CHAPTER 1

Introduction and History of Microbiology

Chapter Outline

- Introduction
- Scientists and their Role (History)

INTRODUCTION

Microbiology

It includes the study of microorganisms like bacteria, viruses, fungi and parasites.

Branches of Microbiology

Medical microbiology: It is the branch of medical science which is related with study of microorganisms and disease produced by them (called infectious diseases) in humans. It includes diagnosis, prevention and treatment of disease and host response against microorganisms and or their products. Various branches of medical microbiology include:

- General microbiology: It includes study on general properties of microorganisms like taxonomy, morphology, physiology, etc.
- Immunology: It deals with the physiological functioning of the immune system in states of both health and diseases.
- Healthcare-associated infection (HAI): It deals with study on diagnosis, treatment and prevention of healthcare-associated infections.
- Systemic microbiology: It includes study on infections to various human body systems like
  - CVS and bloodstream infections
  - Gastrointestinal and hepatobiliary system infections
  - Skin, subcutaneous and musculoskeletal system infections
  - Central nervous system infections
  - Respiratory system infections
  - Urinary system, genital system and sexually transmitted infections
  - Miscellaneous infections like infections to eyes, ears, etc.

Food microbiology: The branch of microbiology that is involved in the study of the microorganisms that inhabit, create, enhance the flavour or contaminate the food.

Industrial microbiology: The branch of microbiology which is applied to create industrial products in mass quantities.

Soil microbiology: The study of microorganisms in soil, their functions and how they affect properties of soil or environment.

Plant microbiology: It is the study of association of plants with microorganisms.

Abiogenesis (Theory of Spontaneous Generation)

In an earliest time, people had believed that living organisms could develop from nonliving things like soil, elements, etc., **called spontaneous generation or abiogenesis.** In later part this theory was challenged by many scientists.

SCIENTISTS AND THEIR ROLE (HISTORY)

Antony Philips van Leeuwenhoek

Birth to death (1632–1723, Fig. 1.1a): He was born in **Delft, Holland**.

(a) Leeuwenhoek (b) Jenner

Fig. 1.1: (a) Antony van Leeuwenhoek and (b) Edward Jenner

Contribution in Microbiology

1. The Dutchman was draper, who 1st prepared the single lens microscope (by own) and observed the diverse materials through it. He observed the minute organisms and other materials in rain water through an instrument (single lens microscope) with 40–300 magnification power and designated them as **animalcules.** He communicated his observation to the Royal Society of London in 1676. However, he did not realize the importance of these **animalcules.** As he worked on inventing different types of microscopes and improving the existing ones. Sure, his work helped to microbiology to achieve new heights because without a microscope, microbiology cannot exist, so he can be **called as father of microscopy.**
2. In 1678, **Robert Koch** developed a compound microscope and confirmed Leeuwenhoek's observation.
3. Almost after a century and after research of many people it was accepted that **animalcules** were the causes of many contagious disease.
4. He observed the *Giardia lamblia* in his own stool in 1681.
5. He defined the shape of bacteria as cocci, bacilli and spirochetes.

Edward Jenner

Birth to death (1749–1823, Fig. 1.1b): He was born in **England.**

Contribution in Microbiology

1. **Smallpox vaccine:** He discovered the prophylactic preparation for smallpox from cow lesion or cowpox. Such prophylactic preparation was labeled as **Vaccine (in Latin cow means Vacca)** by **Pasteur.**
2. **Father of immunology:** He is awarded as **father of immunology** for his contribution in the field of immunology.

Louis Pasteur

Birth to death (27th December 1822–28th September 1895, Fig. 1.2a): He was born in the village Dole, Jura, France on 27th December 1822. His father was a tanner.

Profession: He was trained as chemist, but his studies on fermentation led him to take interest in microorganisms.

(a) Pasteur (b) Lister

Fig. 1.2: (a) Louis Pasteur and (b) Joseph Lister

Contribution in Microbiology

1. **Germ theory of disease (biogenesis) (1857):** He established that putrefaction and fermentation were the result of microorganisms and their activities (Biogenesis).
2. **Disapproved abiogenesis (1860–61):** With series of classical experiments, he proved that all forms of life, even microbes, arouse only from their like and not *de novo* and disapproved abiogenesis.
3. **Contribution in sterilization technique:** He developed the steam sterilizer, hot air oven and autoclave. He invented the pasteurization (1863–65) which is useful for milk sterilization.
4. **Contribution in discovery of Pasteur pipette:** The Pasteur pipette name is given from Louis Pasteur, who used a variant of it extensively during his research. It is used to transfer small quantities of liquids in the laboratory and also to dispense small amounts of liquid medicines like eye drops.
5. **Contribution in cultivation technique:** He showed that growth medium, temperature, acidity, alkalinity and O_2 are required for successful cultivation.
6. **Studies on different diseases:** He identified the Microspora (*Nosema bombycis*) as a causative agent of **pebrine (silkworm disease)** in 1863 in France. He also studied on **anthrax, chicken cholera and hydrophobia (rabies). Pneumococci** were 1st noticed by Pasteur and Stenberg.

Mnemonic

- **Vaccines discovered by Louis Pasture:** CAR → **C**holera, **A**nthrax and **R**abies
- **Causative agents discovered by Robert Koch:** CAT → **C**holera, **A**nthrax and **T**uberculosis

7. **Coined the term vaccine:** Edward Jenner developed the prophylactic preparation for smallpox from cow **(in Latin cow means Vacca)** lesion. Pasteur termed the **word vaccine** for such prophylactic preparation.
8. **Discovery of theory of attenuation and chicken cholera vaccine:** When chicken cholera culture left on the bench for several weeks it lost its pathogenicity, but retains its ability to protect the bird against subsequent infection by it, led the discovery of theory of attenuation and live chicken cholera vaccine.
9. **Discovered live attenuated anthrax vaccine:** He attenuated the *Anthrax bacillus* by incubating at 42–43°C and proved that inoculation of such culture in animals induced specific protection against anthrax. The success of such immunization was dramatically demonstrated by an experiment on a farm at Pouilly-le-Fort in 1881 during which vaccinated sheep, cows and goats were challenged with a virulent *Anthrax bacillus* culture. All the vaccinated animals were survived while simultaneously unvaccinated animals died.
10. **Development of rabies vaccine:** He developed rabies vaccine (hydrophobia in human) in 1885.

Honor

1. **Father of microbiology:** His study on microorganisms leads the development of microbiology and he is awarded as **father of microbiology (medical microbiology, modern microbiology).**
2. **Pasteur Institute, Paris:** It is built in honour of Louis Pasteur in Paris by public contribution. Similar institutes were established in other regions for vaccine preparation and diagnosis of infectious diseases.

