus pyogenes
  - Streptococcus pneumonia
  - Neisseria spp.
  - Staphylococcus epidermis
  - Haemophilus Influenza
- Mouth
  - Streptococci & Strep. Mitis (链球菌中性链球菌)
  - Trichomonas Tenax (特纳克斯毛滴虫)
  - Candida

- These microorganisms can include bacteria, viruses, fungi, and other types of microbes.

Opportunistic Pathogens

- Circumstances → Normal Flora → Pathogens:
  - Weaken immune system
  - Bacteria from the normal flora enter other areas of the body

Pathogen and Infection

Emerging and Re-emerging Infectious Diseases

Emerging infectious diseases are those that have recently appeared in a population or are rapidly increasing in incidence or geographic range. Examples of emerging infectious diseases include:

- SARS (2003), MERS (2012), SARS-CoV-2 (2019)
- Ebola virus disease - Haemorrhagic fever (出血性發燒)
- Zika virus disease - Arthropod-borne viruses （通過蚊子傳播）
- Middle East Respiratory Syndrome (MERS)
- Severe Acute Respiratory Syndrome (SARS)

Re-emerging infectious diseases are those that were once under control but are now showing an increase in incidence or geographic range. Examples of re-emerging infectious diseases include:

- Tuberculosis
- Malaria
- Measles - 麻疹 [Rubella - 德國麻疹]
- Yellow fever - 黃熱病
- Dengue fever

> 💡 Additional knowledge
>
> ▼ Arboviruses [Arthropod-borne]
>
> Arthropod-borne viruses, also known as arboviruses, are a group of viruses that are transmitted to humans and animals through the bites of arthropods, such as *mosquitoes, ticks, and sandflies*.
>
> ▼ Haemorrhagic fever
>
> Haemorrhagic fever is a type of viral infection that is characterized by fever, fatigue, and bleeding disorders. The bleeding disorders can include petechiae (small red or purple spots on the skin), ecchymoses (larger bruises 淤血), and bleeding from mucous membranes and internal organs.
>
> There are several different viruses that can cause haemorrhagic fever, including the Ebola virus, Lassa fever virus (拉沙热病毒), and Marburg virus (马尔堡病毒). These viruses are typically spread through contact with the bodily fluids of infected individuals or animals, such as blood, saliva, vomit, or urine.

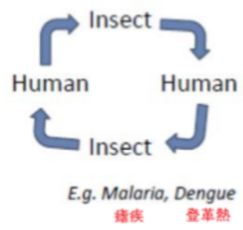
Examples of Pathogenic mechanisms

1. Toxins - Some pathogens produce toxins that can damage cells and tissues. Examples include the botulinum toxin produced by Clostridium botulinum, which causes botulism, and the tetanus toxin produced by Clostridium tetani, which causes tetanus.
   - 毒素 - 一些病原体会产生可以损害细胞和组织的毒素。例如产生肉毒杆菌毒素的肉毒杆菌会引起肉毒症，而产生破伤风毒素的破伤风梭菌会引起破伤风。
   - ▼ Example:

     Diphtheria 白喉, Tetanus 破傷風, Cholera 霍亂
2. Immunopathology - Some diseases are caused by the immune response to a pathogen rather than the pathogen itself. For example, rheumatic fever is caused by an immune response to a Streptococcus infection.
   - 免疫病理学 - 有些疾病是由于对病原体的免疫反应而不是病原体本身引起的。例如，风湿热是由于对链球菌感染的免疫反应引起的。
   - ▼ Example: Tuberculosis, Influenza A virus
     - When M. tuberculosis bacteria are inhaled, they are taken up by immune cells called macrophages. The bacteria can then survive and replicate within the macrophages, leading to the formation of granulomas, which are clusters of immune cells that surround the infected macrophages. However, the immune response to the bacteria can also cause tissue damage and inflammation, which can lead to the symptoms of tuberculosis.
     - In severe cases of Influenza A infection, the immune system can produce an excessive amount of pro-inflammatory cytokines, leading to a phenomenon known as a cytokine storm. This uncontrolled release of cytokines can cause widespread inflammation and tissue damage, *particularly in the respiratory system*. The excessive immune response can contribute to the severity of symptoms and complications associated with Influenza A.
3. Oncogenesis - Some viruses can cause cancer by integrating their genetic material into the host cell's DNA. Examples include human papillomavirus (HPV), which can cause cervical cancer, and hepatitis B virus (HBV), which can cause liver cancer.
   - 致癌 - 一些病毒可以通过将其遗传物质整合到宿主细胞的DNA中来引起癌症。例如可以引起宫颈癌的人类乳头状瘤病毒（HPV）和可以引起肝癌的乙型肝炎病毒（HBV）等。
   - ▼ Example: Epstein-Barr Virus

