DIPLOMA IN REGISTERED NURSING

eLearning Training Program

Course Title: MICROBIOLOGY (MCB 018)

Writer(s): Nyongi C.J.M.

Reviewer(s): SAMUEL CHINTINGIZA JAMES MENSA, SAKWIMBA L AND POMBOLOKA J.C;

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ABBREVIATIONS AND ACRONYMS

CCSD-Central Sterile Supplies Department

MCB- Microbiology

IP- Infection prevention

TB- Tuberculosis

KLB- Klebs Loeffler Bacilli

BCG- Bacillus Camille Guren

DNA- Deoxyribonucleic acid

RNA – Ribonucleic acid

CPE – Cytopathic effect

ZN – Ziehl Nelson

AAFB- Acid Alcohol Fast Bacilli

TEM- Transmission Electron Microscope

SPM – Scanning Probe Microscope

CMV – Cytomegalovirus

KS _Kaposis Sarcoma

HLD – High Level Disinfection

ELISA – Enzyme Linked Immunoabsorbent assay

EPI – Expanded Programme of Immunisation

COURSE INTRODUCTION

Microbiology comprises and integrates the fields of immunology, bacteriology, virology, mycology and parasitology, each of which has seen considerable independent development. The common bond between all these courses under microbiology is the focus on the causes of infectious diseases and on the reaction of the body or the host to the pathogens. Although the advent of antibiotics and vaccines has certainly taken the dread out of many infectious diseases, the threat of infection is still a fact of life; new pathogens are constantly being discovered; strains of some known microorganisms have developed resistance to antibiotics, making therapy more and more difficult; incurable infectious diseases like HIV/AIDS, EBOLA, RABIES are still with us.

Microbiology is also a dynamic discipline with rapid developments as will be seen in its history. It includes fundamental principles and clinical applications. Nowadays, we still live to a ripe old age despite hostile attacks by myriads of pathogenic organisms. These invaders include viruses, bacteria, protozoa or even larger parasites. In addition, we develop immune responses against our own proteins (and other molecules) in autoimmunity and against our own abnormal cells in immunity.

Our first line of defence against foreign organisms is barrier tissues such as the skin that stop the entry of organisms into our bodies. If, however, these barrier layers are penetrated, the body contains cells that respond rapidly to the presence of the invader. These cells include macrophages and neutrophils that engulf foreign organisms and kill them without the need for antibodies. Immediate challenge also comes from soluble molecules that deprive the invading organism of essential nutrients (such as iron) and from certain molecules that are found on the surfaces of epithelia, in secretions (such as tears and saliva) and in the blood stream.

The objective of this course is to instill a broad base knowledge of the etiological microorganism that cause disease; how the body responds to this invasion by pathogenic microorganism and be able to prevent disease in your working environment. This knowledge is a necessary prerequisite for the diagnosis, treatment and prevention of infectious diseases.

This module will therefore explain the origin of microbiology, types of pathogenic microorganisms, infection and body defence mechanisms, means of sterilisation and disinfection then the immunity of an individual.

COURSE OBJECTIVES

Welcome to this course on Microbiology in Nursing. As a healthcare professional, nurses are required to have the knowledge of microbiology in order to provide quality care to clients and patients. The objective of learning microbiology is to enable you acquire l a broad based knowledge of the organisms that cause diseases and the infections that develop as a result. .
This knowledge is a necessary prerequisite for the diagnosis, therapy, and prevention of infectious diseases.

By the end of this course, you should be able to:

1. Describe the characteristics of various microorganisms.
2. Outline the factors that promote growth and development of microorganisms.
3. Explain the host microbial interactions in the human body.
4. Describe laboratory procedures for identifying and examining microorganisms.
5. Interpret various laboratory findings.
6. Apply the principles of microbiology in infection prevention

STRUCTURE OF THE COURSE AND DURATION

This course has five (5) main units based on the objectives stated above as follows:

Unit 1: Introduction to Microbiology

In this unit, you will define terms used in microbiology, outline the history of microbiology and explain the importance of microbiology in nursing. This unit is very important as you will come across terminologies that are commonly used internationally and specifically in the Laboratory Department. You will also know the names of great scientists who made great discoveries which have helped the world understand the range of organisms that are not visible to our naked eyes. In Fundamentals of Nursing, you will learn about role of the nurse as a member of the Health Team and in the case of microbiology you be able to acquire knowledge on the importance of microbiology. Knowledge of micro-organisms will

help you know how to care for patients suffering from particular diseases and also participate in community prevention activities that are aimedat eliminating community diseases.

Unit 2: Types of Microorganisms

This unit discusses different types of microorganisms. It will provide you with an understanding of different types of microorganisms, their classifications, shapes and growth factors. By understanding how micro-organisms are classified, as a nurse you will understand how particular infections come to be and which micro-organism is responsible

Unit 3: Microscopic Examination

This unit will provide you with valuable technical information and knowledge on different types of microscopes and microscopic examination of different microorganisms and preparation of different specimens/samples. This information is very important as it will facilitate your understanding of the next unit which is collection and examination of specimens.

Unit 4: Collection and Examination of Specimens

This unit describes different types of specimens used in microbiology, cultivation and identification of microorganisms, microbial susceptibility to antimicrobial agents and then concludes by outlining the serological examinations done in microbiology. Thisunit further looks at how bacteria grow and what environment is conducive for their growth.

Unit 5: Infection and Defence Mechanisms (immunity)

In this unit, you will gain essential knowledge about sources of infections such as mode of entry, transmission and body's reaction to infection. This unit will further provide you with an understanding of the immune system and how the body responds and defends itself against infection using the immune system.

Course Duration

This course will y take you a minimum of thirty five (35 hours) for theory and twenty (20 hours) practical. You will need to spend time on studying the course content, visiting any institutional hospital laboratory, doing self-help questions and assessment tasks. Set aside time for doing this everyday.

Activities, self-help questions and case studies

You will find activities, self-help questions and case studies in this course. These are part of a planned e-learning program. They are intended to help you make your learning more active and effective, as you process and apply what you read. They will help you to engage with ideas and check your own understanding. It is vital that you take the time to complete them in the order that they occur in the course. Make sure you write full answers to the activities or take notes of the discussions.

Further readings

There is a list of Further Readings at the end of this Course. This includes books and articles referred to in the course and are suggestions in case you wish to explore topics further. You are encouraged to read as widely as possible during and after the course, but you are not expected to read all the books on this list. Although there is no set requirement, you should aim to do some follow-up reading to get alternative viewpoints and approaches.

There no guidelines on how the course will be assessed

UNIT 1: INTRODUCTION TO MICROBIOLOGY

1.1 Unit Introduction

Welcome to our first unit on Introduction to Microbiology. In the course overview given at the beginning of this unit, we indicated that a clear understanding of microbiology will create a good foundation for you to articulate terminologies and concepts used in microbiology. This unit is intended to assist you understand terms used in microbiology, history of microbiology and importance of microbiology in nursing.

Let us start by reviewing our objectives for this unit.

1.2 Unit Objectives

By the end of this unit, you should be able to:

1. Define terminologies used in microbiology
2. Outline the history of microbiology
3. Explain the importance of microbiology in nursing

1.3 Definition of terminologies used in microbiology

There are quite a number of terms used in microbiology. But before we look at them, let us start by defining microbiology.

- **MICRO**----------: Small or minute
- **BIO----------** Life
- **LOGY**---------- Study

From the meaning of these three words, we can see that microbiology is the study of small living organisms. It can also be defined as the scientific study of minute living organisms which include bacteria, viruses, fungi and yeasts.

Now that we know the meaning of microbiology, let us look at the meaning of the other terms:

Microbiology: This is the scientific study of minute living organisms which include bacteria, viruses, fungi and yeasts. Microbiology is also a science that studies micro-organisms and their effects on humans and animals.

Micro- organism (microbe): A microscopic cell or a very small living organism.

Microscopic: This term refers to organisms that are extremely small, visible only with the aid of a microscope.

Dark ground microscopy: This is a method of microscopy which allows unstained microorganisms to be seen.

Pathology: This is the branch of medical science that studies the causes, nature and effects of diseases.

Pathogenic: A disease causing organism.

Infection: The successful invasion and multiplication of pathogenic organisms either on the body surface or in the body systems.

Pathogen: A pathogen is a microbe that has the ability to cause host tissue injury. The host damage can be as a result of direct microbial activity or arise from the host immune response. This definition encompasses classical pathogens and opportunistic pathogens.

Pathogenesis: Pathogenesis is the mechanism involved in the development of a disease.

Pathogenicity: Pathogenicity is the ability of an organism to cause disease.

Virulence: This is defined as the level or degree of pathogenicity. Thus, a pathogen has greater virulence if its capacity to cause host damage is high.

Parasite: This is an organism living upon or within another living organism deriving benefits as well as causing harm to the host. The term also can refer to an animal or plant or microorganism which depends on another living animal or plant to provide some or all necessities for its life process.

Ecto parasite: This term refers to a parasite which lives on the surface of its host e.g. a flea or lice.

Endo parasite: This term refers to a parasite which lives inside its host e.g. malaria parasite or worms.

Bacteriology: This is a branch of microbiology which deals with the scientific study of bacteria or branch of medical science that studies bacteria in relation to disease.

Virology: Virology is a branch of microbiology which deals with the scientific study of viruses or branch of medical science that studies viruses and viral diseases.

Mycology: This is a branch of microbiology which is concerned with the scientific study of fungi or branch of botany that studies fungi and fungus-causing diseases.

Protozoology: The branch of microbiology concerned with the scientific study of protozoa.

Haematology: The science dealing with the formation, composition, functions and diseases of the blood. The branch of science concerned with the study of blood, blood-forming tissues and the disorders associated with them

Oncology: The branch of medicine that deals with the scientific study of tumours.

Attenuated strain: A strain of micro-organism which has diminished virulence or which is weakened.

Autoclave: A device in which objects are sterilized by steam under pressure.

Carrier: A person who, though not suffering obviously from a particular disease, continues to harbour and to excrete the causative organisms which may be passed on to others.

Chemotherapeutic agent: This term refers to a synthetic substance which has a destructive action against microorganisms and which is used to treat infection.

Fermentation: This term refers to the incomplete splitting of sugar by microorganisms to provide energy for their growth which yields alcohol, acids and gases.

Genus: This term refers to a group of animals or plants which though not identical, have many characteristics in common.

Gram stain: This term refers to a method of bacteriological staining which divides bacteria into gram-positive and gram-negative types. The gram reaction depends on the nature of the bacteria cell wall.

Host: The animal or tissue on which a parasite lives and multiplies.

Interferon: A substance released by cells infected with viruses which renders other cells resistant to viral infection.

Infection: A state in which the body or part of it is invaded by a pathogenic organism which under favourable conditions, multiplies and produces effects which are harmful or injurious to the host cells.

Macrophage: A large white blood cell which has the ability to ingest (phagocytose) bacteria and other particles found in chronic inflammation.

Antibody A specific substance (a type of protein produced by plasma cells) found in the blood that is formed in response to an antigen.

Antigen: A substance that stimulates the production of antibody or reacts with them when introduced in the body.

Antitoxin: An antibody which can specifically neutralize a particular toxin.

Toxin: Poisonous substance released by certain organisms which has damaging action on the tissues

Asepsis: Free from germs or from infection

Antiseptic: It is a chemical agent which prevents the growth of micro-organisms, particularly on body surfaces and endothelial linings.

Bacteriocide: It is an agent that kills/destroys bacteria.

Acid fast bacillus: It is an organism which when stained will resist decolorization by acids. e.g Mycobacterium tuberculosis

Aerobe (aerobic organism): It is a micro-organism which can only live or thrive (grow) in the presence of oxygen.

Anaerobe (anaerobic organism): It is a microorganism which can only live or thrive in the absence of oxygen.

Facultative anaerobe: It is a microorganism which can grow under both anaerobic and aerobic conditions.

Commensals (normal flora): These are harmless organisms in their normal sites but capable of causing disease when transmitted to an abnormal site e.g. Escherichia coli (Escoli) are the harmless resident of the gut which can cause infection in the wound or urinary tract.

Medium: The mixture of substances in or on which bacteria are grown or cultivated in the laboratory

Micro aerophilic: Bacteria which grow best in the presence of a low concentration of oxygen i.e. less than that found in the air.

Micron: A unit of measurement of length equals $1/1000^{th}$ of a millimetre.

Motile: Able to move under its own power.

Mutation: The spontaneous, random change which sometimes occurs in the genetic constitution of an organism.

Immunity: The body's ability to resist invading organisms or to resist infection.

Saprophyte: It is a micro-organism which is able to live without parasitizing an animal or plant.

Septicaemia: This is the presence of bacteria and their toxins in the blood stream.

Sepsis: Infection of the body by bacteria or presence of pathogenic micro-organism in the body.

Species: A group of micro—organisms or plants or animals which have common characteristics

Spore: A structure produced by some species of bacteria which is very resistant to adverse conditions e.g. heating or drying which could kill the average bacterium. The spore is also able to survive the adverse conditions and to germinate once conditions are favourable.

We have come to the end of this sub-unit and hope you enjoyed it. In this section we have covered the definition of many, but not all, important terms used in microbiology. You will find these terms used in the various units of this course so it is important to learn them well. Thank you for your active participation. In the next section we shall look at the history of microbiology. Attempt a self assessment to evaluate yourself. You will only refer to the course content under this unit only after you are done with the Self assessment test.

Your next activity is a self-assessment test; this will enable you to assess yourself on how well you have understood the content. Write the self assessment test in your note book. Good luck and now get started.

Self Assessment Test

Multiple Choice Questions

1. A broad branch of biomedical science under medicine that covers the study of all aspects of the immune system in all organisms is known as:

A. Bacteriology
B. Immunology
C. Histology
D. Virology

2. .....is the microscopic cell which is a very small living organism

A. Microrganism
B. Algae
C. Flies
D. Larva

3. .....ability of the organism to cause disease.

A. Virulence
B. Lethal
C. Pathogenicity
D. Bacteraemia

4. .....ability for the organism to move under or using its power

A. Motile
B. Mobile
C. Mitochondria
D. protozoa

Matching Items:

Match the following terms in Column I with their definitions in Column II.

Column I **Column II**

Terms	**Definitions**
1. Septicaemia:	A. These are harmless organisms in their normal sites but capable of causing disease when transmitted to an abnormal site e.g. Escherichia coli (Ecoli) are the harmless resident of the gut which can cause infection in the wound or urinary tract.

2. Microbiology	B. A pathogen is a microbe that has the ability to cause host tissue injury. The host damage can be as a result of direct microbial activity or arise from the host immune response. This definition encompasses classical pathogens and opportunistic pathogens.
3. Saprophyte:	C. This is the scientific study of minute living organisms which include bacteria, viruses, fungi and yeasts. Microbiology is also the science that studies micro-organisms and their effects on humans and animals.
4. Commensals (normal flora)	D. This is the presence of bacteria and their toxins in the blood stream.
5. Pathogen	E. It is a micro-organism which is able to live without parasitizing an animal or plant.

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Well done, now you need to move on to your next topic. In your next topic, you will be looking at History of Microbiology. This topic will assist you to learn people who made valuable discoveries and inventions in microbiology. Read carefully and understand the content.