Note: Who is the actual father of microbiology, A. Leeuwenhoek or Louis Pasteur? (link: https://www.quora.com/Who-is-the-actual-father-of-microbiology-A-Leeuwenhoek-or-Louis-Pasteur)

Antony van Leeuwenhoek can be considered more specifically as the "Father of Microscopy" because of his contribution as mentioned earlier. But had said that the contribution of Louis Pasteur was far more than A. Leeuwenhoek. He single handedly explored all the fields of Microbiology; right from proving that life arises from a preexisting life to industrial microbiology. His studies and sincere work is what makes microbiology one of the most interesting subjects to study. So, Louis Pasteur can rightly be **called the "Father of Microbiology"**.

Joseph Lister

Birth to death (1827–1912, Fig. 1.2b): He was born in **Scotland.**

Contribution in Microbiology

1. Pasteur's work was immediately followed by Joseph Lister in 1867 with introduction of antiseptic techniques in surgery resulting decreased morbidity and mortality due to surgical sepsis.
2. He 1st used the carbolic acid as an antiseptic agent in surgery (1865).
3. He was awarded as **father of antiseptic surgery.**
4. **Lister Institute, London:** Was built in honour of Joseph Lister in London in 1891. It works for vaccine preparation and diagnosis of infectious diseases.

Robert Koch

Birth to death (11th December 1843–27th May 1910, Fig. 1.3a): He was born in Clausthal village, Hanover, Germany, on 11th December 1843.

Profession: He was German physician and pioneering Microbiologist.

(a) Koch (b) Ehrlich

Fig. 1.3: (a) Robert Koch and (b) Paul Ehrlich

Contribution in Microbiology

1. **Contribution in microscopy:** In 1678, Robert Koch developed a compound microscope and confirmed Leeuwenhoek's observation.
2. **Contribution in staining technique:** He described the staining method for identification of bacteria in dried fixed films stained with aniline dyes.
3. **Contribution in cultivation technique:** Robert Koch invented the culture method for pure isolation of bacteria over solid media. Earliest solid medium was **cooked cut potato** used by him, later he used gelatin for solidification of media, but gelatin is not satisfactory as it has tendency to get liquefy at 24°C and also by proteolytic bacteria. **Use of agar** in solidification of media was suggested by Frau Hesse, the wife of one investigator in Koch's laboratory, who had seen her mother using agar to make jellies.
4. **Hanging drop technique:** He was the 1st to use hanging drop method to detect bacterial motility.
5. **Koch's phenomenon (1890):** Koch observed that a guinea pig already infected with tubercle bacilli gives exaggerated response when injected with tubercle bacilli or tuberculin protein. This hypersensitivity or allergic reaction **called Koch's phenomenon.**

Note: Molecular Koch's postulates

Postulates: Gene presents in microbes should encode for disease production. Gene that satisfies molecular Koch's postulates is often referred as virulence factor. The postulates were formulated by the microbiologist Stanley Falkow in 1988 and are based on Koch's postulates as follow:

- The gene should be associated more with pathogenic species/strains than with nonpathogenic species/strains.
- Specific inactivation of the gene associated with the suspected virulence should lead a loss in pathogenicity or virulence.
- Replacement of the mutated gene should restore pathogenicity or virulence.
- The gene should be expressed at some point during infection or disease process.
- Antibodies or immune cells direct against the gene products should protect the host.

Limitation: For many pathogenic microorganisms, it is not currently possible to apply molecular Koch's postulates, because of lack of suitable animal model for many important human diseases. Additionally, many pathogens cannot be manipulated genetically.

Difference with Koch's original postulates: Instead of the presence or absence of a particular microorganism, they consider whether a particular virulence gene is present and active.

6. **Koch's postulates (1876)**

- **Principles:** Any organism will be accepted as causative agent of disease if it satisfied following four generalized principles called **Koch's postulates**.
  - The organism must be **present** in disease.
  - The organism must be **isolated** from the disease in pure culture.
  - Samples of the organism taken from pure culture must cause the same disease when inoculated into a healthy and susceptible **animal** in the laboratory.

- The organism must be **re-isolated** from the inoculated animal.
- **Additional criterion in Koch's postulates:** Later additional or fifth criterion was added, which is the **detection of antibody (Ab)** from patient's serum.

- **Limitations (clinical applications) of Koch's postulates:** Following bacteria are not satisfying the Koch's postulates.
  - *M. leprae*: Not growing over artificial media.
  - *T. pallidum*: Pathogenic strains are not growing over artificial media, but non-pathogenic can grow.
  - *N. gonorrhoeae*: No animal model.
- **Molecular Koch's postulates:** Follow box.

Honour

1. He was the founder of role of bacteria in production of diseases.
2. He identified the causative agents of cholera (*Vibrio cholerae* in 1883), anthrax (*Bacillus anthracis* in 1876) and tuberculosis (*M tuberculosis* in 1882).
3. Winner of **Nobel Prize** in 1905 and known as **father of Bacteriology.**

Paul Ehrlich

Birth to death (1854–1915, Fig. 1.3b): He was born in Germany.

Profession: He was German scientist.

Contribution in Microbiology

1. He **stained** the cells and tissues to reveal their functions.
2. He reported the **acid fastness of tubercle bacilli.**
3. He introduced the method for **standardization of toxin and antitoxin and** coined the term **minimum lethal dose (MLD).**
4. **Father of chemotherapy:** He used **salvarsan** (an arsenical compound) sometimes called '**magic bullet** 'to kill spirochetes of syphilis with moderate toxic effect. He continued with his experiments till 1912 and discovered **neosalvarsan** and new branch in medicine **called chemotherapy**. Because of his extraordinary activities in medicine he is **called father of chemotherapy.**

Other Important Scientists and their Contribution in the Field of Microbiology

- Hans Christian Gram: A histologist developed the technique to identify the bacteria in tissue in 1884.
- Ziehl and Neelsen: Initially Ehrlich developed the acid fast stain in 1882 and later modified by Ziehl and Neelsen in 1882.
- Ernst Ruska and colleagues: Invented the electron microscope in 1931 for which Ernst Ruska won the Nobel Prize in Physics in 1986.
- Alexander Fleming: He discovered the penicillin from the fungus *Penicillium notatum* in 1928 and got Nobel Prize in 1945.
- von Behring Kitasato: He described antibody.
- Good Pasture: He developed the viral culture method in chick embryo in 1931.
- Kleinberger: He described the cell wall deficient form of bacteria in 1935, while studying the culture of *Streptobacillus moniliformis* in the Lister Institute, London called L-forms after the Lister Institute. He won Nobel Prize in 1941.
- Karry B Mullis: Invented the PCR technique in 1993.