     Epstein-Barr virus (EBV) is a type of herpes virus that is best known for causing infectious mononucleosis, also known as the "kissing disease". However, EBV has also been linked to the development of certain types of cancers, including Hodgkin's lymphoma, Burkitt's lymphoma, and **nasopharyngeal carcinoma**. The virus is transmitted through contact with infected bodily fluids, such as saliva, blood, and semen. Once inside the body, the virus can remain dormant for long periods of time, but can reactivate when the immune system is weakened. There is currently no known cure for EBV, but symptoms can be managed with rest, fluids, and over-the-counter pain relievers.
     - Epstein-Barr病毒（EBV）是一种疱疹病毒，最为人所知的是其引发的传染性单核细胞增多症，也称为“接吻病”。然而，EBV也与某些类型的癌症有关，包括霍奇金淋巴瘤、布基特淋巴瘤和鼻咽癌。该病毒通过接触感染的体液，如唾液、血液和精液传播。一旦进入体内，该病毒可以在长时间内保持休眠状态，但在某些情况下，如免疫系统受损时，可能会重新激活并导致疾病或疾病。目前尚无已知的EBV治愈方法，但可以通过休息、补充液体和非处方止痛药来缓解症状。

Common Pathogens & Route of Transmission



E.g. Malaria, Dengue
疟疾 登革热

E.g. Yellow fever, Pandemic influenza

E.g. Zika 寨卡

Direct	Touching, Kissing	- Streptococcus pyogenes - Staphylococcus aureus
	Sexual contact	- HIV
	Droplets	- Bacteria - Respiratory viruses
	Medical procedure	- Bloodborne virus (i.e.: Hepatitis B, HIV)
	Transplacental - 通过胎盘	- Congenital infection

Indirect	Vehicle-borne (Food, water, fomites)	Foodborne Infections
	Vector-borne (通過原動物宿主傳播)	- Malaria - Dengue - Japanese encephalitis (日本腦炎)
	Airborne (Droplet nuclei)	- Measles (麻疹) - Chickenpox (水痘) - Tuberculosis (肺結核)

▼ Addition: **Congenital infection (先天性感染)**

- A congenital infection is an infection that is present at birth. These infections can be passed from mother to baby during pregnancy or delivery. Some examples of congenital infections include rubella, cytomegalovirus (CMV), and toxoplasmosis. These infections can cause serious health problems for the baby, including birth defects, developmental delays, and other complications.
- 先天性感染是出生时存在的感染。这些感染可以在怀孕或分娩期间从母亲传给婴儿。一些先天性感染的例子包括风疹病毒、巨细胞病毒（CMV）和弓形虫病。这些感染会给婴儿带来严重的健康问题，包括先天畸形、发育迟缓和其他并发症。

▼ **Addition: Koch's Postulates**

> 如何判斷A Pathogens will Cause This Disease

1. The microbe must be present in every case of the disease
2. The microbe must be isolated from the diseased host and grown in pure culture
3. The cultured microorganism should cause disease when introduced into a healthy organism
4. The microbe must be recovered from an experimentally-infected host

▶ Translation

▼ Diagnosis & Treatment

Diagnosis	Clinical Diagnosis
	Direct microscopic examination
	Culture (培植)
	Antigen / antibody detection
	Nucleic acid amplification and sequencing
	Histopathology (檢測細胞組織)
	Antibiotic susceptibility testing (測試抗生素有效性)

Treatment	Antibiotics (抗生素) Penicillin is the first antibiotics discovered [Amoxicillin belongs to the same class]
	Antivirals (抗病毒藥) Inhibiting the replication of viruses or preventing them from entering host cells.
	Vaccines (疫苗)

▼ Addition: How do antibiotics work against bacterial infections?

1. Inhibition of cell wall synthesis: Antibiotics such as penicillin and cephalosporins interfere with the synthesis of the bacterial cell wall, leading to the weakening and eventual lysis of the bacteria.
2. Inhibition of protein synthesis: Bacterial cells rely on ribosomes to synthesize proteins necessary for their survival. Antibiotics like tetracyclines and macrolides bind to bacterial ribosomes and prevent them from functioning properly, thereby inhibiting protein synthesis and ultimately killing the bacteria.
3. Inhibition of nucleic acid synthesis: Antibiotics such as fluoroquinolones and rifampin interfere with the replication and transcription of bacterial DNA or RNA.
4. Disruption of bacterial metabolism: Some antibiotics, like sulfonamides and trimethoprim, interfere with specific metabolic pathways within bacterial cells. By inhibiting the production of essential metabolites, these antibiotics disrupt bacterial metabolism and prevent their survival.

> 💡 Antibiotics target on specific bacterial processes

▼ Addition: How do antiviral drugs work?

Here are a few examples:

1. ***Oseltamivir (Tamiflu)***: This antiviral medication is commonly used to treat influenza (flu) infections. It works by inhibiting the **neuraminidase enzyme**, which is necessary for the release of new viral particles from infected cells.
2. ***Acyclovir***: Acyclovir is used to treat infections caused by the herpes simplex virus (HSV), including genital herpes, cold sores, and shingles. It works by inhibiting the replication of the virus.
3. ***Ganciclovir***: Ganciclovir is primarily used to treat infections caused by the cytomegalovirus (CMV), which can be particularly dangerous for individuals with weakened immune systems. It works by inhibiting viral DNA synthesis.
4. ***Ribavirin***: Ribavirin is used to treat several viral infections, including respiratory syncytial virus (RSV) infection, hepatitis C, and certain viral hemorrhagic fevers. It works by interfering with viral RNA synthesis.
5. ***Zidovudine (AZT)***: Zidovudine is an antiretroviral drug used in the treatment of HIV infection. It inhibits the reverse transcriptase enzyme, which is necessary for the replication of the virus.

> 💡 Antiviral drugs target on replication of virus.