1.4 History of Microbiology

We have covered the definition of terms used in microbiology. We shall now discuss the history of microbiology. By the end of this section, you are expected to outline the history of microbiology.

Microbiology has had a long, rich history. It initially focused on the causes of infectious diseases but now covers practical applications of the science. Microbiology has developed over a period of years. The notable periods start from 1500 AD to the year 1900 AD to the present time. . The events were happening simultaneously in different countries. Many individuals have made significant contributions to the development of microbiology. The following are the notable ones:

Antonius Van Leeuwenhoek - (1676)

(A Dutch [draper] merchant who lived from 1632-1723)

He was the first to invent a primitive microscope. It consisted of a single magnifying lens held in a flame but he was able to see objects which he called animalcules in rain water from pools, scrapings (tartar) from teeth and in faeces.

He noted that some were actively moving, and described stick like shapes and spirals after that. The microscope raised a lot of media arguments to the scientists as to whether the animalcules were produced spontaneously (spontaneous generation) which means creation of living from non-living. People believed that mice, maggots and micro-organisms arose spontaneously from nowhere. The argument resulted in experiments which often gave conflicting results. Until his death in 1723, van Leeuwenhoek revealed the microscopic world to scientists of the day and is regarded as one of the first to provide accurate descriptions of protozoa, fungi, and bacteria.

Francesco who lived from 1626-1697.

Through his experiments he discovered that maggots were not spontaneously formed in decomposed meat but that larvae were the maggots which came from the flies.

Lazzare Spallanzani-1776

He was an Italian priest and the first person to cultivate bacteria in a sterilized media with and without air. He also demonstrated that heating (boiling) meat for a sufficient length of time and then seal the cooking utensil would not contain bacteria.

His experiments excluded air from heated organic materials. By this time, it was becoming clear that air is the common source of microorganism. The theory of spontaneous generation was finally thrown out and the idea of boiling as a means of sterilization was generally accepted.

Edward Jenner- 1798

He introduced the cowpox vaccine/vaccination

Fracastoro (An Italian physician)-1546

He first suggested that infection is the same for who received and who has given the infection (like other known living things animalcules arose from others like them).

Infection is caused by minute insensible particles and is spread by means of them. He also introduced the idea of contagium vivum.

Semmelewes-1847

A Viennese obstetrician, he noted that puerperal fever was transmitted from one patient to another through hands of attendants. He showed that infection could be reduced by hand washing in between patients using chlorinated lime as an antiseptic. This discovery made the foundation stone of modern antiseptic techniques being used in hospitals.

John Snow-1854

John Snow was a scientist in London who demonstrated that cholera was transmitted through drinking contaminated water.

Loius Pasteur- (1822-1895)

Pasteur was a French chemist from France who demonstrated that the microscopic organism called yeast caused the fermentation of sugar and starch into alcohol and that the presence of bacteria was spoiling the wine.

He also investigated a silk worm disease which was damaging the silk industry. He developed methods of culture and showed that micro-organisms cause diseases, and this led to the Germ theory of disease.

He further developed vaccines for cholera, anthrax and rabies. He also introduced/invented pasteurization. This is a method of sterilization by heat where milk is heated at a very high temperature and then cooled rapidly.

Robert Koch- (1843-1910)

He was a German doctor (physician) and his first investigation was into the case of anthrax, (he isolated anthrax bacteria). He developed the bacteriological techniques which form the basis of modern diagnostic bacteriology e.g. use of dyes to colour bacteria and so make them more easily visible under the microscope.

He produced the first satisfactory solid media from blood agar for growth of bacteria. This enabled cultures of a single strain of bacterium to be obtained more readily. He also noted that organisms grew in clusters called colonies which were visible to naked eyes. He discovered the bacterial causes of many diseases including Tuberculosis in 1882 (isolated and described the Tubercle bacilli in 1882-TB/Koch's disease)

He also discovered the substance tuberculin in the colonies of TB bacilli which when injected in the body; it causes antigen-antibody reaction. He defined a system for attributing an organism as the cause of a specific disease.

Koch propounded his famous postulates which are that: a bacterium should always be found in association with its own particular disease

It should be isolated in pure growth from that disease and that; if then given to a suitable animal should reproduce the disease from which it was isolated.

Klebs and Fredrick Loeffler- (1852-1920)

A German bacteriologist who with Klebs isolated the Diphtheria Bacilli which they named after themselves as ***Klebs Loeffler Bacilli*** **(KLB)**

In 1888, they discovered that symptoms of diphtheria were not caused directly by bacteria but by a substance known as toxin produced by the bacteria, carried in the blood stream and able to produce tissue damage.

Emil Vanbehring -(1854-1917)

He discovered Diphtheria antitoxin in 1890. He showed that diphtheria could be prevented and cured by the administration of serum from the horse convalescent from diphtheria. This was the discovery of antitoxins.

Jenner -1749 -1823

The microbiologist was well known around the world for his innovative contribution to immunisation and ultimate eradication of small pox. This made the foundation for immunology. He discovered vaccination against small pox.

Theillers-1927

He was a microbiologist who used chicken eggs to culture the yellow fever virus and won the Nobel Peace Prize in 1951. He discovered the vaccine for yellow fever.

Salk and Sabin

They discovered the vaccine for poliomyelitis.

From the presentation of the scientists who made significant contributions to the study of micro-biology, we note that the progress in the study of microbiology became extremely rapid in the latter part of the 19^{th} century. The following years saw much of the knowledge confirmed. Scientists investigated the detailed structure and physiology of bacteria, the ways in which animals become immune to infectious diseases, and latter it became possible to cultivate and examine viruses.

Other advances are the advent and development of substances which kill bacteria in the tissues and so cure many infections, antibiotics and chemotherapy.

Antibiotic- is a substance produced by a micro-organism which, in high dilution, kills or inhibits the growth of other micro-organisms.

Chemotherapeutical agents - are substances which have similar effect, but which are synthesized or made in the laboratory. Examples of chemotherapeutical agents are *sulphonimides*. The first was *sulphanilamide*, the active compound of *prontosil* shown by Domagk in Germany in 1935. The best known antibiotic, penicillin was discovered by Alexander Fleming in 1929. This was further developed by Florey and Chain in Oxford in 1940. Penicillin is produced by the mould *penicillium notatum.* It was called the *magical-bullet* which cured anything at that time.

Other Microbiologists

KIYOSHI SHIGA- (1870-1959)

He discovered the dysentery bacilli known as ***shingella shiga***

Albert Neisser- (1855-1916)

He discovered the gonococco organism which causes ***Gonorrhoea***, It was named after him and called it ***Neisseria Gonorrhoea***

Edward Klein- (1844-1925)

He identified streptococcus as the cause of scarlet fever.

Angus Von Wasserman- (1866-1925)

He introduced the first use for diagnosis of syphilis which is known as Wassermann's Reaction

Leon Calmette - (1863-1933)

Together with **Camille Guren**, they introduced a BCG vaccine (Bacillus Camille Guren) against tuberculosis.

William Welchi- (1850-1935)

He discovered and described the organism that causes **GAS GANGRENE as *Clostridium Welchi***

Sir William Alexander Flemming -(1891 1955)

A British bacteriologist who in 1929 discovered the antibiotic penicillin

Prince Charles Chamberland- (1857-1908)

He discovered an instrument called an Autoclave used in the sterilization of surgical instruments.

We have now come to the end of this section on the most important scientists who made major contributions to the field of microbiology. We hope you found it very interesting to find out the different scientists who made valuable discoveries to enhance humanity and health. You have a self-assessment test to evaluate yourself. Pick your note book and answer this self-test.

Self Assessment Test

Multiple Choice Questions

1. _____ was a German Physician and Nobel Prize winner in Physiology of Medicine, he became famous for isolating bacilllus anthracis in 1877, the tuberculosis bacillus in 1882 and vibrio cholerae in 1883 and later developed the Koch's postulates:

A. Heinrich Hermann Robert Koch
B. Alexandar Flemming
C. Joseph Lister
D. Louis Pasteur

2. Which one of the following was the father of microbiology?

A. Dr John snow
B. Dr koch
C. Dr lister
D. Antonius Van Leeuwenhoek

3. Which of the following is not one of Koch's postulates?

A. The organism is regularly found in lesions of the disease
B. The organism can be isolated from diseased tissues in pure culture on artificial media
C. Inoculation of this pure culture produces a similar disease in experimental animals
D. Treatment of the disease with a broad spectrum oral antimicrobial dependably eradicates the organism and cures the disease

Match the following scientists in Column I with their discoveries in Column II.

Scientist	**Discovery**
1. Lazzare Spallanzani-1776	A. A French chemist from France demonstrated that microscopic organism yeast caused the fermentation

	of sugar and starch into alcohol and that the presence of the bacteria was spoiling the wine
2. Loius Pasteur (1822-1895)	B. He was an Italian priest; he was the first to cultivate bacteria in a sterilized media with and without air. He also demonstrated that heating (boiling) meat for a sufficient length of time and then sealed would not contain bacteria.
3. Edward Jenner-1796	C. He was the first to invent a primitive microscope. It consisted of a single magnifying lens held in a flame but he was able to see objects which he called animalcules in rain water from pools, scrapings (tartar) from teeth and in faeces.
4. Antonius Van Leeuwenhoek (1676)	D. Introduced cowpox vaccine/vaccination

Well done and congratulations, that was a very good try. We have come to the end of this sub-unit and hope you enjoyed it. We discussed the history of microbiology and hope that now you know the people who have greatly contributed to the development of modern medicine such as those who discovered penicillin's and polio vaccine. Thank you for your active participation.

In the next sub-unit, we shall discuss the importance of microbiology in nursing

1.5 Importance of microbiology in nursing

We have discussed the history of microbiology. We will discuss the importance of microbiology in nursing. By the end of this section, you are expected to explain why it is important for a nurse to study microbiology.

The following are some of the reasons why you as a nurse should study microbiology:

I. It helps the nurse understand and apply the underlying principles in the prevention and control of infection.
II. It helps the nurse to understand how normal flora contribute to the health of an individual, as well as how they can cause disease
III. The nurse needs to know the different organisms that cause diseases in man and their modes of transmission.
IV. As a nurse, you will be allowed by law to prescribe certain drugs, including antibiotics. Studying microbiology, therefore, helps the nurse to make scientific decisions when prescribing treatment for infections.
V. Microbiology helps the nurse to know how to render and keep certain instruments aseptic in order to prevent cross infection
VI. Studying microbiology also helps the nurse to recognise the signs and symptoms of infection.

Self Test

Write this question in your note book.

Explain three (3) reasons why microbiology is important in nursing?

1.6 Unit Summary

We have now come to the end of unit 1, well done. Let us now review what you have learnt. In this section we started by discussing the meaning of key terminologies used in microbiology such as microorganism, pathogen, pathogenesis, anaerobes, host and many more terms. We also discussed the history of microbiology in which you saw how microbiology has evolved from ancient to modern science. This unit has ended with the discussion to explain why microbiology is important in nursing. The next Unit two (2), will discuss the types of microorganisms.

1.6 References

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UNIT 2: TYPES OF MICROORGANISMS AND THEIR EXAMINATION

2.1 Introduction

Once more, well done for successfully completing unit I in which we discussed the key terms used in microbiology, the history of microbiology and its importance in nursing. Welcome to unit II in which we shall discuss the types of microorganisms. Kindly read the unit objectives and understand your objectives well. A **microorganism** or **microbe** is any organism too small to be viewed by the unaided eye and is unicellular (single –celled), such as bacteria or some fungus are microorganisms live in all parts of the biosphere where there is liquid water, including Earth's crust. However, pathogenic microbes are harmful, since they invade and grow within other organisms, causing diseases that kill people. Microorganism can be cultured in a media in the laboratory and be seen with the aid of a microscope.

2.2 Unit Objectives

By the end of this unit, you should be able to:

1. Describe different types of microorganisms
2. Explain in detail the different morphology or shape of types of microorganisms
3. Describe the various growth requirements of microorganisms
4. Outline the main properties that distinguish viruses from other living microorganism.

You are beginning to read and study a unit where you will find the names of the different types of microorganisms, strange, difficult to grasp and understand. I want to encourage you to take your time as you read through this content, learn all these new names and apply them to the various infections and diseases that they cause. Learn also to consult other books for microbiology as you read through the content.

2.3 Types of Micro-Organisms

Micro-organisms are classified into two broader groups:

1. Non-pathogenic micro-organisms which are normal, do not produce disease and are beneficial to human beings

2. Pathogenic micro-organism which cause disease

However, there are other types of micro-organisms which may be non-pathogenic in one part of the body but become pathogen in another. The best example is e-Coli. e-Coli is very harmless in the gastrointestinal tract but if introduced in the urinary tract, they cause infection.

Micro-organisms can further be sub-divided into two groups: Those that require Oxygen and are called Aerobic and those which do not require oxygen and are referred to as Anaerobic

List of family groups of micro-organisms

Micro-organisms are classified into six (6) classes namely:

1. Bacteria
2. Protozoa
3. Fungi
4. Rickettsiae
5. Viruses
6. Helminths or worms

Activity

Do this activity in your note book.

Make a list of (10) microorganisms that you know and the infections they cause.

Good try, now go through the following content, read carefully and understand the different types of microorganisms and the respective infections and diseases they cause.

Bacteria

A bacterium is a minute unicellular organism only seen by the use of a microscope. *Bacteria* are simple, cellular organisms lacking a nucleus as well as other characteristics of procaryotes which distinguish them from organisms that have nucleated cells.

Each bacterium is a complete and independent unit of life.

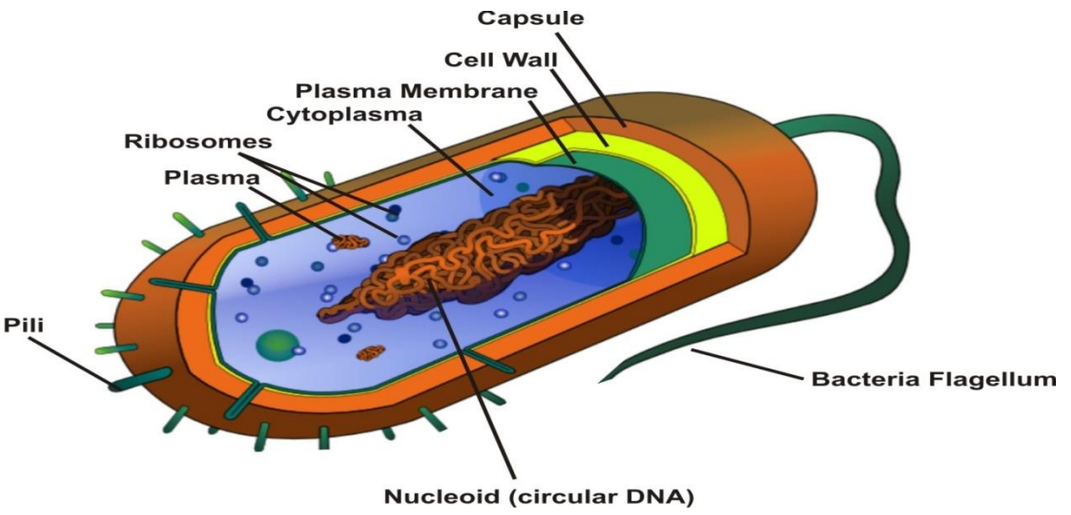

Figure 1: Structure of Bacteria

Source: Wikipedia-bacteria; www/hppt, Wikipedia.com

Bacteria are cells with a rigid cell wall which surrounds the protoplasm. This consists of cell membrane enclosing internal exponents (supporter) and structures. These structures are:

- Cell wall
- Cell membrane
- Nucleoplasm:
- Ribosomes
- Inclusion Granules

Let us now look at these structures in some detail:

a. Cell Wall

It is rigid and surrounds the protoplasm. Cell wall protects against osmotic pressure. It is porous and permeable to substance of low molecular weight. In Gram staining, it's either positive or negative depending on the types of proteins.

b. Cell Membrane

It is a double layer structure comprising lipids and proteins which act as semi-permeable membrane for uptake of nutrients through passive or active diffusion.

c. **Nucleoplasm*:*** It is a single circular chromosome which contain the bacterial DNA
d. **Ribosomes:** These are formed by invagination of the cytoplasmic membrane of the cell membrane.
e. **Inclusion Granules***:* They are mainly fat globules for storage of energy. These structures described above are found in all bacteria.