Nobel Prizes

A number of scientists have been awarded with Nobel Prizes for their significant contribution and research work in the field of microbiology and are shown in Table 1.1.

Note: Year in **Table 1.1** indicates the time of Nobel Prize given.

TABLE 1.1: Nobel Laureates

Nobel Laureate	Year	Contribution
Emil A Behring	1901	Developed antitoxin of Diphtheria
Sir Ronald Ross	1902	Studied life cycle of *Plasmodium* in Mosquito
Robert Koch	1905	Invented the *M. tuberculosis*
Charles LA Laveran	1907	Studied the *Plasmodium* in unstained slide of blood
Paul Ehrlich and Elie Metchnikoff	1908	Discovered the selective theory of antibody formation
Charles Richet	1913	Discovered the anaphylaxis
Jules Bordet	1919	Role in complement and CFT
Kleinberger	1941	Defined the L-Forms
Alexander Fleming	1945	Discovered the penicillin from the *P. notatum*
F Enders, FC Robbins, TH Weller	1954	Developed the tissue culture of polio virus
JL Lederberg and EL Tatum	1958	Discovered conjugation theory in bacteria
Sir M Burnet and Sir PB Medawar	1960	Immunological tolerance
Watson and Crick	1960	Discovered the double helix DNA structure
Peyton Rous	1966	Searched viral oncogenesis
Holley, Khurana and Nirenberg	1968	Invented the genetic model
BS Blumberg	1976	Discovered the HBsAg
Barbara Mc Clintoch	1983	Discovered the transposon
George Kohler	1984	Discovered the hybridoma technique for mononclonal antibodies production
Stanley B Prusiner	1997	Discovered Prions
J Robin Warren and Barry J Marshal	2005	Discovered the *H. pylori* and its role in peptic ulcer
Luc Montagnier and F Barre Sinoussi	2008	Discovery of HIV

(*Contd…*)

TABLE 1.1: Nobel Laureates (*Contd…*)		
Nobel Laureate	**Year**	**Contribution**
Bruce A Beutler and Jules A Hoffmann	2011	Discovery of the theory of innate immunity
Ralph M Steinman	2011	Searched dendritic cell and its role in adaptive immunity
Sir John B Gurdon and Shin-ya Yamanaka	2012	Mature cell can be reprogrammed to become pluripotent

Common Name of the Microorganisms from the Name of Scientists

Follow Table 1.2.

TABLE 1.2: Common name of the microorganisms from the name of scientists		
Scientists	**Common name**	**Scientific name**
Victor Morax and Theodor Axenfeld	Morax-Axenfeld bacillus	*Moraxella lacunata*
Klebs and Loeffler	Klebs-Loeffler Bacillus (KLB)	*Corynebacterium diphtheriae*
Preisz and Nocard	Preisz-Nocard Bacillus	*Corynebacterium pseudotuberculosis*
Arthur Nicolair	Nicolaier's bacillus	*Clostridium tetani*
Robert Koch	Koch's bacillus	*Mycobacterium tuberculosis*
Heinrich A Johne	Johne's bacillus	*Mycobacterium paratuberculosis*
Gerard HA Hansen	Hansen's bacillus	*Mycobacterium leprae*
George Hoyt Whipple	Whipple's bacillus	*Trophyrema whipplei*
Carl Friedlander	Friedlander's bacillus	*Klebsiella pneumoniae*
Abel Rudolf	Abel's bacillus	*K. pneumoniae* subsp. *ozaenae*
Anton Von Frisch	Frisch's bacillus	*K. pneumoniae* subsp. *rhinoscleromatis*
Gaffky and Eberth	Gaffky-Eberth bacillus	*Salmonella* Typhi
Alexander Yersin	Yersin bacillus (plague bacillus)	*Yersinia pestis*
Whitmore	Whitmore's bacillus	*Burkholderia pseudomallei*
Pfeiffer	Pfeiffer's bacillus	*Haemophilus influenzae*
Koch and Weeks	Koch Weeks bacillus	*Haemophilus aegypticus*
Jules Bordet and Octave Gengou	Bordet–Gengou bacillus	*Bordetella pertussis*
Albert Doderlein	Doderlein's bacillus	*Lactobacillus acidophilus*
Eaton	Eaton agent	*Mycoplasma pneumoniae*

Scientific Name of the Microorganisms from the Name of Scientists

Follow Table 1.3.

TABLE 1.3: Scientific name of the microorganisms from the name of scientists	
Scientists	**Scientific name**
Bacteria	
Shiga and Flexner	*Shigella flexneri*
Shiga and Boyd	*Shigella boydii*
Shiga and Sonne	*Shigella sonnei*
Amedee Borrel and Bergdorfer	*Borrelia burgdorferi*
Cox and Burnet	*Coxiella burnetii*
Parasites	
Leishman and Donovan	*Leishmania donovani*
Wucherer and Bancroft	*Wuchereria bancrofti*

Special Honor to Scientists

- Father of Microscopy: Antony van Leeuwenhoek.
- Father of Microbiology (Medical Microbiology, Modern Microbiology): Louis Pasteur.
- Father of Immunology: Edward Jenner.
- Father of Antiseptic Surgery: Joseph Lister.
- Father of Bacteriology: Robert Koch.
- Father of Virology: WM Stanely.
- Father of Tumor Virology: Peyton Rous.
- Father of Mycology: Raymond Jacques Sabouraud.
- Father of Chemotherapy: Paul Ehrlich.

Causative Agents of Infectious Diseases, Methods of Detection and their Role in Health and Diseases

These include bacteria, viruses, fungi and parasites. Their detection methods and their role in health and diseases are described in respective chapter.

ACCESS YOURSELF

Short Notes

1. Robert Koch.
2. Louis Pasteur.

Short Questions for Theory/Viva Questions

1. What are Koch's postulates?
2. What are molecular Koch's postulates?
3. Name the bacteria which are not satisfying the criteria of Koch's postulates.
4. Write the common name for following bacteria.
   - *C. diphtheriae*
   - *M. tuberculosis*
   - *S.* Typhi
   - *L. acidophilus*
5. Name the following.
   - Father of microbiology
   - Father of immunology
   - Father of antiseptic surgery
   - Father of bacteriology

Comments on

1. *Mycobacterium leprae* is not satisfying the Koch's postulates.