Outside the cell wall the following structures are seen in some species:

a. **Flagella:** These are hair like processes which propel bacteria. They are organs of locomotion (movement)

b. **Fimbriae:** These are shorter filament protruding from the cell membrane. They are responsible for adhesion and for conjugation when the genes are transferred from one bacterium to another.

c. **Capsule:** They are amorphous (irregular) material which surround many bacterial species on their outer most layer and are usually polysaccharides occasionally protein. They often inhibit phagocytic, so their presence correlates with virulence.

d. **Spores:** Some organisms contain spores. A spore is a thick cell wall with many layers surrounding the micro-organism especially the nuclear material. It protects against adverse environmental conditions which threaten the bacteria. It can either be terminal (situated at the end) or sub terminal.

Now that you have successfully read and understood the content above, find below a diagram illustrating the general structure of a bacterium. This diagram shows the different parts of a bacterium that you have already covered above.

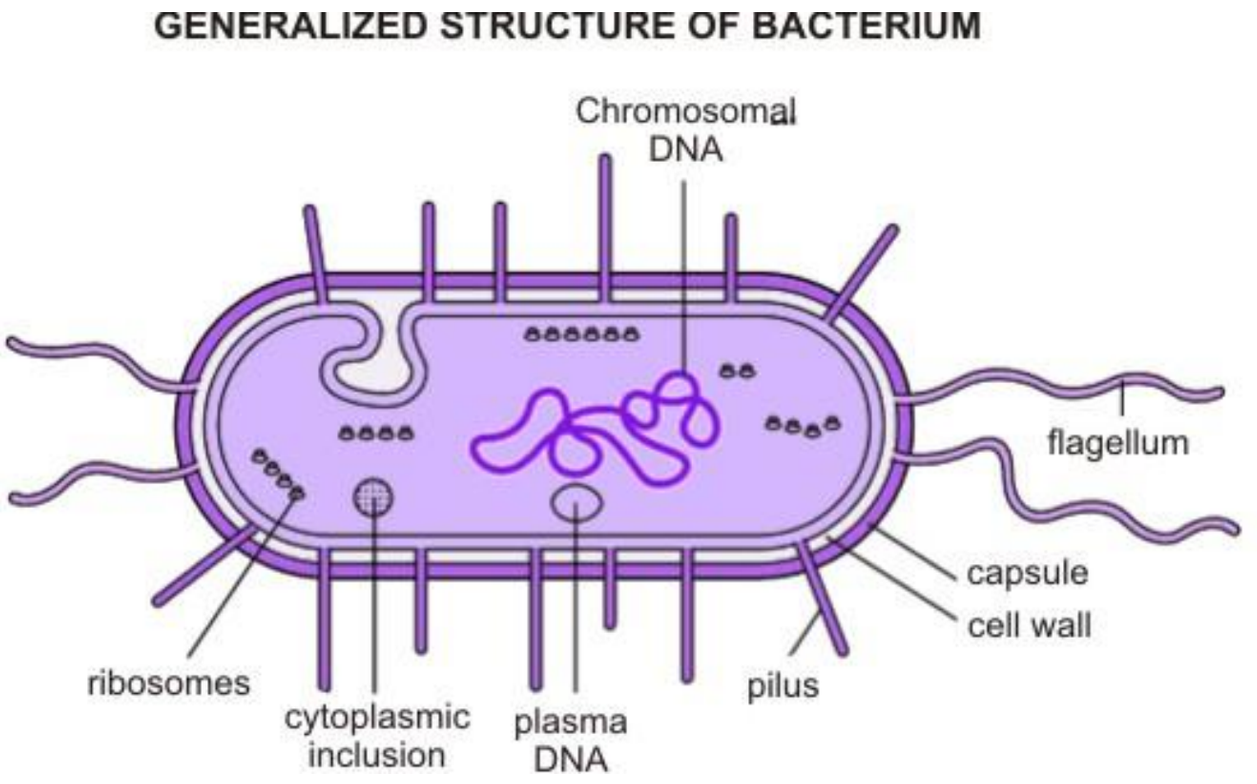

Figure 2 : Generalized Structure of Bacterium

Classification of Bacteria

A. **According to Morphology or Shape**

Find below a diagram illustrating bacterial morphology. It is important for you to know that this is a generalised illustration showing the different morphology and shapes of microorganisms**.**

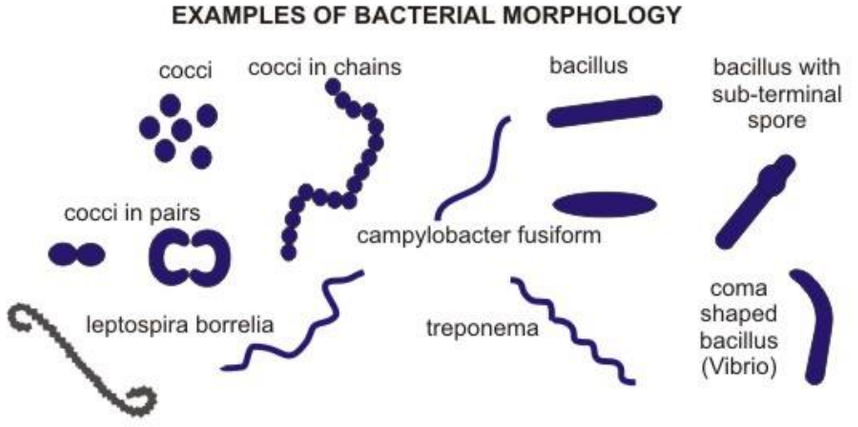

Figure 3: Generalized Structures of Bacterium and Morphology

When we classify bacteria by shape, they can be grouped into one of the following shapes:

- **Spherical or oval** are also referred to as Cocci and examples are Staphylococci, Streptococci and Diploccuci.
- **Bacilli** are rode shaped and **can** either be single, in pairs or chains. They may have flagella and form spores
- **Spiral shaped** bacteria are larger and longer. Organisms with spirals which are uniform and are flexible and elongated are called ***spirochetes,*** for example,. treponema pallidum which causes syphilis.

You have successfully read about bacterial shapes and morphology, now you need to look at bacterial classification according to oxygen requirements. The diagram below is illustrating the different bacterial classifications

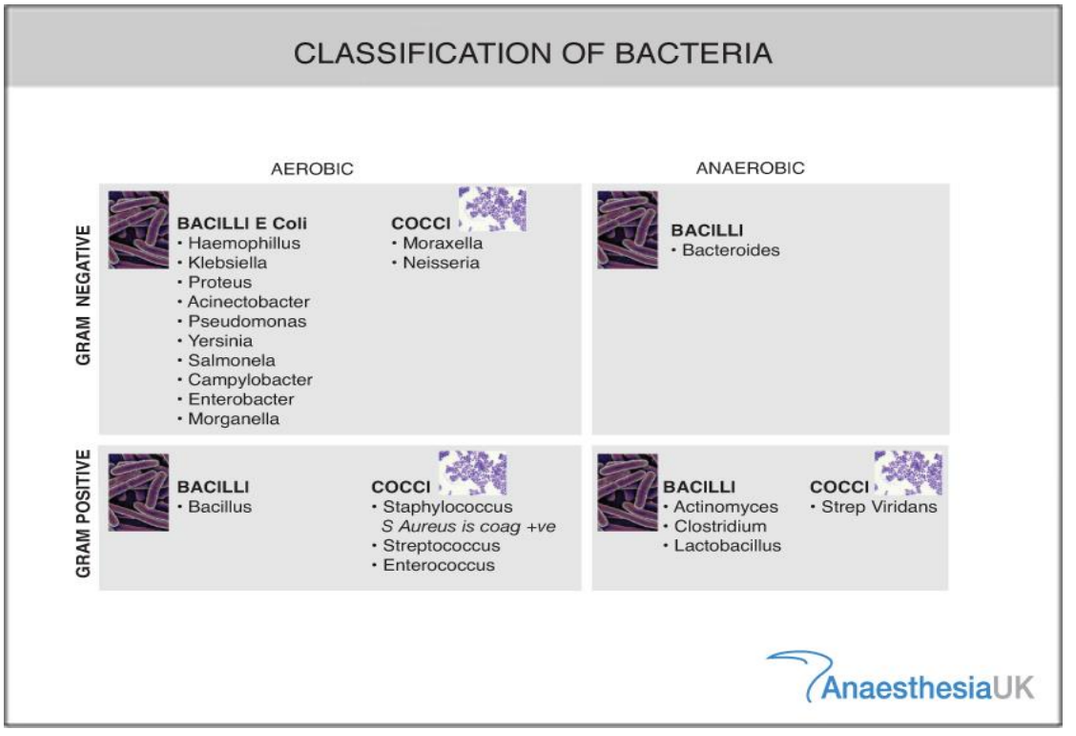

Figure 4 : Classification of Bacteria

Source: http://www.frca.co.uk/images_main/resources/bacteria_fig.jpg. Accessed 10/10/2013 (16:55hrs).

B. **Classification according to oxygen requirement**

Some bacteria need oxygen to grow, however, oxygen is not always necessary in the respiration of bacteria. The following bacteria fall in this category:

a. Strict aerobes/obligate aerobes

These can only grow in the presence of oxygen, i. e such bacteria can only be found in places with oxygen e.g. mycobacterium tubercle is found in the lungs. Others are found on the surface of wounds, skin or mucus membrane.

b. Strict anaerobes

These are able to grow only in complete absence of oxygen. They are found in deep wounds e.g. clostridium tetani, clostridium welchii which causes gas gangrene.

c. Facultative anaerobes

These grow or survive in either presence or absence of oxygen. Majority of micro-organisms fall under this grouping.

1. Classification according to gram staining reaction.

A stain is a substance/dye used to give colour to tissues, cells or micro-organisms to facilitate microscopic study and identification. Those organisms retaining the dye are called ***Gram-positive*** while those losing it are ***Gram-negative.***

Below are various examples of gram positive and gram negative microorganisms. This classification is a resultant of microbial reaction to different types of staining

a. Examples of Gram positive bacteria

Cocci:

- Streptococci
- Staphylococci
- Anaerobic cocci
- Micro cocci

Bacilli

- Clostridia {tetani, Welchi and Botulinum}

- Bacillus
- Corynebacteria
- Listeria
- Lacto bacteria
- Myco bacteria

b. Examples of Gram-negative bacteria

Cocci

- Neisseria
- Veillonella
- Branahanella

Bacilli (small ones)

- Bacteriodes, haemophillus, bordetella, yorsima, brucella, pasturella.

Bigger bacilli

- Pseudomonad
- Salmonella {typhi, paratyphi}
- Shingella {shiga, flexina, boyd, sonnei}
- Proteus
- Enterobacter
- Klebsiella

You have come to the end of sub-topic on bacteria. Please, attempt the self-test below with specific questions on bacteria and its characteristics.

Activity

1. Specific organisms that are considered strict anaerobes include:
   A. E. coli and Streptococcus pneumoniae
   B. Bacteroides and Klebsiella
   C. Fusobacterium and Clostridium
   D. Peptostreptococcus and Nocardia
2. The single most important characteristic of diarrhea caused by Vibrio cholera is:
   A. Profound watery diarrhea
   B. Severe abdominal pain
   C. Massive bloody diarrhea
   D. Renal insufficiency

Your answers for these two questions would be 1. C and 2. A

We have come to the end of our discussion on bacteria. Next, let us look at the second group of micro-organisms known as Viruses.

Viruses

Viruses are very small micro-organisms which cannot be seen by naked eyes or light microscopes except the use of an electronic microscope. *Viruses* are infectious agents, so small that they pass through filters known to stop bacteria. *Viruses* are not cellular and therefore are classified as neither prokaryotes nor eukaryotes. *Viruses* are obligate, intracellular parasites of cellular organisms.

The diagram in figure 6 is an illustration of the cross section of a virus. Look at the diagram carefully and master the different parts of the virus

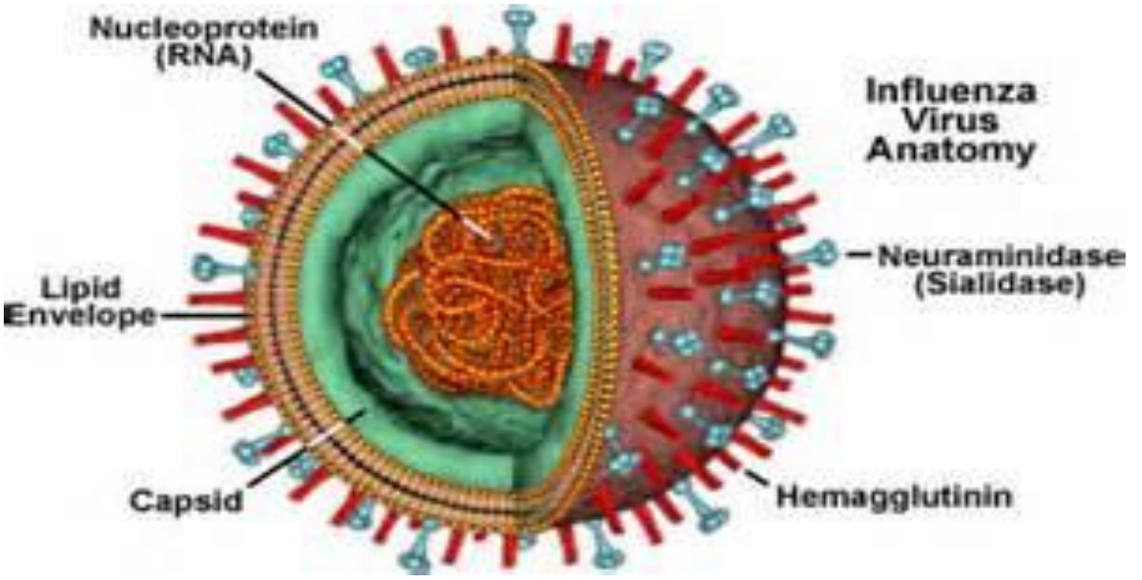

Figure 5 : Diagram of cross section of a virus

Now that you have studied the diagram, continue with your content. Look at your next sub-topic which is looking at the main properties that distinguish viruses from other living microorganisms

Main properties that distinguish viruses from other living micro-organisms

1. Small size: viruses are smaller than any other organisms although they vary in size from 10nm to 300nm bacteria is about 1000nm.
2. Genome: the genome of viruses may be either DNA or RNA. Viruses contain only one kind of nucleic acid.
3. They do not grow on artificial medium but live only in living cells. They cannot exist independently because they lack enzymes and other pathways.
4. Reproduction is from nucleic acid (genome) not by binary fusion but by transcribing itself into a virus specific messenger or MRNA which then directs the replication of new virus particles.
5. They are highly resistant to all antibiotics; hence they usually do not have specific treatment.

Thank you for your active participation, you are doing very well. Now study Figure 6 below - Diagram of a HIV virus-showing different stages of viral insertion and reproduction. This diagram is important as it illustrates different stages of viral insertion and reproduction.

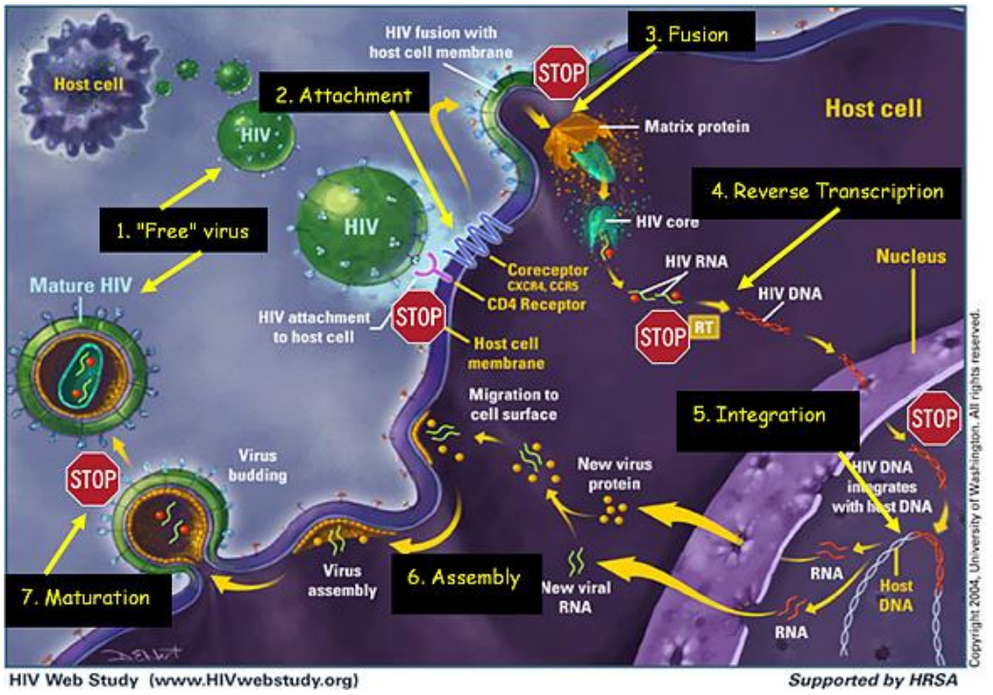

Figure 7 Diagram of a HIV virus-showing different stages of viral insertion and reproduction.

Having looked at the diagram of a HIV virus-showing different stages of viral insertion and reproduction, now look at the HIV virus anatomy in figure 8.

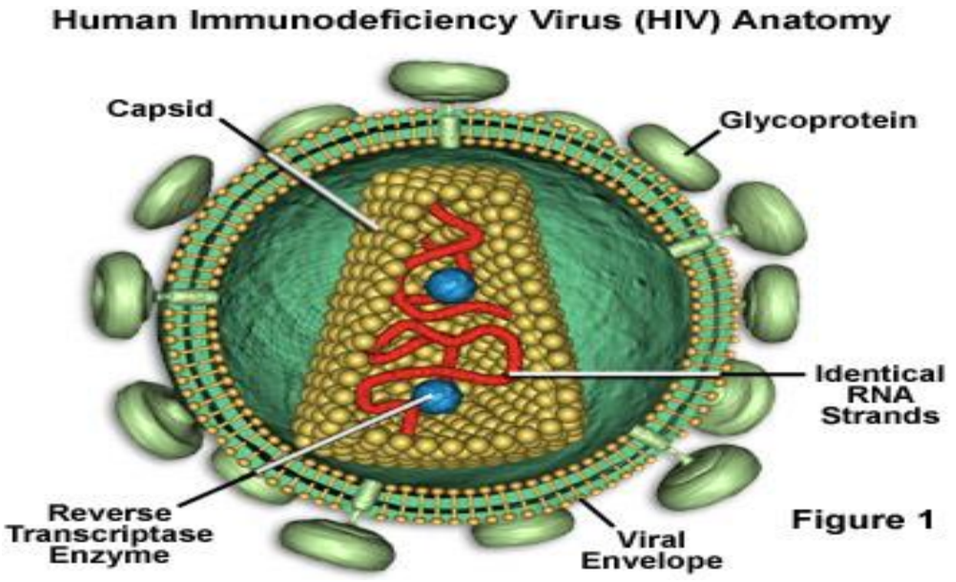

Figure 8 : HIV Anatomy

Source: RNA virus-wikipedia-http//en.org/wiki/

Structure of a virus

Viruses consist basically of a core of nucleic acid (either DNA or RNA) by a protein coat (Capsid)

- **Virion:** The intact virus particle
- **Capsid:** the protein coat

It protects the nucleic acid (viral genome) from inactivation by adverse environmental factors. It facilitates the attachment of the virus to the host cell. It also contains antigenic material and often responsible for stimulating the production of protective antibodies.

Capsomeres: They are protein structural units of which the Capsid is composed.

Envelope: the particles of many viruses are surrounded by a further layer lipoprotein envelope containing viral antigens but also partly derived from the plasma or the nuclear membrane of the host cell.

Shape

Virus particles show three types of symmetry

1. **Cubic:** The particles are icosahedral shells with the nucleic acid contained inside.
2. **Helical:** The particle contains an elongated nucleo-capsid in the form of helix or spiral e.g. influenza virus.
3. **Complex:** These are neither cubic nor helical e.g. small pox virus.

All viruses contain protein; others contain liquids and carbohydrates in various concentrations.

Effects of viruses on cells

The following are the effects of viruses on cells:

1. **Cell death:** the infection is lethal, it causes cytopathic effect (CPE) which kills the cell
2. **Cell transformation:** The cell is not killed but is changed from a normal cell to tumour producing cells one with the properties of a malignant or cancerous cell (neoplastic or orchogenic properties.)
3. **Latent infection:** The viruses remain within the cell in a potentially active state but provide no obvious effects on the cell's functions in response to certain stimuli. Latent viruses can be activated and become active e.g. Herpes virus causing Herpes zoster.
4. **Haemadsorption:** Some viruses have protein (haemaglutinin) in their outer coat which adheres to erythrocytes causing them to agglutinate.

Classification

We will now classify the different viruses according to their common classifications.
Viruses are assigned to groups mainly according to:

1. Morphology of the viral particle
2. Type of disease produced
3. Antigenic reaction
4. Their nucleic acid and method of RNA transcription. (chemical and physical properties)

The table below illustrates various viral classifications according to family, specific viruses, disease they cause, genetic make-up and the shape.

Table 1: Common types of viruses

FAMILY	VIRUSES	DISEASES	NUCLEIC ACID	SHAPE
Adenoviruses	Adenoviruses (they are above 31)	They attack lymphoid tissue • Sore throat • Conjunctivitis • Mesenteric adenitis	DNA	Cubic
Herpes Viruses	-Herpes simplex -Varicella Zoster -cytomegalovirus	-Herpes/cold sores -chicken pox (the virus remain dormant in the nerve until immunity is decreased) to reactivate the virus into herpes zoster (shingles attack). -Generalized Neonatal infection.	DNA	Cubic
Pox Viruses	-Variola Molluscum	-Small pox (eradicated in 1980) -molluscum contagiosum	DNA	Complex
Myxoviruses	-Influenza A -Influenza B	- Common cold/flue or influenza (they attack upper respiratory track)	RNA	Helical
FAMILY	VIRUSES	DISEASES	NUCLEIC ACID	SHAPE
Paramyxo – viruses	Para influenza Respiratory syncytial	respiratory infection Bronchitis -measles -mumps	RNA	Helical
Paramyxo-viruses	Rubella	-German measles	RNA	Helical
Hepadna-viruses	Hepatitis virus A Hepatitis virus B	Infectious hepatitis Serum hepatitis	RNA DNA	Helical Helical
papovaviruses	Papilloma	-warts	DNA	Helical
Parvoviruses	B19	-Erythema infectiosum, haemolytic crises	DNA	Helical
Picornaviruses	Enteroviruses	-meningitis	RNA	Cubic

	Rhinoviruses Polio viruses	-common cold -poliomyelitis paralysis		
Rhabdoviruses	Rabies	-rabies	RNA	Helical
Reoviruses	Rotavirus	-Gastroenteritis	RNA	Helical
Flaviruses	-Flaviruses	-Yellow fever -Encephalitis -Febrile disease	RNA	Helical
Togaviruses	-Alphaviruses -Rubivirus	-Encephalitis -febrile disease -Rubella	SS RNA	Helical
Arena viruses	Lymphocytic Choriomeningitis -Lassa virus	-meningitis Febrile disease (Lassa fever)	RNA	Helical
Bunya viruses	-Bunya viruses -Hantaan virus	-Encephalitis -Febrile disease	RNA	Helical
Retro viruses	-HTLV I,II -HIV 1,2	-T-Cell Leukaemia- lymphoma - AIDS	RNA	Helical
Filorinidae	-Ebola	-Ebola	RNA	Helical

I believe Table 1 above has given you knowledge of different types of viruses and the family they belong. You need now to begin to study how viral replication/reproduction takes place.

Virus replication/production

Viruses have no metabolic activity of their own, they replicate by taking over the biochemical machinery of the host cell and redirecting it into the synthesis of virus components. This takeover is achieved by virus RNA (Messenger). Virus growth cycle takes place in 7 stages.

1. **Adsorption: (virus infection):** The virus attach to the cell membrane of the host cells and then the viral genetic material is transferred to host's cell membrane (injects DNA or RNA into the host cell) to initiate infection.

2. **Entry:** Is achieved by invagination of cell membrane around virus particle to enclose it in a pinocytotic vacuole or is by fusion of virus envelope with cell membrane.
3. **Uncoating:** This is when Cell enzymes (from lysosomes) strip off the virus protein coat. It is also called Releases stage which makes viral nucleic acid to have access to host cell's genetic material (DNA)

4. **Transcription:/messenger RNA Production:** For some RNA viruses, the infecting RNA produces messenger RNA (mRNA). So translation of the genome into proteins produces. For others with negative stranded RNA and DNA viruses are produced by transcription then translation.

    - **Synthesis of virus components:** Viral protein synthesis: virus m RNA is translated on cell ribosomes into two types of virus protein.
    - **Structural** – the proteins which make up the virus particle
    - **Non – structural** – not found in particle, mainly enzymes for virus genome replication.
    - **Viral nucleic acid synthesis** (genome replication) new virus genome are synthesized, templates are either the parental genome or with single stranded nucleic acid genomes, newly formed complementary strands. This is done in rapidly dividing cells.
    - **Virion Assembly:** New virus genomes (nucleic acid) and proteins are assembled to form new virus particles. This may take place in cell nucleus, cytoplasm, or at plasma membrane for most enveloped viruses.

5. **Release (liberation stage):** Mature virus are released by either sudden raptures or gradual extrusion.(budding) of enveloped viruses through cell membranes. The new virus may invade or attack other cells or remain dormant in the cell.

You have learnt about viral replication and reproduction, find below a diagram showing the various stages involved in viral replication and reproduction in Figure 9. Follow the illustrations, as they will help you understand how replication and reproduction occurs.

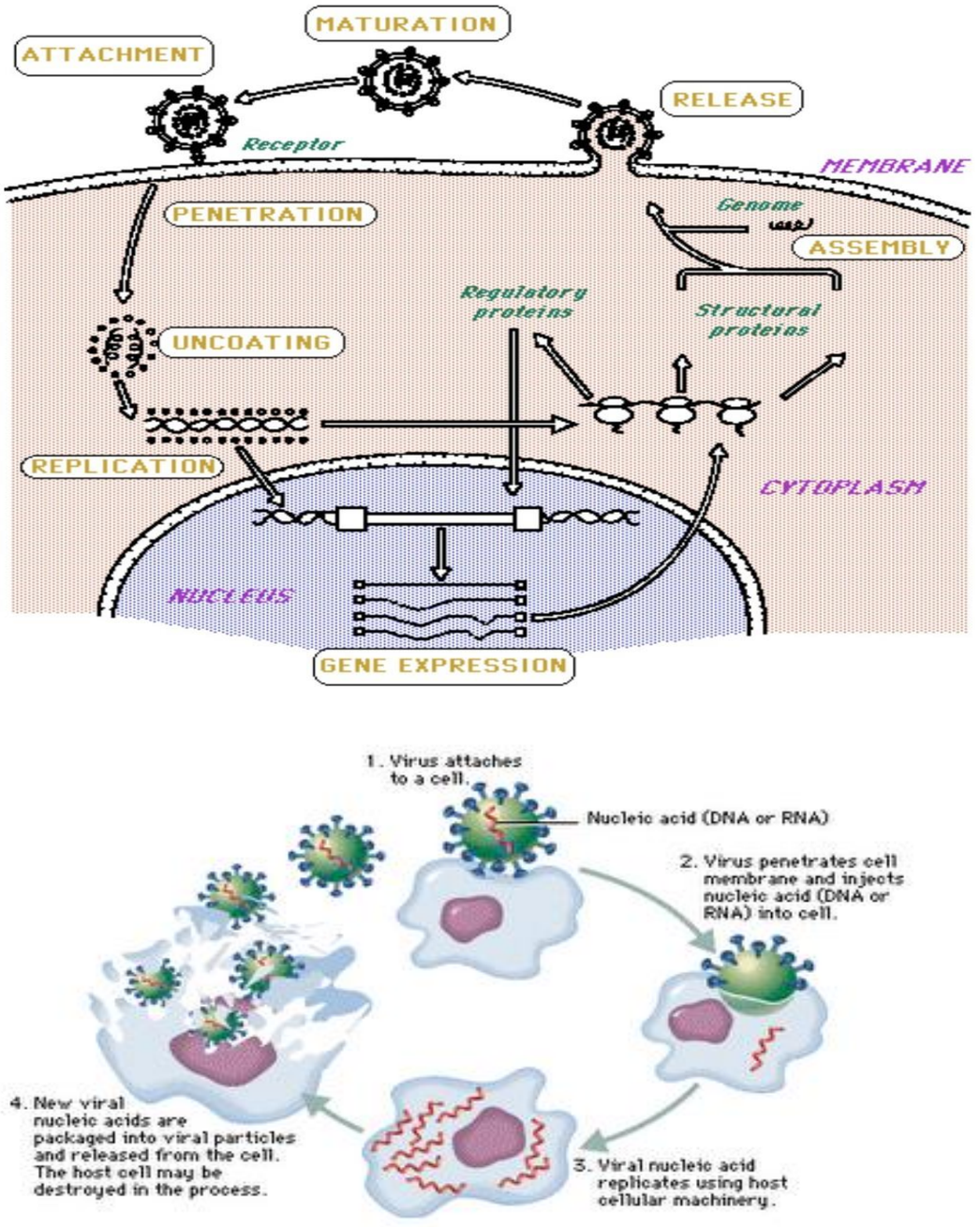

Figure 9: Virus replication/production

You have been reading and studying about viruses. This is one sub-unit which is very interesting and scientific. I believe you have noted that viruses are obligate microorganism that cannot survive outside the host. It is also very important to understand the viral

replication process. This is very important as you will need to apply this knowledge when you will be doing medicine and medical nursing, and pharmacology in nursing.