MCQs for Chapter Review

Antony Philips Van Leeuwenhoek

1. Antony Van Leeuwenhoek is associated with:
a. Telescope
b. Microscope
c. Stains
d. Immunization

Louis Pasteur

2. Louis Pasteur is not associated with:
a. Introduction of complex media
b. Discovery of rabies vaccine
c. Discovery of *M. tuberculosis*
d. Discovery of spontaneous generation theory

3. Louis Pasteur is associated with:
a. Discovery of the bacillus of tuberculosis
b. The cellular concept of immunity
c. Introduction of anthrax vaccine
d. Discovery of penicillin

4. Vaccine of rabies was first discovered by:
a. Louis Pasteur
b. Robert Koch
c. Edward Jener
d. Landsteiner

5. Pasteur developed vaccine for:
a. Anthrax
b. Rabies
c. Chicken cholera
d. All of the above

Robert Koch

6. Microorganism that does not obey Koch's postulates:
a. *M. tuberculosis*
b. Polio virus
c. *M. leprae*
d. *Streptococcus*

7. *Vibrio cholerae* was discovered by:
a. Koch
b. Metchnikoff
c. John Snow
d. Virchow

Other Important Scientists and their Contribution in the Field of Microbiology

8. Electronic microscope was invented by:
a. Ruska
b. Robert Koch
c. Antony van Leeuvenhock
d. Louis Pasteur

9. Egg inoculation technique for cultivation of viruses was first reported by:
a. Louis Pasteur
b. Ellermann and Bang
c. Good Pasteur
d. Lord Lister

Common Name of the Microorganisms from the Name of Scientists

10. *C. diphtheriae* is also called as:
a. Klebs-Loeffler Bacilli (KLB)
b. Roux bacilli
c. Koch's bacilli
d. Yersin bacilli

11. Which of the following is called Preisz-Nocard bacillus?
a. *C. diphtheriae*
b. *C. pseudotuberculosis*
c. *M. tuberculosis*
d. *Mycoplasma*

12. Eaton agent is:
a. *Chlamydia*
b. *Mycoplasma pneumoniae*
c. *Klebsiella*
d. *H. influenzae*

Answers and Explanation of MCQs

1. b
- Follow section, **Antony Philips van Leeuwenhoek** for explanation.

2. a and c
- *M tuberculosis* was discovered by Robert Koch.
- Follow section, **Louis Pasteur** for explanation of other options.

3. c
4. a
5. d
} Follow section, **Louis Pasteur** for explanation.

6. c
- Follow section, **Robert Koch (limitation of Koch's postulates)** for explanation.

7. a
- **Robert Koch** discovered the causative agent of **C**holera, **A**nthrax and **T**uberculosis (**Mnemonic** CAT).

8. a
- Ernst Ruska and colleagues: Invented the electron microscope in 1931 for which Ernst Ruska won the Nobel Prize in Physics in 1986.

9. c
- Good Pasture developed the viral culture method in chick embryo in 1931.

10. a
- *C. diphtheriae* was 1st identified by **Klebs** in 1883 but 1st cultivated by **Loeffler** in 1884 hence commonly **called Klebs-Loeffler Bacillus (KLB).**
- Emile Roux contributed in the discovery of diphtheria toxin along with Alexander Yersin.
- Koch's bacilli is the common name given to *Mycobaterium tuberculosis* from the name of Robert Koch.
- Alexander Yersin who discovered the bacilli along with Kitasato in 1894 from Hong Kong at the beginning of last epidemic, from his contribution genus **called *Yersinia*;** however Yersin bacilli word is not used for all species of genus, but only for *Yersinia pestis* which also **called plague bacillus.**

11. b
12. b
} Follow **Table 1.2** for explanation.

CHAPTER 2

Taxonomy of Microorganisms

Chapter Outline

- Definition and Components

DEFINITION AND COMPONENTS

Definition

Taxonomy is defined as description, identification, nomenclature and ordered classification of organisms according to their presumed natural relationships.

Components

Taxonomy includes following three components:

A. Classification/orderly arrangements.

B. Identification of unknown with known unit.

C. Nomenclature/naming of unit (bacteria).

A. Classification/orderly arrangements

Five kingdom system of classification: In 1969, RH Whittaker placed all organisms in five groups **called five kingdom system of classification.**

1. **Monera:** Prokaryote and unicellular, e.g., bacteria, blue green algae and archaebacteria.
2. **Protista:** Eukaryote and unicellular, e.g., protozoa
3. **Fungi:** Eukaryote and uni- or multicellular, e.g., fungi
4. **Plantae:** Eukaryote and multicellular, e.g., plants
5. **Animalia:** Eukaryote and multicellular, e.g., metazoa (helminths/worms), birds, animals, human, reptiles, arthropod, molluscs and coelenterates.

Modification of five kingdoms system of classification: It is modified by Margulis and Schwartz, which includes two kingdoms like **Prokaryotes and Eukaryotes** as shown in **Table 2.1** with differences.

General scheme of classification: Kingdom → Phylum (Division) → Class → Order → Family (Tribe) → Genus → Species (Specific Epithet) → Subspecies (Strain/type).

Phylogenetic classification: This hierarchical classification represents a branching tree like arrangement based on evolutionary arrangement of species.

Adsonian classification: It based on all features expressed at the time of study.

Molecular or genetic classification: Based on genetic relatedness.

Abbreviation of species: Species word is common for both singular and plural form, but abbreviation may be used as sp., and spp., for singular and plural forms, respectively.

Intraspecies classification: It is useful for epidemiological purposes. It classifies species/unit up to subspecies/strain/type by using following methods.

- **Biotypes:** Based on biochemical properties.
- **Serotypes:** Based on serological properties.
- **Bacteriophage types:** Based on susceptibility to Bacteriophage.
- **Colicin types:** Based on production of bacteriocin.

B. Identification of unknown with known unit

It is done by using morphological, biochemical, genetic and other properties.

C. Nomenclature/naming of unit/species of bacteria

- **Order:** It is labeled with suffix **"ales".**
- **Family:** It is labeled with suffix **"aceae".**
- **Genus name:** It is the Latin noun and starts with capital letter. Scientific name includes genus and epithet/species with Italic pattern.
- **Species/epithet name:** It starts with small letter and in Italic pattern irrespective of person or place name. It based on different properties of unit like
  - *albus* meaning white.
  - *suis* meaning pig origin.
  - *pyogenes* meaning pus.
  - *welchii* meaning person who discovered it.
  - *tetani* meaning disease produced.
  - *australis* meaning place of origin.

TABLE 2.1: Differences between prokaryotes and eukaryotes

Features	Prokaryotes	Eukaryotes
General features		
Meaning	Pro = primitive/immature + Karyotes = nucleus (contains immature nucleus)	Eu = true/mature + Karyotes = nucleus (contains immature nucleus)
Organism's examples	Monera (bacteria, blue green algae)	Protista, fungi, plantae and animalia
Evolutionary ancient	Yes	No
Anatomy		
Number(s) of cell	Unicellular	Uni- and multicellular
Nucleus		
• Nuclear membrane	–	+
• Nucleolus	–	+
• Chromosome	Single-circular	Multiple-linear
Cytoplasm		
• Ribosomes	+ 70S	+ 80S
• Plasmid, episomes, transposon	+	–
• Golgi complex	–	+
• Endoplasmic reticulum	–	+
• Triglyceride fats	–	+
• Mitochondria and lysosomes	–	+
Physiology		
Site of respiration	Mesosome/chondroid (It is the invagination or infolding of cytoplasmic membrane contains respiratory enzymes)	Mitochondria
Reproduction	Mostly by asexual method (binary fission)	By asexual method (budding) and/or sexual method (meiosis or mitosis)
Pinocytosis	–	+
Protoplasmic streaming	–	+
Biochemistry		
Plasma membrane		
• Sterol	– (Except in *Mycoplasma* and *Ureaplasma*)	+ (like cholesterol, ergosterol, etc.)
• Phospholipid	+	+
Cell wall		
• Muramic acid/peptidoglycan	+	–
• Diaminopimelic acid	Present in few GNB in pentapeptide bridge	Absent
• Others	Lipid and protein	Chitin, mannan, cellulose (green plants)

– (Absent), + (Present)

Notes:

Ancient: Prokaryotes are evolutionary ancient. Probably they are 1st organisms to evolve and eukaryotes evolving from prokaryotes like predecessors.

Viruses: Viruses are neither classified as prokaryotes nor eukaryotes.

Phospholipid: Present in both.

ACCESS YOURSELF

Short Notes

1. Differences between prokaryotes and eukaryotes.

Short Questions for Theory/Viva Questions

1. What is protista?

MCQs for Chapter Review

Components (Classification/Orderly Arrangements)

1. Prokaryotes are:
a. Bacteria
b. *Mycoplasma*
c. Fungi
d. Blue green algae
e. Protozoa

2. Which is an eukaryote?
a. *Mycoplasma*
b. Bacteria
c. Fungus
d. *Chlamydia*

3. Fungi are:
a. Prokaryotes
b. Eukaryotes
c. Plants
d. Animals

4. Site of respiration in prokaryote is:
a. Mitochondria
b. Mesosome
c. Endoplasmic reticulum
d. All of above

5. **Mesosomes are:**
   a. Respiratory enzymes in bacteria
   b. Cytoplasmic membrane invaginations
   c. Destructive bodies
   d. Protein-forming bodies
6. **Prokaryotes are characterized by:**
   a. Absence of nuclear membrane
   b. Presence of microvilli on its surface
   c. Presence of smooth endoplasmic reticulum
   d. All of above
7. **Which of the following is protista?**
   a. Algae b. Fungi
   c. Protozoa d. Bacteria
8. **Which of the following is/are bacterial taxonomy?**
   a. *Chlamydia* b. *Rickettsia*
   c. *Mycoplasma* d. Prion
   e. Bacteriophage
9. **True about bacteria:**
   a. Mitochondria always absent
   b. Sterols always present in cell wall
   c. Divide by binary fission
   d. Can be seen only under electron microscope
10. **Eukaryotes are different in causing infection because:**
    a. Divide by binary fission
    b. Highly structure cell with organized cell organelles
    c. Do not have all organelles
    d. Evolutionary ancient

1. **a, b, d**
2. **c**
3. **b**
4. **b**
5. **a, b**
6. **a**
7. **c**
   - Follow section, **classification/orderly arrangements (five kingdom system of classification and Table 2.1)** for explanation of answers of MCQs 1–7.
8. **a, b and c**
   - *Chlamydia. Rickettsia* and *Mycoplasma* are bacteria**.** Prion is proteinaceous infectious virus like-particle without nucleic acid. Bacteriophage is a virus which eats bacteria.
9. **a and c**
   - Mitochondria always absent in bacteria and respiration is possible by presence of mesosome/chondroid. Sterol is not present in all bacteria but only in *Mycoplasma*. and *Ureaplasma.* Bacteria divide by binary fission and can be seen under all types of microscopy.
10. **b**
    - Eukaryotes are divided by meiosis or mitosis. Eukaryotes have highly structured cell with all organelles. Prokaryotes are evolutionary ancients (**Table 2.1**).

CHAPTER 3

Epidemiology of Infections

Chapter Outline

- Definitions and Types of Infections
- Reservoirs, Sources and Modes of Transmission

DEFINITIONS AND TYPES OF INFECTIONS

Definitions

Infestation

- The lodgment and multiplication of infectious agents on the body surfaces or on the cloths of a host constitute infestation
- It is the lodgment and multiplication over the surfaces but no entry in body.

Contamination

- Only presence of infectious agents on surface or inside the body or inanimate object like fluid, food, clothes or soil but no multiplication
- It is the lodgment over surfaces or entry in body but no multiplication.
- Example: Bacteremia means entry of bacteria in blood and no multiplication (only detectable bacteria in blood).

Infection

- The entry and multiplication of infectious agents in the body of a host constitute infection
- It is the entry in body and multiplication but no sign-symptoms.
- Example: **Bacteremia** means entry of bacteria in blood (transient presence) and no multiplication.
- Infection is an interaction between microbes and host.

Infectious disease

- The entry, multiplication and production of clinical sign-symptoms **called infectious disease**
- It is the entry in body, multiplication and sign and symptoms.
- Examples:
  1. Septicemia: Means entry of bacteria in blood, multiplication and clinical sign-symptoms
  2. Toxemia: Means entry of bacteria in blood, multiplication and clinical sign-symptoms are due to toxin production. It is one type of septicemia.
  3. Pyemia: Septicemia and abscess in organs like liver, spleen and other tissues.

Contagious disease: A disease that can be transmitted from one host to another by direct contact.

Communicable disease: A disease that can be transmitted from one host to another either direct or indirect mode of transmission.

Non-communicable disease: A disease that is not transmitted from one host to another.

Types of Infections

A. According to habitat/involvement of systems

Following systemic infections are described in details in respective chapters.

1. Cardio vascular system infections
2. Bloodstream infections
3. Lymphatic system infections
4. Gastrointestinal tract infections
5. Infections of abdominal viscera
6. Skin and subcutaneous tissues infections
7. Musculoskeletal infections
8. Central nervous system infections
9. Respiratory tract infections
10. Urinary tract infections (UTIs)
11. Genital tract infection
12. Eye and ear infections
13. Oral cavity, dental, periodontal and salivary gland infections.