I want you to try a self assessment pertaining to the topic you have just covered. Write your answers in your note book. Read the questions carefully. If you are not finding any answers, consult any microbiology text book.

Self-Test

Multiple Choice Questions

1. One of the characteristics of HIV infection is that:

A. The virus multiplies slowly with a half-life of weeks matching the slow rate of disease progression

B. There is rapid dissemination of virus within the first few weeks of infection to all tissues

C. In early infection the virus is most actively multiplying within the bloodstream

D. There is little if any immune response to HIV infection, and that is why this infection is so overwhelming

2. All of the following are true statements regarding viruses EXCEPT:

A**.** They contain both RNA and DNA

B. The nucleic acid may be single or double stranded

C. They are obligate intracellular parasites

D. They reproduce using host cell energy

E. The infectious particle is called a virion

3. HIV reverse transcriptase, a critical target in modern antiretroviral chemotherapy, performs which critical function for the virus:

A. Cleaves polyprotein precursor leading to functional assembly of viral core

B. Cleaves sialic acid residue from glycoprotein permitting attachment and entry into cell

C. Transcribes RNA into DNA

D. Activates 2',5' oligoadenylate synthetase

Your have successfully done your self-assessment and i believe it was helpful, now your next sub-unit is about fungi. Read the content carefully. Enjoy as you go through this content, taking note of some special points. Use your nurses' medical dictionary for you to learn some difficult terms.

. Take your time to understand this topic carefully. Before you proceed, here is a quick assignment.

Activity

Using your note book: write some examples of the fungi you may be aware of?

Fungi

Fungi are unicellular, eukaryotic organisms that derive nourishment from their liquid environment, often by engulfment.

Find below a diagram illustrating a fungi.

A Fungi is a plant like organism which can be unicellular or multicellular. It is a low form of vegetable life

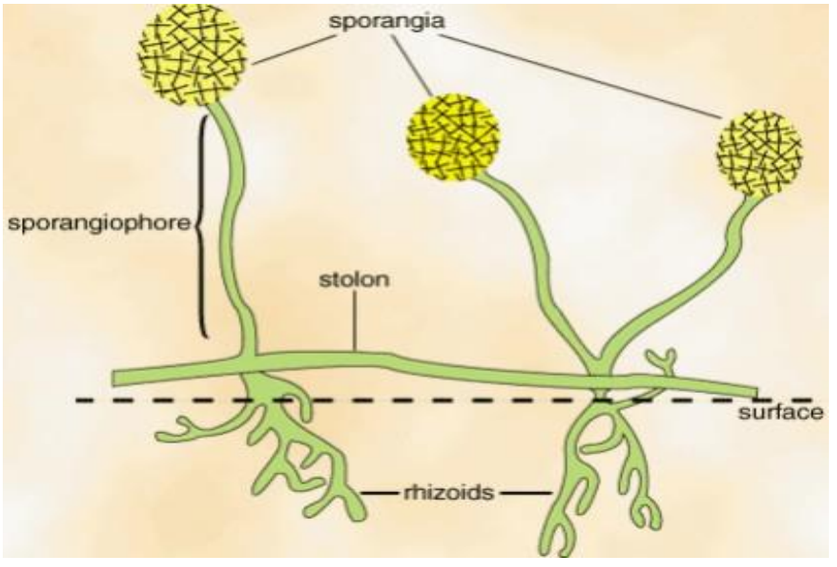

Figure 10 : Diagram of fungi

Zygostructure

Source: Fungi-wikipedia-http//en.org/wiki/

Fungi are described as:

- **Saprophytes:** those which live on nutrients from dead plants or animals (decayed matter)
- **Parasites:** those which depend on living things or plants. (Living organisms) for example moulds and yeast. They do not contain chlorophyll

Fungi vary in size. The largest being the mushrooms which are visible. It is taken as food by man. Some are only seen under the microscope as network of bright thread or filaments. The filaments have round bodies which project into the air. Each bright thread is called ***hypha*** which is used for water and food absorption. Human infection due to fungi are called ***mycoses.***

Classification

Under this sub-topic, we shall look at at the classifications of fungi.

Based on morphology, Pathogenic fungi are classified into four (4) groups.

1. Yeasts:

These are oval or round shaped and do not develop threads. They are used in brewing and baking industries. They reproduce by budding, for example, Cryptococcus.

2. Yeast like fungi

These grow as ovoid cells or as non-branching filaments (pseudo hyphae). They extend from the yeast cell

.

3. Filamentous fungi (Moulds)

These grow as branching filaments or hyphae that interlace to form a tangled mass (mycelium). They reproduce asexually by means of spores which are formed on special fertile hyphae and discharged into the air e.g. microsporium, trichophyton and epidermophyton. Moulds grow in most of the objects in the absence of sunlight, moisture, warmth and humidity. They are found in ordinary soils and are called ***Actinomytes***. Actinomycete contributes to the breaking down of organic waste into simple substances to be utilized as food. Some moulds are used for drugs, for example,. penicillium notum which is a source of an antibiotic penicillin.

4. Dimorphic fungi

These are so called because they can grow on tissues and in culture at 37 degrees Celsius. They appear in yeast forms at body temperature and as filamented forms, for example, histoplasm when cultured and incubated at 22 degrees Celsius. Dimorphic fungi are classified as:

- **Cryptococcus neoformous**

These cells have a gelatinous (glue like) capsule. It is found in the excreta of birds especially pigeons. It is an opportunistic pathogen affecting mainly immune suppressed patients. Infection occurs by inhalation where it causes a subclinical lung infection. It may spread systematically to meninges causing sub-acute or chronic meningitis.

- **Candida Albicans**

It's anoval budding yeast which produces pseudo hyphae. It is a normal inhabitant of the mouth, vagina and intestine. In these sites it may predominate and cause super infection especially on prolonged treatment with broad spectrum antibiotics. It causes oral or vaginal candidiasis and may cause diarrhoea in children or immune suppressed.

- **Dermatophytes:** They include three genera:
    - Epidermophyton
    - Microsporium
    - Trichophyton

These organisms affect keratinized tissues such as skin, hair and nails but they do not invade deeper tissues. They spread peripherally from the fossae to produce ring like lesions hence the name ring worm.

    - Athletes food
    - Candida or monilia which affects mucus membrane of the mouth and the vagina.

- **Dermorphic fungi**

These cause disease in both man and animals. In man the disease is mainly in immuno compromised patients.

We have now come to the end of this sub-unit where we were looking at fungi. I hope you found the sub-unit interesting and you have learnt a lot of new things. Now it is time to begin a new sub-unit on Protozoa. Please, read through the content carefully, and try to understand the content very well. Good luck

2.4 Protozoa

We shall begin this section by defining the various terms used.

Protozoa are a group of complex unicellular organisms which are able to function on their own by nutrition digestion, locomotion and reproduction.

Description of terms:

Trophozoite: is the vegetative mobile stage of protozoa which feeds, multiplies and forms colonies in the host.

Cyst: is a non-motile resisting protected by a cyst wall. Protozoa may be readily transmitted to a new host by ingestion of the mature cyst.

Encystation: is the transformation of a Trophozoite to a cyst forming a cyst wall.

Karyosome: A mass of chromatin with the nucleus like the nucleolus in the metazoan

Chromatin: the part of the nucleus which readily stains due to its staining affinity.

Chromatoid body: A flexible extra nuclear body composed of stained like chromatin contained in the cytoplasma.

Flagella: A long hair like process attached to a protozoa and it is used for locomotion.

Blepheroplast: A chromatic dot from which flagella arises and functions as a locomotive apparatus.

Axostyle: Is an axial rod of a flagellate acting as its support

Cystosome: It corresponds to a mouth part of a ciliate

Cytopyge: The excretory or anal opening of the ciliate.

Structure of protozoa

The protozoon cell consists of protoplasm divided into cytoplasm and nucleoplasm having nucleus which may be one or two.

Figure 11 is an illustration of the structure of protozoa. Read carefully and understand the different parts of a protozoa

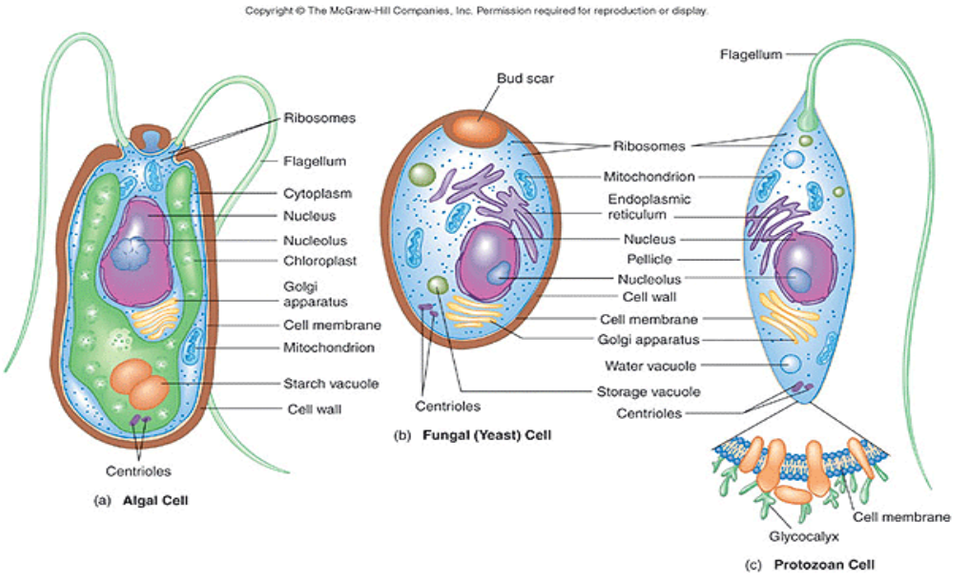

Figure 11: Structure of protozoa

A. Cytoplasm

The cytoplasm is divided into ectoplasm and endoplasm

i. **Ectoplasm: This is** the external hair like part of the cell such as the. Flagella and cilia pseudopodia. They are chiefly concerned with locomotion, response to stimuli, excretion and protection.
ii. **Endoplasm:** The internal granular portion of the cell contains food vacuoles which help in food digestion, various granules like glycogen, fat globules and protein also contain mitochondria.
iii. **Nucleoplasm:** May be one or more and chiefly concerned with nutrition and reproduction. It contains achromatic and chromatic substances.

Achromatic Substances: are nuclear membranes, nuclear sap, nuclear reticulum and nucleo-plast or nucleoli

Chromatin: acts as the governing centre of vital activities, it is essential for cell division, growth and reproduction.

Reproduction: Reproduction is both sexual and asexual

Asexual: Occurs by binary fission

Sexual: Occurs where the cells are males and females

Classification of protozoa

Protozoa are classified by mainly their type of locomotion or organelle locomotion. The following are the four classes.

1. Rhizopoza: (amoaeba)

Rhizo - root poda - foot

This class of rhizopoza move by producing pseudo podia like roots of a tree.
The following are the common ones:

In intestines – entamoeba with the following classes:

- Coli
- Histolytica
- Gingivalis
- Endolinax nana
- Iodmoeba butschilli
- Diantamoeba flagilis

2. Mastigophora

Mastig = whip and **Phora =** bearing

These move by means of flagella and binary fission occurs by longitudinal division. The following are the common ones

a. In blood:

Lash mania

- Donovani
- Tropica
- Brazellnsi

Trypanosoma

- Gambiense
- Rhodesense
- Cruzi

b. In intestines

- Trichomonas
- Hominis
- Chilomestix – mensitilliGiadia lamblia

•

3. Protozoa

Sporo = seed **Zoon =** living animal.

These have no organ of locomotion and move slightly only by amoeboid movement with change in the form and position. They live in cells of infected people or mosquito. They multiply asexually and sexually. The following are the common ones:

In blood

Plasmodium which causes malaria

- Malariae
- Falciparum
- Vivax
- Ovale

In intestine:

I sospora hominis

Organs:

Toxoplasma Gondi

Lungs:

Pneumocystis carini

3. Ciliata

These move by cilia (hair like structure shorter than the flagella). They multiply by transverse division of the body. They produce cysts.

Intestines:

Balantidium coli

Rickettsiae

Definition: Rickettsiae are obligate intracellular parasites containing both DNA and RNA with a structure more like that of gram – negative bacteria. Their natural habitat is the cells of the gut of arthropods.

Size

About 0.3 u

They are smaller than bacteria but larger than the virus. They can be seen under a height microscope and are sensitive to antiseptics and antibiotics.

Three main groups:

Typhus Group

- R. Prowazeki transmitted by body lice/louse
- R- Tyhi transmitted by mouse/rat flea. This causes typhus fever which results in fever, severe headache and skin rash.

Scrub typhus group

R. tsutsugamushi transmitted by mite causing scrub typhus fever.

Spotted fever group

- R. rickettisii
- R. conorri
- R. sibilica
- R. akari
- R. australis

They are transmitted by ticks except B akali by mites. They cause Rocky mountain fever and other –born fevers. The disease is found in epidemic in conditions of poverty, malnutrition and overcrowded place. They multiply by binary fission.

We have now come to the end of the whole of unit 2. I would like you to attempt these multiple choice questions. Read through your self-assessment test carefully. Attempt all the questions in your note book.