B. According to causative agents

1. Bacterial infection
2. Viral infection
3. Fungal infection
4. Parasitic infection

5. Mixed infection: It means more than one organisms cause infection simultaneously. Following are examples:
   - Gas gangrene: **Ch. 55**
   - Fournier gangrene: **Ch. 39**
6. Co-infection or symbiotic infection: Concomitant infection by combination of microbes called co-infection. Following are examples:
   - Vincent's angina or fusospirochetosis: **Ch. 73.**
   - Adeno Associated Virus (AAV) and adeno virus: Exact infection by AAV is not known but it always required adenovirus as a helper virus to produce the infection.
   - HDV and HBV: **Ch. 88.**

C. According to nature of onset and progress

1. Acute infection: Infection characterized by sudden onset, rapid progression and often with severe symptoms.
2. Chronic infection: Infection characterized by gradual onset and slow progression.

D. According to sequence of involvement of host

1. Primary infection: Initial infection in a host by organisms.
2. Re-infection: Subsequent infection in a same host by same organisms.
3. Opportunistic infection: Infection in an immuno-deficient host by organisms.

E. According to sites/locations

1. Local or focal infection (focal sepsis): Infection that is restricted to a specific location within the body of the host.
2. Systemic or generalized infection: Infection that has been spread to several organs or areas in the body of the host.

F. According to sources of infection

1. If source is human body itself or outer source

- **Endogenous infection:** Organisms are originated from host itself. These are mostly normal flora from different parts of body. For example meningitis by *N. meningitidis* from nasopharynx.
- **Exogenous infection:** Organisms are originated from outside, mostly from environment, soil, water, human, etc.

2. If source is hospital itself or outer source

- **Nosocomial (hospital-acquired or healthcare associated) infection: Ch. 29.**
- **Community acquired infection:** Infection originated from outside the hospital environment.
- **Iatrogenic (physician induced) infection:** Infection acquired by patients from physician during diagnosis, treatment or prevention of disease.

3. If source is animal/animal products, human body or non-living objects

- **Anthroponoses/cross infections:** It means entry of infection from one human host to another human host. Word derived from anthrópos (Greek) means man and nosos (Greek) means disease. Examples include rubella, smallpox, diphtheria, gonorrhea, ringworm (*Trichophyton rubrum*), and trichomoniasis.
- **Anthropozoonoses/zoonotic infections/zoonotic diseases/zoonosis:** It means infection of human from animal or animal products. Word derived from anthrópos (Greek) means man, zoon means animal and nosos (Greek) means disease. For examples and more details follow **Ch. 47.**
- **Zooanthroponoses/reverse zoonosis:** This word is abandoned and not of much significance. It means infection of animal from human. Following are examples:
  - Tuberculosis: Both zoonotic and reverse zoonotic, with birds, cows, elephants, meerkats, mongooses, monkeys, and pigs known to have been affected.
  - Leishmaniasis: Both zoonotic and reverse zoonotic.
  - Influenza, measles, pneumonia and other pathogens are reverse zoonotic for many type of primates.
- **Sapronoses:** It means entry of infection from abiotic/nonliving substrate like soil, water, decaying plants, or animal corpses, excreta, and others. Word derived from sapros (Greek) means decaying and nosos (Greek) means disease. Following are examples:
  - Dimorphic fungi like coccidioido-mycosis and histoplasmosis
  - Monomorphic fungi like aspergillosis and cryptococcosis
  - Certain superficial mycoses like *Microsporum gypseum*, some bacterial diseases like legionellosis, and protozoan like primary amoebic meningo-encephalitis.

G. According to clinical presentation

1. **Overt infection:** Presence of clinical features of disease.
2. **Inapparent/subclinical infection:** Clinical features (C/Fs) are not apparent. It includes inapparent, missed or abortive cases. It can be detected by laboratory tests.
3. **Atypical infection:** Infection in which the typical clinical manifestation of disease are not present.
4. **Relapse:** It is the primary infection with on-off features. Following are examples:
   - Relapsing fever: It is caused by bacteria from *Borrelia* spp. Sudden onset of fever (bacteria are in blood) which lasts for 3–5 days followed by afebrile period (bacteria are in brain). After afebrile period of 3–5 days another bout of fever will occurs.
   - Relapses in malaria: In the initial infection patient feels fever during erythrocytic phase and another episode of fever during exo-erythocytic phase in case of *P. vivax*, *P. malariae* and *P. ovale*, but in *P. falciparum* there is no exo-erythocytic phase, so there is no relapse or subsequent attack of fever.

5. **Latent (recrudescence):** Following primary infection parasites remain in the body in silent/latent form for a very long period and again proliferating and producing the clinical disease in a later part of life when the host resistance is lowered or by specific stimulation called latent infection. For example zoster/zona/shingles by varicella zoster virus (VZV).

H. Epidemiological types

1. **Sporadic:** It means scattered about. Few cases occur irregularly, haphazardly from time to time and separated widely in space neither identifiable common sources of infection nor connected with each other. It is a starting point of epidemic when conditions are favorable for spread of infection.
2. **Endemic disease:** 'En' means in and 'demos' mean people. It defined as constant presence of a disease within a given geographic area or population group without importation from outside.
3. **Epidemic disease:** Epi means upon and demos mean people. It defined as sudden onset of disease clearly in excess of "expected occurrence."
4. **Outbreak:** Small, usually localized epidemic in the interest of minimising public alarm, unless the numbers of cases are indeed large.
5. **Pandemic:** Epidemic that spreads in many areas of the world and affecting large population.
6. **Prosodemic diseases:** Some pandemic disease (like water or air borne) spread very rapidly while some spread very slowly by person to person contact called prosodemic diseases, e.g., cerebrospinal fever.
7. **Exotic:** Disease is imported in to country in which, it do not occur otherwise.

RESERVOIRS, SOURCES AND MODES OF TRANSMISSION

Reservoirs of Infections

Definition: Persons, animals, insects, plants or inanimate objects like water, soil, etc., (or combination of all these) in which infectious agents can live, multiply and pass to susceptible host called reservoirs of infections. It includes survival, multiplication and transmission of organism.

Types of reservoirs: Reservoirs for different agents are described in respective chapters. Few are described below in two different categories.

A. According to living or non living objects which act as reservoirs

- **Living reservoirs: (1) Human reservoir:** It includes human case or carrier. For example *M. tuberculosis* (tuberculosis), *S.* Typhi (typhoid), *V. cholerae* (cholera), *B. recurrentis* (louse borne relapsing fever), *N. gonorrhoeae* (gonorrhea), *Cl tetani* (tetanus, it also has non living reservoir), *T. pallidum* (syphilis), measles, etc., **(2) Animal reservoir:** It includes zoonotic disease. For example *M. bovis* (bovine tuberculosis), rabies, yellow fever, swine flu, bird flu, etc.
- **Nonliving reservoirs:** Soil and inanimate matter can also act as reservoir. For example soil is reservoir for *Cl. tetani* (tetanus), *B. anthracis* (anthrax), *C. immitis* (coccidioido-mycosis), agents causing mycetoma, etc.