Self- Assessment Test

Multiple Choice Questions

1. Which of the following virulence factors of E. coli is important for attachment to host epithelial cells in the pathogenesis of urinary tract infections?
   A. Aerobactin
   B. Alpha hemolysin
   C. Urease
   D. K1 antigen
   E. Pili
2. Characteristics of a bacterial capsule include:
   A. All bacteria have one
   B. It is composed of peptidoglycan
   C. It is an important mechanism for protecting a bacteria against ingestion by PMNs
   D. It is what causes the gram stain reaction
3. An important characteristic of mycobacteria is that they are:
   A. Gram negative
   B. Rapid growing (doubling time 15 minutes)
   C. Acid fast
   D. Alpha haemolytic
4. A 30 year old patient with advanced HIV infection comes into clinic complaining that food is sticking in the back of his throat and in his chest when he tries to swallow. You look in his mouth and see patches of whitish material on the surface that can easily be removed and leaves a red base. The organism most likely to cause this is:
   A. Histoplasma
   B. Candida albicans
   C. Group A strep
   D. Strongyloides
5. The substance that carry the genetic code of all biological activities of an organism that is transmitted from generation to the next is the: -

   A. Chromosome
   B. Genome
   C. Gene
   D. DNA
6. Salmonnella tyhpi is a causative organism for_____
   A. Gardiasis
   B. Typhoid fever
   C. Enteric fever
   D. Dysentry
7. Oral thrush and candiasis are caused by_____

   A. Candida albicans
   B. E.Coli

C. Samonnella
D. Candida purgians

8. All of the following are true statements regarding viruses EXCEPT:
A**.** They contain both RNA and DNA
B. The nucleic acid may be single or double stranded
C. They are obligate intracellular parasites
D. They reproduce using host cell energy
E. The infectious particle is called a virion

9. HIV reverse transcriptase, a critical target in modern antiretroviral chemotherapy, performs which critical function for the virus:
A. Cleaves polyprotein precursor leading to functional assembly of viral core
B. Cleaves sialic acid residue from glycoprotein permitting attachment and entry into cell
C. Transcribes RNA into DNA
D. Activates 2',5' oligoadenylate synthetase

10. An important characteristic of mycobacteria is that they are:
A. Gram negative
B. Rapid growing (doubling time 15 minutes)
C. Acid fast
D. Alpha hemolytic

2.4 Unit Summary

We have come to the end of this Unit 2 and hope you enjoyed it. We discussed that microorganisms are classified as bacteria, virus, fungi, protozoa and Rickettsiae.
Thank you for your active participating.

References

Burton, G.R.W. (1995) Microbiology for Health Sciences, Philadelphia. Lippincott.

Norton, C.T.(1981) Microbiology, London: Addison-Wesley Publishing Company,Inc.

UNIT 3: MICROSCOPIC EXAMINATION (MICROSCOPE)

3.1 Unit Introduction

We have discussed the different types of microorganisms. This unit discusses the different types of microscopes, including how they are used to examine specimens. By the end of this section, you are expected to describe the different types of microscopes and explain how microscopic examination of specimens is done. Before you proceed into the content, do this activity:

3.2 Unit Objectives

By the end of this unit you should be able to:

1. Distinguish between the various types of microscopes used in a medical lab
2. Explain how microscopic examination of specimens is done

Activity 3.1

Last time during orientation, you had the privilege to enter the laboratory, mention the type of microscope that you saw. If you are unable to remember the exact type of a microscope, you can write any three (3) microscopes that you know? Write your answer in your note book.

Good attempt, now you can proceed to read the content and find answers to the above activity.

3.3Types of microscopes and how they are used

There are several different types of microscopes used in light microscopy, and the four most popular types are Compound, Stereo, Digital and the Pocket or handheld microscopes.

Some types are best suited for biological applications, where others are best for classroom or personal hobby use.

Outside of light microscopy are the exciting developments with electron microscopes and in scanning probe microscopy

Below is a brief introduction of the different types available.

The compound light microscope

Commonly binocular (two eyepieces), the compound light microscope, combines the power of lenses and light to enlarge the subject being viewed. Typically, the eyepiece itself allows for 10X or 15X magnification and when combined with the three or four objective lenses, which can be rotated into the field of view, produce higher magnification to a maximum of around 1000X generally. The compound light microscope is popular among botanists for studying plant cells, in biology to view bacteria and parasites as well as a variety of human/animal cells.

It is a useful microscope in forensic labs for identifying drug structures. Compound light microscopes are one of the most familiar of the different types of microscopes as they are most often found in science and biology classrooms. For this reason, simple models are readily available and are inexpensive.

Below in Figure 12; is an illustration of a compound light microscope.

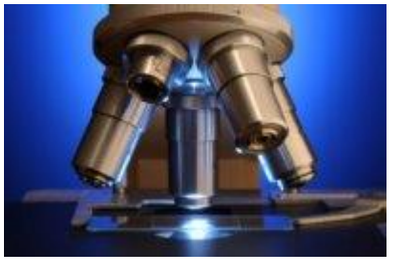

Figure 12 : The compound light microscope

The stereo microscope

The Stereo microscope, also called a dissecting microscope, has two optical paths at slightly different angles allowing the image to be viewed three-dimensionally under the lenses. Stereo microscopes magnify at low power, typically between 10X and 200X, generally below 100x. With this type of microscope you generally have the choice of

purchasing the fixed or zoom variety from a manufacturer and they are relatively inexpensive. Uses for this type of microscope include looking at surfaces, microsurgery, and watch making, plus building and inspecting circuit boards. Stereo microscopes allow students to observe plant photosynthesis in action.

Digital microscope

The digital microscope, invented in Japan in 1986, uses the power of the computer to view objects not visible to the naked eye. Among the different types of microscopes, this kind can be found with or without eyepieces to peer into. It connects to a computer monitor via a USB cable, much like connecting a printer or mouse. The computer software allows the monitor to display the magnified specimen. Moving images can be recorded or single images captured in the computer's memory. An advantage of digital microscopes is the ability to email images, as well as comfortably watch moving images for long periods.

The USB Computer microscope

Although not well suited to the same scientific applications as other light microscopes, the USB Computer microscope, among the different types of microscopes, can be used on almost any object and requires no preparation of the specimen. It is essentially a macro lens used to examine images on a computer screen plugged into its USB port. However, the magnification is restricted and is not comparable to your standard compound light microscope at only up to 200X with a relatively small depth of field.

Pocket microscope

In examining the different types of microscopes available on the market, the pocket microscope may be tiny but its abilities are impressive. This is a device which is a great gift for a child or your student. It is used by scientists for hand-held imaging of a variety of specimens/objects in the field or in the laboratory. It is small, durable and portable with a magnification ranging from 25x to 100x. There are many different models available.

The electron microscope

Among the different types of microscopes, the Electron Microscope (EM) is a powerful microscope available and used today, allowing researchers to view a specimen at nanometer size. The transmission electron microscope (TEM), the first type of EM, is capable of producing images 1 nanometer in size. The TEM is a popular choice for nanotechnology as well as semiconductor analysis and production.

A second type of electron microscope is the scanning electron microscope (SEM)are approximately 10 times less powerful than TEMs, they produce high-resolution, sharp, black and white 3D images. The Transmission Electron Microscopes and Scanning Electron Microscopes have practical applications in such fields as biology, chemistry, gemmology, metallurgy and industry as well as provide information on the topography, morphology, composition and crystallographic data of samples.

Find below an illustration of an electron microscope (Figure 13)

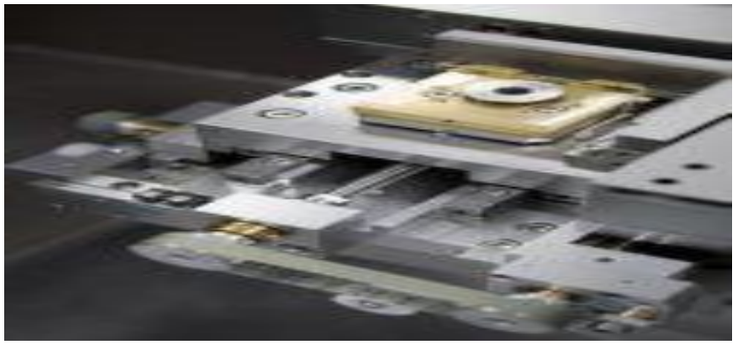

Figure 13 : The electron microscope

Scanning probe microscope (SPM)

Among the different types of microscopes and microscopy techniques, scanning probe microscopy is used today in academic and industrial settings for those sectors involving physics, biology and chemistry. These instruments are used in research and development as standard analysis tools.

Images are highly magnified and are observed as three-dimensional-shaped-specimens in real time. SPMs employ a delicate probe to scan the surface of the specimen eliminating the limitations that are found in electron and light microscopy.

The Acoustic Microscope

The Acoustic Microscope has less resolution and more powerful at finding faults, cracks or errors from samples during the manufacturing process. With the use of high ultrasound, this type of microscope is the easiest intra-cavity imaging tool available. It is a microscope that is under used primarily due to the fact that it is less known for its capabilities.

Scanning acoustic microscopy, or SAM, is the most current type of acoustic microscopy available to today's scientists. They can use it to view a sample internally without staining it or causing it any damage thanks to point focusing technology, which relies on a beam to scan and penetrate the specimen while it is in water.

I hope you found it interesting to learn about the different types of microscopes and how they are used. Now you need to move on and learn how these microscopes can effectively be used in providing precise diagnosis. Your next sub-unit topic is staining. Staining is an important aspect which facilitates visualization of various specimens under the microscope.

Self Assessment Test

Match the components in column A to the answers in column B

Column A	**Column B**
1.compound light microscope	*A. Moving images recorded in the computer*
2.Stereo Microscope	*B. Hand held images in the laboratory*
3.Pocket microscope	*C. To study plant cells, bacteria and parasites*
4.Digital Microscope	*D. Micro-surgery and watch making*
5.USB computer microscope	*E. Images on the computer screen*

3.4 Use of microscopes

Microscopes are tools used by laboratory personnel to visualize pathogens or microorganisms to assist the physician in precise diagnosis. Let us look at the methods commonly used.

Staining

This is an artificial colouring of tissues to facilitate the identification and examination under the microscope. The microscopic examination of stained properties enables the morphology, relative size and arrangement of micro-organisms to be seen clearly.

Stain

Stains are chemical salts which can be base, acid, or neutral depending on whether the colouring component is contained in the base, acid or both parts of the stains. Most stains used to stain bacteria are of basic types such as ***crystal violet, basic fuchsine and methlin blue.***

Mordant

The chemical which helps to bring about the stain reaction, for example,iodine in Gram stain and phenol in Ziehl Nelson (ZN)

Decolourization

This is the selective removal or washing out of the excess stain.

Counter stain

The stain is taken up by the organism which has been decoloured to provide a good background.

Making of smears/preparation of films

1. Use a clean slide free from grease
- Mark with a glass writing diamond pencil
- Make the smear from liquid, solid media or swab spread out smear over the microscopic slide air dry the smear.
- Fix by passing it 3 times over a flame, cool and stain.

Staining of films

The staining of films should be carried out over a sink and near a supply of water. Two pieces of glass rods must be level

A piece or rubber tubing may be attached to the water tab so that the stain may be washed off the slide without removing it from the glass rods. Blotting paper should be at hand for drying slides after staining.

- A spirit lamp or a swab dipped in methylated spirit should be available to apply to stains which require warm
- Forceps are used for lifting slides off the staining rack to keep fingers clean.

Staining methods

Leoffler's alkaline methylene blue

This is a basic dye for routine use in studying the morphology of micro – organisms in smears from cultures. The stain is more intense than natural solutions of methylene blue and may show some degree of poly chromatic staining (many colours) chromatic means a change in colours.

Method

- The heat fixed smear/the slide is flooded (applied) with methylene blue stain which is allowed to act for 3 minutes, 30 seconds
- Then wash off with water and the slide blotted dry
- Examine under oil immersion.

Bacteria stain deep blue

Pus cells stain deep blue

Cytoplasm's stain a paler shade

Bacteria and yeast granules stain red or purple

- Bacteria and yeast cells with granules
- Bacteria in pus
- Spore forming bacilli because the stain does not penetrate the spore.

Gram's stain

In 1884, Hans Christian Gram described this method which is the most important in routine bacteriology. Gram's stain shows up bacteria and also divides them into 2 groups, gram positive and gram negative. Depending on whether they can be decoloured or not

The film is first stained with methyl violet, or crystal methyl or gentian violet and treatment with iodine which colour the bacteria a **deep violet colour.** The film is then washed with absolute alcohol, acetone and aniline oil which decolorizes some bacteria. Those which retain the purple colour after washing are known as **gram positive** and those which are decolourized and take up a red counter stain are called **gram negative.**

Solutions required for gram stain

1. 0.5% Crystal violet
2. Lugols iodine
3. A cetone / alcohol
4. Neutral red

Method

1. Prepare a smear, allow to dry fix with gentle heat.
2. Slide is flooded with solution 1 (crystal violet) which is allowed to act for about 30 seconds.
3. The slide is lifted so that solution 1 runs off below and solution 2 poured on to slide. Allow to act for 30 seconds.
4. Rinse with water.
5. Rinse with solution 3 applied from drop bottle (dropper) until no more colour comes out.
6. Wash with water.
7. Apply solution 4 (neutral red) and allow to act for ½-1 minute.
8. Rinse with water and blot dry slide.
9. Examine under oil immersion.

Results

- Gram positive organisms stain violet

- Gram negative organisms stain red

Ziehl – Neelsen's stain (acid – fast stain)

This is used for the identification of tubercle bacilli (mycobacterium) which do not stain with ordinary dyes due to a very resistant outer envelope of a fatty nature which prevents penetration of the stain but can be stained with carbolfuchsin (The tubercle bacilli is difficult to stain and has long resistance to decolourisation)

The carbol fuchsin – a bright red stain colours all bacteria and can be removed by sulphuric acid but the tubercle bacillus differs from other bacteria in being difficult to stain and in long resistant to decolourisation once the red stain has penetrated into tubercle bacilli it is difficult to get it out again even with strong acids and also with alcohol. Because of its resistance to decolourisation by acid it is known as Acid –Fast Bacilli (AFB) or Acid-Alcohol Fast bacteria (AAFB)

This include the causative organism of leprosy

Solution

1. Carbol fuchsin 20%

2. 3% acid alcohol/sulphuric acid

3. Malachise green /methylene blue

Method

1. Prepare 2.-3 cm smear, allow to air dry and fix by flaming (pass it 3 times in flame for smear to stick on slide)

2. Flood slide with carbol fuchsin and then heat underneath the slide until steam rises, leave to stain for 5 minutes

3. Rinse the slide in running water

4. Apply 3% acid alcohol for 5 minutes

5. Wash with water the slide should have a faint pink colour

6. Apply malachite green/methyline blue for 30 seconds (counterstain)

7. Wash slide with running water blot and air dry.

8. Examine under oil immersion.

Results

- Acid alcohol fast bacteria appear bright red

- Background and other bacteria and pus cells appear green/blue

Other differential stain

Wright's stain: This is a mixture of eosin and blue which is used to identify blood cells and malaria parasites

Giemsa's stain: A solution of eosin, glycerine and methanol it is used to identify trypanosomes, viral inclusion bodies and rickettsia.

You have successfully finished reading about staining, attempt the question below.

Self-Assessment Test

1. In gram stain method of staining bacteria, gram's iodine is referred to as a _____

    A. Decolorizer

    B. Mordant

    C. Primary stain

    D. Secondary stain

2. Briefly describe the different types of staining method that are used in the laboratory.

3.4 Unit summary

We have come to the end of this unit and hope you enjoyed it. We discussed the different types of microscopes and how they are used for examination of specimens. We also discussed how specimens are prepared for microscopic examination

Under this topic we discussed microscopic examination of different clinical specimens by use of a microscope. We discussed the following types of microscopes and their uses: compound light microscopy, stereo microscope, digital microscope, USB computer microscope, pocket microscope, scanning probe microscope (SPM) and acoustic Thank you for your active participation. In the next sub-unit, we shall discuss the collection and examination of specimens.

References

Burton, G.R.W. (1995) Microbiology for Health Sciences, Philadelphia: Lippincott Norton,
C.T. (1981) Microbiology, London: Addison-Wesley Publishing Company, Inc.

UNIT 4: COLLECTION AND EXAMINATION OF SPECIMENS

4.1 Introduction

We have discussed the different types of microscopes and how they are used to do microscopic examination. We also discussed how specimens are prepared for microscopic examination.In this unit, we will discuss collection of specimen. This topic is not new to you because you probably have already covered it in Fundamentals of Nursing. In nursing, a laboratory specimen is a biological specimen taken from patients and clients, that is, gathered matter of a medical patient's tissue, fluid, or other material derived from the patient which is used for laboratory analysis to assist in diagnosis or staging of a disease process. Common examples of specimens include throat swabs, sputum, urine, blood, surgical drain fluids and tissue biopsies..

4.2 Unit Objectives

By the end of this Unit, you should be able to:

1. Describe the different types of specimens
2. Explain how they are collected.
3. Explain different culture media
4. Explain how each culture media is prepared for antimicrobial sensitivity and serological tests

4.3 Types of specimens

Before we look at the different types of specimens, it is very important to remember from our lesson in Fundamentals of Nursing what the reasons are for collecting clinical specimens and these are:

- To aid in diagnosis –depending the results after examining the specimen you can make a diagnosis basing on the results
- To determine treatment-After examining and making the diagnosis the patient can be put on treatment basing on the results
- To check the patient's condition before administering certain drugs especially anaesthesia to know whether the patient is fit or not.
- To monitor the effect of treatment-the doctor can prescribe treatment after discovering that there is an abnormality, after treatment a specimen can be collected if no abnormality found then the treatment is effective.

We also learned from Fundamentals of Nursing the main four types of specimens that are usually collected in the hospital.

- **Urine**
- **Stool**
- **Sputum**
- **blood**

However, besides the four types of specimens listed above, the table below illustrates the specimen, uses, examination technique, storage and characteristics of specimens.

Table 2: Types of specimens

Specimen	**Uses**	**Extraction technique**	**Storage**	**Characteristics**
Cheek tissue	DNA profiling	Buccal swab		participants can collect themselves; can be collected by mail; so easy to collect that informed consent may be insufficiently addressed
Whole blood	Gives analysis of cellular and plasma components of blood	Requires a nurse, doctor, lab technologist to collect by vein puncture		
Dried blood spot	Gives high quality DNA and RNA	Finger stick		
Organ tissue	Gives high quality DNA, RNA, Mitochondrial DNA, and source of disease	Biopsy	Stores easily for years at room temperature	Many uses shared with blood; also suitable for proteomic analysis; may be difficult to obtain
Plasma	limited DNA	Blood plasma		Requires lab-

	and RNA content	fractionation		technologist to collect
Urine	marker for some diagnostic tests	Urination		non-invasive
Feces	marker for some diagnostic tests	Stool sample		Non-invasive
Skin	Mostly used by forensic teams investigating criminal cases			In criminal cases, collected without consent of donor
Hair	Mostly used by forensic teams investigating criminal cases	Hair analysis		In criminal cases, collected without consent of donor

•

4.4 Cultivation and identification of microorganisms

Culture

Cultivation is the process of propagating (growing) organisms by providing the proper environmental conditions. Growing microorganisms are making replicas of themselves, and they require the elements present in their chemical composition. Nutrients must provide these elements in metabolically accessible form. In addition, the organisms require metabolic energy in order to synthesize macromolecules and maintain essential chemical gradients across their membranes. Factors that must be controlled during growth include the nutrients, pH, temperature, aeration, salt concentration, and ionic strength of the medium *(Jawetz, Melnick and Adelberg 2007).*

Before we discuss the actual process of growing micro-organisms, it very important that we understand how a bacteria grows and the enabling environment for it's growth.

Growth and Reproduction of Bacteria

We shall first look at the growth of bacteria before moving on to look at how they reproduce

Growth of Bacteria

Bacteria, just like other living cells, require nutrients for the maintenance of their metabolism and division. Bacteria differ widely in their nutritional requirements. Some can synthesize all they require from the simplest elements while others, including most pathogens, are unable to do this. They need already made supply of some organic compounds. Other compounds can be synthesized from the breakdown products of complex micro-molecules e.g. proteins.

There are 5 elements that are needed for bacteria to grow. These are:

- Hydrogen and oxygen
- Carbon
- Nitrogen
- Organic growth factors
- Other factors such as calcium

Let us look at each element in detail.

- **Hydrogen and Oxygen.**

These are obtained from water and from by-products of broken down macro-molecules., strong acids and alkaline are harmful to most bacteria except the mycobacterium bacilli.

- **Carbon**

Autotrophs: these are free living non-parasitic bacteria which can use carbon dioxide from the atmospheric air as their carbon source. When Energy for metabolism is from sunlight, they are called *Photo Autotrophs* and it is from organic compound, they are called *chemo Autotrophs*

***Heterotrophs*:** These are generally parasitic bacteria like human pathogens. They derive their carbon from nutrients readily made in complex forms and freely available. The principle sources of carbon are *carbohydrates.*

- ***Nitrogen***

The main source of nitrogen is ammonia usually in the form of ammonium salt. This is available either in the environment or produced by the bacterium as a result of *Deamination of amino acids.*

- ***Organic growth factors***

These are products that can't be synthesized by many bacteria. An outside supply is required e.g. some amino acids, purines.

- ***Others Growth Factors***

Bacteria also need other elements for growth and their functioning e.g. potassium, calcium, magnesium, copper, colbot, manganese, zinc. This act either as activators of reactions or enzyme co-factors. *Enzymes* are used to breakdown the more complex foods into nutrients which are more absorbable by the bacteria.

Environmental Growth Requirements

There are four (4) environmental factors that influence the growth of bacteria. These are:

- Water
- Oxygen
- Carbon dioxide
- Temperature

Let us look at each environmental factor:

Water: moisture is an absolute requirement for growth. It also helps to dissolve food materials for bacteria. It is a major component of bacteria cell (80% of water). It also determines the size of the population that can be supported by the skin.

Oxygen: bacteria differ in their need for oxygen. Anaerobes don't even need a trace of oxygen, whilst strict aerobes can only grow in the presence of oxygen.

Carbon dioxide: this is required by all bacteria and is usually available as a product of metabolism.

Temperature: bacteria differ in their requirements but the optimal temperature for their normal growth is 37 degrees it can vary from:

- Psychrophiles: can only grow below 20 degrees
- Mesophiles: can grow between 25-40 degrees
- Thermophiles: can grow between 55-80 degrees, very low temperatures retard the growth whilst very high temperature will destroy them except for spore-forming organisms.

Stages of Bacteria Growth

There are four (4) main phases of bacteria growth. These are:

- Lag phase
- Exponential phase
- Stationery phase

- Decline phase

We shall look at each phase in turn.

- ***Lag phase:*** This is a stage of metabolic activity. Bacteria undergo a period of adaptation and active macro-molecular synthesis. It increases in size without multiplying/dividing immediately.
- ***Exponetial phase (logarithmic):*** Cell division proceeds at logarithmic rate. Bacteria multiply and each cell divides taking about 30 minutes.
- ***Stationary phase:*** The growth rate decreases so that the number of viable organisms remains constant. This is reached when there is an accumulation of toxic waste or when one or two nutrients ran out. The cell dividing is equal to the number of cells dying.
- ***Decline phase:*** The living bacteria decrease in number. The number of cells dying greatly outnumbers those which are producing and eventually due to accumulation of toxic substances, the cells die.

You are doing very well and i would like to encourage you to continue in the same line. If you are having any challenges and difficulties, write all the specific challenges in your note book. Make references to your microbiology text reference book. You are now starting a new sub-topic, the importance of the Stages of Bacteria Growth.

The Importance of the Stages of Bacteria Growth

You will find this information important and useful when administering antibiotics. It is important so that we know when to give antibiotics as most bacteria are susceptible to antibiotics during the logarithmic phase. In the stationary phase bacteria cannot be killed as this time they would have started forming spores. During the decline phase bacteria could have already built resistance to antibiotics.

Reproduction in bacteria

The type of reproduction found in bacteria is asexual and therefore, it does not involve the exchange of genetic materials between two different bacteria. There are four types of reproduction found in bacteria. These are:

- Binary fission
- Mutation
- Transformation
- Budding

Binary fission: Bacteria are prokaryotic organisms that reproduce asexually. Bacterial reproduction most commonly occurs by a kind of cell division called binary fission. The diagram in Figure 5 is an illustration of binary diffusion.

Figure 14: Diagram of bacterial Binary Fission

Figure 2.2 Bacterial Reproduction: This salmonella bacterium is undergoing the process of binary fission. The cell divides resulting in the formation of two identical cells. (*Janice Haney Carr/CDC)*

Binary fission results in the formation of two bacterial cells that are genetically identical. The bacteria split into two, forming two new cells. When a parent cell reaches its maximum size, it is ready to form new cells, the nucleus doubles in amount, and then division of cytoplasm occurs. The nuclear material divides into two. The cell wall then divides across the bacteria forming walls of two new cells.

Mutation: This is a chemical change of the genes of bacteria causing it to show new characteristics.

Transformation: The mature organism divides into smaller proportion after incorporating foreign DNA into its own DNA. Transformation is common in viruses. Some bacteria are capable of taking up DNA from their environment. These DNA remnants most commonly come from dead bacterial cells. During transformation, the bacterium binds the DNA and transports it across the bacterial cell membrane. The new DNA is then incorporated into the bacterial DNA.

Budding:

The elongation of a cell in one direction and forming new cell walls at the growing point

Spore formation

Spore: this is a thick cell wall with many layers surrounding the micro-organism especially the nuclear material. It is a way of protective means against the adverse environmental (unfavourable) conditions which threatens the bacteria. Unfavourable conditions include:

- Inadequate nourishment
- Extreme heat (dryness) or cold temperature
- Chemicals disinfectants

Therefore bacteria with spores are able to withstand dryness, heat, boiling, strong chemicals and sunlight. They can then germinate when favourable growth conditions occur.

Types of Spores:

There are two types of spores:

- Terminal spore: these are situated in the terminal end of the bacteria protecting the bacterial material.
- Endospore: spore situated inside the bacteria cell protecting the nuclear material.

Organisms that form spores

- Clostridium group
- Anthrax bacilli

You have come to the end of sub-topic on bacteria. Please, attempt the self-test below with specific questions on bacteria and its characteristics.

A. Cultivation

Definition of Cultivation: This is the growth of microorganisms on artificial media under conducive condition for their growth.

B. Medium (culture media)

***Definition of media*:** This is the material in or on which the culture (microorganism) is grown. Cultures may be grown in test tube, dilution bottles and special dishes known as petri-dishes. Organisms are grown at their optimum conditions. This includes: temperature, need for oxygen, carbon dioxide and pH etc.

Types of Culture Media

a. Nutrient broth

The culture media (organisms' food) can be liquid or solid. Below are examples culture media used in the hospital laboratory.

- **Serum agar**: sterile serum added to nutrient agar.
- **Blood agar.** Sterile blood added to melted nutrient agar.
- **Chocolate agar** (boiled blood agar) made by adding blood to melted nutrient agar and then heating the mixture until it turns to dark brown colour
- **Glucose agar**: nutrient agar added to ordinary 1% glucose used for growth of yeasts and moulds.
- **Maltose agar**: (sabouraud's medium) ordinary agar added to 4% maltose used for the growth of yeasts and moulds.
- **Mackonkeys Agar**: This is nutrients agar added to 0.5% bile salts, 1% lactose and neutral red as an indicator. The purpose of bile salts is to restrain growth of all except intestinal group of bacteria (coli-typhoid and dysentery bacilli –gram negative bacilli.
- **Loeffler's blood** serum opaque yellowish-white medium made from a mixture of glucose and blood serum.

Common specimens, micro-organisms looked for and the culture media used.

Type of Specimen	Type of Pathogens	Type of Culture Media
Urine: A specimen of urine is taken when urinary tract	• Gonococci	**Culture media**

infection is suspended.	• Coliforms • Enterococci • Pseudomonas • Trichomonas Vaginalis • Staphylococci • Streptococci	Blood agar – Aerobic Name of Media: Mackonkeys agar – Aerobic
Stool	• Shigella • Salmonella	• Desoxycholate citrate Agar (DCA)
1. **High vaginal swab** (H.V.S) – sterile	• **Staphylococcal** • **Streptococcal** • **Coliform** • **Yeast**	• Blood agar –aerobic • Mackonkeys –aerobic • Blood agar – anaerobic • Chocolate agar –CO2 • Sabourauds agar – aerobic
Pus swab		Glucose agar: nutrient agar added to ordinary 1% glucose used for growth of yeasts and moulds. • Maltose agar (sabouraud's medium) ordinary agar added to 4% maltose used for the growth of yeasts and moulds. • Mackonkeys Agar: this is nutrient agar

		added to 0.5% bile salts, 1% lactose and neutral red as an indicator. The purpose of bile salt is to restrain growth of all except intestinal group of bacteria (coli-typhoid and dysentery bacilli – gram negative bacilli). • Loeffler's blood serum opaque yellowish white medium made from a mixture of glucose and blood serum.

Cultivation of viruses

Since viruses will only replicate within living cells, special methods are employed for culture in vitro

1. **Tissue culture:** cells are obtained from man or animals and then grown in artificial culture in glass vessels in the laboratory. The cells are living and metabolizing and so can support viral replication.
2. **Chick embryo:** Some viruses grow in the cells of the chick embryo. Fertile eggs are kept in an incubator in the laboratory for this purpose. It is rarely used now for virus diagnosis but useful for preparation of buck virus e.g. for antigen or vaccine production.
3. **Laboratory animals**: Some viruses can only be isolated by inoculation of laboratory animals such as mice, rabbits, ferrets and monkeys. After inoculation the animals are

observed for signs of disease or death. The viruses are identified by testing for neutralization of their pathogenicity for animals by standard antiviral.

4.5 Antimicrobial susceptibility and sensitivity testing

In the previous sections we looked at the methods for cultivation and identification of microorganisms culture. We shall now look ate antimicrobial susceptibility and sensitivity testing.

a. Antimicrobial Susceptibility

Antibiotic susceptibility testing (AST) is usually carried out to determine which antibiotic will be most successful in treating a bacterial infection *in vivo*. Ideal antibiotic therapy is based on determination of the aetiological agent and its relevant antibiotic sensitivity. Empiric treatment is often started before laboratory microbiological reports are available when treatment should not be delayed due to the seriousness of the disease. The effectiveness of individual antibiotics varies with the location of the infection, the ability of the antibiotic to reach the site of infection, and the ability of the bacteria to resist or inactivate the antibiotic. Some antibiotics actually kill the bacteria (bactericidal), whereas others merely prevent the bacteria from multiplying (bacteriostatic) so that the host's immune system can overcome them.

b. Sensitivity Testing

Antibiotic sensitivity is the susceptibility of bacteria to antibiotics, it involves the testing of living organisms against a number of antibiotics. A number of antibiotics are introduced to the cultured organism in order to determine the drug which can kill or inhibit the growth of micro-organism. If the organism is sensitive then that drug can be used for treatment. If resistant, the drug may not be used for treatment.

Serological test

Serology is the scientific study of plasma serum and other bodily fluids. In practice, the term usually refers to the diagnostic identification of antibodies in the serum. Serological test maybe any of several laboratory procedures carried out on a sample of blood serum, the clear liquid that separates from the blood when it is allowed to clot.