B. Other types: (1) Homologous reservoir: It means reservoir and susceptible host are from same species. For example *V. cholerae* where reservoir is man and susceptible host is man. **(2) Heterologous reservoir:** It means reservoir and susceptible host are from different species. For example, typhoid where reservoir is man, and susceptible host is bird/animal.

> **Note: Multiple reservoirs**
> *Cl. tetani* (tetanus): Human and soil reservoirs.
> *E. coli:* Human and animal reservoirs.

Sources of Infections

Definition: Persons, animals, insects, plants or inanimate objects like water or soil (or combination of all these) from which infectious agents can pass to susceptible host. It includes survival and transmission only but no multiplication.

Confusion with reservoir of infection: Sometimes it seems that reservoir and source of infection are synonyms but in fact both are different. For example;

- **Hookworm:** Reservoir of infection is man but source of infection is soil.
- **Tetanus:** Reservoir of infection and source of infection are soil.

Types of sources: Sources for different agents are described in respective chapters. Following are types (also reservoir).

A. Humans: Human is the commonest source of infections. Human may be case (patient) or carrier.

1. **Case (patient):** It is a person who harbors the pathogens with sign-symptoms of disease and serves as potential source of infection for others.
2. **Carrier:** It is a person who harbors the pathogens without any sign-symptoms of disease and serves as potential source of infection for others. Following are different types of carrier:
   - **According to clinical status: (1) Healthy carrier:** It harbors the pathogens but never suffered from the disease, e.g., polio, meningococcal meningitis, cholera, diphtheria, etc. **(2) Convalescent carrier:** It is a carrier who recovered from the disease and continue to harbors the pathogens in his body, e.g., typhoid fever, bacillary and amoebic dysentery, cholera, diphtheria, etc. **(3) Incubatory carrier:** It sheds pathogens during the incubation period of infection, e.g., measles, mumps, HBV, polio, pertussis, etc.
   - **According to duration: (1) Temporary carrier:** Carrier state lasts for <6 months, e.g., it may be healthy or convalescent or incubatory carrier. **(2) Chronic carrier:** Carrier state lasts for several

years or may for rest of life, e.g., typhoid fever, HBV, gonorrhea, etc.

- **According to portal of exit:** (1) Urinary, e.g., typhoid fever. (2) Intestinal (fecal), e.g., typhoid fever. (3) Respiratory, e.g., Influenza. (4) Nasal, e.g., Influenza. (5) Skin eruption, open wound and blood are also carriers.
- **Other types of carrier: (1) Contact carrier:** Person who acquires the pathogen from carrier. **(2) Paradoxical carrier:** Carrier who acquires pathogen from another carrier.

B. Animals and birds: These may act as case or carrier. Infectious diseases transmitted from animals to humans are called zoonoses. **(1) Cattle:** Anthrax, brucellosis and bovine tuberculosis. **(2) Goats:** Brucellosis. **(3) Sheeps:** Anthrax. **(4) Dogs:** Rabies and hydatid disease. **(5) Horses:** Glanders. **(6) Rats:** Rat bite fever, Weil's disease and plague. **(7) Pigs:** Swine flu. **(8) Birds:** Bird flu and ornithosis (psittacosis from parrot).

C. Insects: Diseases transmitted by insects are called arthropod-borne disease and that insects are called vectors. They may also act as sources of infections.

D. Soil: Spores of tetanus bacilli, fungi (*Histoplasma capsulatum*), *Nocardia asteroids*, larvae of round worm and hookworm are found on soil.

E. Water: *Vibrio cholerae*, infective hepatitis viruses (HAV) are found in water.

F. Food: Food may contain either preformed toxin of microorganisms (like *Staphylococcus aureus, B. cereus, Salmonella* species, *Cl. botulinum*, *Cl. perfrigenes*, etc.,) causing food poisoning or preexisting infectious agents (like beef tape worm in beef, pork tape worm in pork, etc.,) causing disease.

Modes of Transmission of Infections

Two categories modes of transmission of infections are as follows:

A. Direct transmission: Here mediators/vehicles for transmission of infections are not required.

1. **Droplet infections:** Droplet nuclei/particles of saliva or nasopharyngeal secretions arise during coughing, sneezing, speaking, talking or invasive procedures (bronchoscopy) are entering in to other host directly who is in close contact. Such particles are 5 µm in diameter and spread to short distance (<3 feet) can directly enter in other host. However, such larger particles can be filtered by nose. Particles 5 µm in diameter traverse to long distance and produce the air borne (indirect) infection described later in this chapter. Infection by droplet nuclei is increased in close contact, overcrowding and lack of ventilation. **Bacteria** transmitted by droplet nuclei are *Strept. pyogenes, N. meningitidis, C. diphtheriae, H. influenzae* type b, *B. pertussis, Y. pestis* and *M. pneumoniae.* **Viruses** transmitted by droplet nuclei are influenza virus, rubella virus, mumps virus, adeno virus and parvo virus B19.
2. **Infections by inoculation/injection under skin or mucosa:** Such infections are transmitted by contaminated needles or syringes like, HBV, HCV, HIV, etc., mainly in healthcare workers.
3. **Infections by contact with skin/mucosa:** Following are examples:
   - Sexually transmitted infections/diseases (STIs or STDs): **Ch. 44.**
   - Direct skin-to-skin contact transmits diseases like scabies, fungal and viral infections such as HHV-1 and 2 (HSV-1 and 2, respectively), HHV-3 (VZV) pox virus, molluscum contagiosum, etc.
4. **Infections by contact with soil**
   - **Bacteria**
     - *Cl. tetani* spores are present on soil and deposition of such soil on wounded skin allows the transmission.
     - *Bacillus anthracis* spores are present in soil and in dead animal products. Animal acquired the infection by ingestion of spores present in soil, but human infection direct from soil spore is query. Human infection of anthrax occurs from animal products.
   - **Parasites:** Infection occurs by walking with bare foot on contaminated soil like in *Ancyclostoma duodenale* and *Strongyloides stercoralis.*
5. **Vertical infections:** Follow **Table 3.1**.

B. Indirect transmission: Here mediators/vehicles for transmission of infections are required.

1. **Inhalation (air-borne) infections:** Particles arise during coughing, sneezing, talking or invasive procedure from patients, which are ≤5 µm in diameter and traverse to long distance can produce the air borne infection. Some droplet nuclei settle over different objects and become part of dust and cause air borne infections. **Bacterium** transmitted by air-borne route is *M. tuberculosis* (open/active pulmonary tuberculosis). **Viruses** transmitted by air borne route are measles virus, VZV, influenza virus and hemorrhagic fever viruses with pneumonia. Spores of many systemic (dimorphic) **fungi** are present in soil and they are transmitted to man by air like *Histoplasma capsulatum, Coccidioides immitis, Blastomyces dermatitidis* and *Paracoccidioides brasiliensis.*
2. **Ingestion (food- and water-borne) infections:** Like *E. coli*, *V. cholerae*, *Salmonella* spp., hepatitis A and E, poliovirus, *Rotavirus*, etc.
3. **Vector-borne infections:** For more details follow **Ch. 47.**
4. **Blood-borne infections:** By transfusion of blood or blood products following organisms are transmitted:
   - **Bacteria:** *T. pallidum.*
   - **Viruses:** HHV-4 (EBV), HHV-5 (CMV), HHV-8 (KSHV), HBV, HCV, HDV, HGV (GB/G Baker virus

TABLE 3.1: Vertical infections

Time	Infections
Antenatal/before birth/congenital/ transplacental/ teratogenic Commonly called TORCH agents	• T: Toxoplasmosis (***T****oxoplasma gondii*) • O: **O**thers – Congenital listeriosis (*Listeria monocytogenes*) – Congenital syphilis (*Treponema pallidum*) – Zika virus – Parvo virus B19 – Chikungunya virus – Malaria in pregnancy (*Plasmodium falciparum*) – Congenital trypanosomiasis (*Trypanosoma cruzi*) • **R:** Congenital rubella syndrome (**R**ubella virus) • **C:** Congenital cytomegalovirus infection (**C**MV) • **H:** – **H**erpesviruses like (1) congenital herpes simples (HSV) (2) Fetal varicella syndrome and congenital/ neonatal varicella by VZV – **H**BV – **H**IV-AIDS
Intranatal/during birth (transcervical)	Candidiasis, gonorrhea (ophthalmia neonatorum), listeriosis (neonatal listeriosis), *Strept. agalactiae* (neonatal meningitis), HSV, CMV and HPV
Postnatal/after birth by breast feeding	• Tuberculosis • CMV • HIV

C) HTLV-I, HTLV-II, HTLV-III (HIV), parvo virus B19, zika virus, etc.

- **Parasites:** *Trypanosoma cruzi*, *Leishmania donovani*, *Plasmodium* spp., *Babesia* spp., *Toxoplasma gondii*, etc.

5. **Saliva-borne infections:** Many microbes are present in saliva of humans and animals, which are deposited in tissues following bites. Following are the different examples of saliva borne infections:
   - **From human saliva (human bites): Viruses** transmitted by human saliva are HHV-4 (EBV), HHV-6 (HBLV), HHV-7 (RK virus), ECHO virus, mumps virus, etc. **Aerobic bacteria** transmitted by human bites are *Streptococcus, Staphylococcus* and *Eikenella corrodens.* **Anaerobic bacteria** transmitted by human bites are anaerobic streptococci, *Fusobacterium* and *Prevotella.* Bites by children rarely get infected while bites from adults get infected in 15–20% cases. Human bites carry aerobes (44%) and anaerobes (55%).
   - **From monkey bites:** Herpes virus simiae or B virus.
   - **From dog bites:** Like rabies virus.
   - **From cat bites:** Like *Bartonella henselae.*
   - **Both by dog and cat bites:** *Pasteurella multocida.*
   - **From rat bites (rat bite fever):** Like *Streptobacillus moniliformis* and *Spirillum minus.*
6. **Fomites-borne infections:** Contamination of fomites like towels, handkerchiefs, pens, pencils, clothes, cups, spoons, keys, etc., may transmit the infections like eye disease (trachoma), ear infection, diphtheria, dysentery, hepatitis A, etc.
7. **Infections by unclean hands and fingers:** It may transmit the infections like dysentery, trachoma, etc.

ACCESS YOURSELF

Essay/Full Question

1. Describe the epidemiological basis of common infectious diseases.

Short Notes

1. Congenital infections.

Short Questions for Theory/Viva Questions

1. Define infestation and infection.
2. What are contact carrier and paradoxical carrier?
3. Define case and carrier.
4. What are TORCH agents?

MCQs for Chapter Review

Definitions and Types

1. **Septicemia is:**
   a. Bacteria in blood
   b. Toxin in blood
   c. Pus in blood
   d. Multiplication of bacteria and toxin in blood

Reservoirs, Sources and Modes of Transmission

2. **Which of the following does not have non human reservoir**
   a. *Salmonella* Typhi
   b. *N. gonorrhoeae*
   c. *E. coli*
   d. *Clostridium tetani*
   e. *Treponema pallidum*
3. **Man is the only reservoir of:**
   a. Rabies b. Measles
   c. Typhoid d. Japanese encephalitis
4. **Which of the following is not transmitted by soil?**
   a. Coccidioidomycosis b. Tetanus
   c. *Brucella* d. Anthrax
5. **Vertically transmitted disease caused by all *except*:**
   a. *Toxoplasma* b. CMV
   c. HIV d. *Treponema pertenue*
6. **Which of the followings are transmitted by blood?**
   a. *Toxoplasma* b. Syphilis
   c. CMV d. Hepatitis B and C
   e. Hepatitis A
7. **All of the following infections may be transmitted via blood transfusion *except*:**
   a. Parvo B-19 b. Dengue virus
   c. CMV d. Hepatitis G virus

8. Most common agents responsible for human bite infections are:

a. Gram-negative bacilli

b. Gram-positive bacilli

c. Sporochetes

d. Anaerobic streptococci

Answers and Explanation of MCQs

1. d

- Multiplication of bacteria and toxin in blood **called toxemia**, which is one type septicemia.

2. c

3. b, c

- Follow section, **reservoirs of infection** for explanation of answers of MCQs 2–3. Also follow respective chapters for more explanation.

4. c and d

- Spores of coccidioidomycosis are present in soil and transmitted by air borne route. Follow section, **modes of transmission [indirect → inhalation (air borne)]** for more explanation.
- Option b and d: Follow section, **modes of transmission (direct → contact with soil)** for explanation.
- No role of soil transmission of brucella.

5. d

- Follow section, **Table 3.1 and respective chapters** for more explanation.

6. a, b, c, d

7. b

- Follow section, **modes of transmission (indirect → blood borne)** for explanation of answers of MCQs 6–7.

8. d

- Follow section, **modes of transmission (indirect → saliva borne)** for explanation.