The purpose of such a test is to detect serum antibodies or antibody-like substances that appear specifically in association with certain diseases. Such antibodies are typically formed in response to an infection (against a given microorganism), against other foreign proteins (in response, for example, to a mismatched blood transfusion), or to one's own proteins (in instances of autoimmune disease).

Serological tests may be performed for diagnostic purposes when an infection is suspected, in rheumatic illnesses, and in many other situations, such as checking an individual's blood type. Serology blood tests help to diagnose patients with certain immune deficiencies associated with the lack of antibodies. There are several serology techniques that can be used depending on the antibodies being studied. These include: ELISA, agglutination, precipitation, complement-fixation, and fluorescent antibodies.

Some serological tests are not limited to blood serum, but can also be performed on other bodily fluids such as semen and saliva, which have (roughly) similar properties to serum.

Unit Summary

Well done. We have come to the end of unit 4 and hope you enjoyed it. In Unit 4, we discussed the different types of specimens being Cheek Tissue, Whole Blood, Dry blood spot, and Organ tissue, Plasma, Faeces, Hair and Urine. In this unit, we went on to define Cultivation of Micro-organism, Antimicrobial Susceptibility and Serological Tests. We defined Cultivation as the growth of microorganisms on artificial media under conducive condition for their growth. We also defined Medium (culture media) as the material in or on which the culture (microorganism) is grown. The unit also discussed the fact that cultures may be grown in test tube, dilution bottles and special dishes known as petri-dishes. Later we discussed the different types of Culture Media being used. The culture media (organisms' food) can be liquid or solid and examples are:.

- **Serum agar**
- **Blood agar.**
- **Chocolate agar**
- **Glucose agar**:

- **Maltose agar**:
- **Mackonkeys Agar**:
- **Loeffler's blood**

Cultivation of viruses

Since viruses will only replicate within living cells, special methods are employed for culture in vitro. Examples are:

Tissue culture: cells are obtained from man or animals and then grown in artificial culture in glass vessels in the laboratory. The cells are living and metabolizing and so can support viral replication.

Chick embryo: Some viruses grow in the cells of the chick embryo. Fertile eggs are kept in an incubator in the laboratory for this purpose. It is rarely used now for virus diagnosis but useful for preparation of buck virus e.g. for antigen or vaccine production.

Laboratory animals: Some viruses can only be isolated by inoculation of laboratory animals such as mice, rabbits, ferrets and monkeys. After inoculation the animals are observed for signs of disease or death. The viruses are identified by testing for neutralization of their pathogenicity for animals by standard antiviral. Finally the in this Unit, we also discussed:

Topics such as Antimicrobial Susceptibility are usually carried out to determine which antibiotic will be most successful in treating a bacterial infection *in vivo*. While Sensitivity Testing involves the testing of living organisms against a number of antibiotics and Serological test maybe any of several laboratory procedures carried out on a sample of blood serum, the clear liquid that separates from the blood when it is allowed to clot

In the next unit, which is Unit 5, we shall discuss infections and defence mechanisms.

But just before that, here is an activity for you. Write it in your note book

Self-Assessment Test

1. The propagation of a microorganism outside of the body, usually on or in artificial growth media is known as _____
   A. Culture media
   B. Culture
   C. Incubator
   D. Morphology

2. The study of the physical shape and size of a specimen or microorganism is known as _____
   A. Motility
   B. Morphology
   C. Pathology
   D. Doxology

Well done, the answers are to the two questions are:

1. B
2. B

References

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UNIT 5: INFECTIONS AND DEFENCE MECHANISMS (IMMUNITY)

5.1 Introduction

Welcome to the last unit in Microbiology. This Unit looks at very interesting topics on; infections and defence mechanisms. Having studied the previous topics very carefully, I am convinced that you are now able to connect very well with the topics you had earlier covered under introduction to microbiology and types of microorganisms. This topic is also covered in more detail in Anatomy and Physiology. In Anatomy and Physiology, we learned that from the time one is in their mother's womb to the end of their life, they are constantly under attack from a wide range of pathogenic micro-organisms such as bacteria, virus, fungi etc. The body in return develops defence which can be divided into Non-specific and Specific defence Mechanism

Most of the infections are caused by microorganisms which can also be referred to as pathogens. Pathogens are microorganisms that are capable of causing disease and commensals are the normal body flora. The pathogenicity of a microbe depends on the host as much as the microbe and commensals may act as pathogens in a susceptible patient. The effects that may result from disease process include tissue destruction as a result of inflammatory reaction, fluid leakage and so on. Therefore on this topic will discuss the pathogenicity of infection and how the body defends itself against infection.

5.2 Unit Objectives

By the end of this unit you should be able to:

1. Define the key terms
2. Identify sources of infections
3. Outline mode of entry and transmission
4. Explain the body's reaction to infection
5. Explain the defence mechanisms of the body
6. Describe nosocomial and opportunistic infections

5.3 Definition of common terminologies

Before we get into a detailed discussion, let us discuss specific terms used in this topic. It is important to master these terms as they will help you understand this unit better.

- **Local or focal infection**: this is infection confined to one area/part of the host e.g joint
- **Generalised or systemic** i**nfection;** this is when pathogenic micro-organisms spread from one part to other parts of the body
- **Primary infection:** this is the initial infection (first infection)
- **Secondary infection:** infection that comes during the course of a primary infection e.g. a child with measles may develop bronchial pneumonia. It is also called superimposed infection
- **Mixed infection:** Infection caused by more than one type of pathogen
- **Acute**: Depending on the onset; acute infection is the sudden occurrence of infection with immediate manifestations of signs and symptoms
- **Chronic**: prolonged infection, lasting more than 2 weeks to manifest clinical signs and symptoms
- **Endogenous infection;** this is an infection of the body tissues whose causative organism comes from outside the body. May also be referred to as cross infection
- **Opportunistic infection;** this is an infection whose causative organisms takes advantage of lowered immunity of the host for example Normal floras which take advantage of the lowered immunity.
- **Communicable disease, this is the condition** which can be passed or carried or transmitted from one person to another either directly or indirectly e. g Tuberculosis, HIV/AIDS
- **Non communicable disease**, this is a condition which cannot be transferred to another individual e.g hypertension, diabetes mellitus
- **Bactereamia:** Presence and multiplication of bacteria in the blood.
- **Septicaemia:** Microorganisms have entered the blood stream and are actively multiplying and producing toxins
- **Toxaemia:** The concentration of bacterial toxin in the blood

- **Pyaemia:** type of septicaemia where micro-organisms are clumped together into small thrombi, they (disseminate) go to various sites through the body causing small scattered abscess.

- **Reservoir;** It is defined as “any person, animal, arthropod, plant, soil, or substance “(or combination of these in which an infectious agent lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host”

- **Carrier;** a carrier is defined as an infected person or animal that harbours a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection for others

- **Incubation** it is defined as the time between exposure to an infectious disease and the appearance of the first signs or symptoms It could be directly or indirectly from an infected person to another person, from an infected animal to man , or from an infected person to an animal, including arthropods

- **Endemic disease;** it is the disease present in the community all the time but only recognisable in few cases e.g malaria is endemic in Zambia

- **Epidemic;** the disease affecting many people in a region at the same time and spreading rapidly e.g cholera outbreak

- **Pandemic;** it is the unusual occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health related events clearly in excess of normal expectancy (LAST,1995) The disease affecting many people spread all over the world e. g HIV/AIDS

- **Outbreak;** this is where two or more related cases in infections, suggesting the possibility of a common source or transmission between cases

5.4 Sources of infection

Source of infection is defined as the person, animal, objects or substance from which an infectious agent passes or is disseminated to the host. It is the invasion or entrance and growth of a pathogen (microorganisms) into the body tissues causing disease.

The main source of infection is the excretions and secretions of people and animals harbouring the organisms:

- Excretions: These include faeces, urine, pus, sputum

- Secretions: They include nasal digalets e.g sneezing, cough droplets and saliva.

- Contaminated food, water, milk etc
- Infected farm animal
- Unwashed hands
- Contaminated air, soil, dust and plants
- Human beings: People who harbour micro-organisms are classified in 3 groups.

i. Typical cases**:** those suffering from the disease

ii. Non recognised cases: these have no signs and symptoms but can spread the disease

iii. Carriers: Those who harbour the disease and carriers are in two groups:

a. *Convalescent carrier* People who suffered from the disease signs and symptoms have disappeared and are recovering from the disease but the organism is still in the body for weeks or months.

b. *Health carrier:* These are people who harbour the organism but have not developed the disease at any time.

Factors determining the development and spread of infection

i) An etiological agent responsible for the disease should be present
ii) There should be a reservoir or carrier for the etiological agent to survive
iii) The infecting agent should be able to escape from the reservoir of infection through the portal of exit
iv) There should be a possible source of entry to transmit the agent to a new susceptible host
v) The agent should be able to invade the new host
vi) The host should be susceptible

We have come to the end of this sub-unit on sources of infection and hope you enjoyed it. In this section, we defined key terminologies, outlined the media through which infection is spread and explained the factors that contribute to development and spread of infection in the host. In the next section we shall look at the modes of entry and spread of infection.

5.5 Mode of entry and transmission of infection

We have discussed the sources of infection in relation to outlined media through which infection is spread and explained the factors that contribute to development and spread of infection in the host. In this sub-unit, we will discuss the modes of entry and spread of

infections. By the end of this section, you are expected to explain the different routes of entry and spread of infections in the body

1. Mode of entry

- **Inhalation:** This is through the nose and mouth to the respiratory tract during coughing and sneezing. Examples of organisms which can be inhaled are T.B .Bacillus mumps virus, diphtheria, common cold etc.
- **Ingestion:** Through the mouth to the alimentary tract eg dysentery, cholera, typhoid bacteria poliomyelitis and hepatitis A viruses
- **Inoculation:** This is penetration through the skin and mucous membrane due to trauma and insect bite. Eg malaria parasite, worms, syphilis and Gonococci
- **Transplacental:** Through or across placenta from other to foetus. Eg rubella virus, syphilis, small pox virus and HIV

2. Mode of transmission

Infection is transmitted in any of the following ways namely:

a. Contact

i. Direct contact: a person comes in physical contact with pus, draining skin, stool urine and mucous secretion.

ii. Indirect contact: this is via inanimate material when people come in contact with contaminated material eg drinking glasses, spoons, toys, door handles and bathroom pans etc.

b. **Through blood**

Infected blood can enter through blood transfusion and inoculation i.e. cuts in the skin

c. Airborne

These are droplets of one person to another during pelting coughing and sneezing or shed from infected surfaces.

d. Vector borne

These are transmitted by pest's insects etc. Mosquito – malaria dogs

We have come to the end of this sub-unit on the modes of entry and spread of infections in the body.

In the next section we shall look at the body reaction to infection.

5.6 Body reaction to infection

We have discussed the modes of entry and spread of infection in the body. I hope you enjoyed it. In this sub-unit, we will discuss the body reaction to infection. By the end of this section, you are expected to to explain how the body responds when pathogens have managed to break the natural barriers. This section basically discusses the non-specific and specific defence mechanisms of the body. The most important defence mechanism is immunity.

Immunity

.Definition of Immunity

Immunity is a system of biological structures and processes within an organism that protects against disease by identifying and killing pathogens and tumour cells. It detects a wide variety of agents, from viruses to parasitic worms, and needs to distinguish them from the organism's own healthy cells and tissues in order to function properly. It is composed of leucocytes (white blood cells), tissue macrophages and lymphoid tissues.

A. Types of immunity

I. Natural acquired immunity

This is passed from one generation to another though genes or if one has suffered from a disease.It may be passive or active.

- **Natural passive acquired immunity**

  Here the antibody is obtained by the child from the mother either across the placenta or in breast milk. The human placenta allows maternal antibodies to pass into the foetal circulation. The baby is then born having maternal antibodies against the diseases to which the mother is immune. This provides

the baby with defence immediately after birth. The antibodies do not persist. They disappear after a few months.

- **Natural active acquired immunity**

  Natural active acquired immunity: this is the type of immunity which is acquired in response to the entry of a live pathogen into the body (i.e., in response to an actual infection) - it has long duration. Examples are typhoid fever, measles and small pox.

II. Artificial acquired immunity

This is subdivided into active or passive according to whether the person actively participates by making his own antibodies (active) or passively through receiving antibodies present in therapeutic sera.

- **Artificial passive acquired immunity**
  In here the antibody is obtained or protection is derived from the injection (serum) of prepared or readymade antibodies. e.g administering preformed antibodies of rabies vaccine following a rabies dog bite..

- **Artificial Active acquired immunity**
  In here the antibody is obtained or protection is derived from introducing antigens such as vaccines into the body and then the body produces specific antibodies against them. Expanded Program of Immunization (EPI) is aimed at stimulating the bodies of children to produce specific antibodies against the common childhood killer diseases such as measles, poliomyelitis etc

You have come to the end of this topic in which you were looking at the body immunity. I would like you to attempt the activity below. There are various questions on immunity and other related topics.

5.7 Self Assessment Test

1. Immunity due to injection of an antigen is an example of_____

   A. Artificially acquired active immunity
   B. Active acquired immunity

C. Natural immunity
D. natural passive acquired immunity

2. What type of immunity results from vaccination?

A. Artificially acquired active immunity

B. Natural immunity

C. Natural passive acquired immunity

D. Autoimmune system

3. What type of immunity results from transfer of antibodies from one individual to a susceptible individual by means of injection?

A. Natural immunity
B. Natural passive acquired immunity
C. Autoimmune system
D. Artificially acquired passive immunity

4. What type of immunity results from recovery from mumps?

A. Natural acquired active immunity
B. Natural passive acquired immunity
C. Autoimmune system
D. Artificially acquired passive immunity

5. Newborns' immunity due to the transfer of antibodies across the placenta is an example of_____

A. Natural immunity
B. Natural acquired passive immunity
C. Autoimmune system
D. Artificially acquired passive immunity

6.White Blood Cells (WBC) are cells of the immune system involved in defending the body against both infectious diseases and foriegn material. There are several different WBCs, they all have many things in common, but are all distinct in form and function. WBCs are often characterised as granulocytes or agranulocytes. Which of the following leucocytes are agranulocytes:

A. Neutrophils

B. Basophils

C. Macrophages

D. Eosinophils

Thank you for attempting the self test above, find the answers below to the questions above:

1.

Congratulations, now you need to move on to your next sub-topic on Antibody-antigen reaction.**5.8 Antibody-antigen reaction**

Welcome to this topic where we are going to discuss Antibody-antigen reaction. This topic is very interesting and it will help you to link the immunity and how the body responds to infections and various diseases caused by different microorganisms. There are some terms very important for this topic that you need to learn before you move. Please, take your time to grasp the meanings of these terms;

Affinity

Antibody affinity is the strength of the reaction between a single antigenic determinant and a single combining site on the antibody. It is the sum of the attractive and repulsive forces operating between the antigenic determinant and the combining site of the antibody

Avidity

Avidity is a measure of the overall strength of binding of an antigen with many antigenic determinants and multivalent antibodies. Avidity is influenced by both the valence of the antibody and the valence of the antigen. Avidity is more than the sum of the individual affinities.

Specificity

Specificity refers to the ability of an individual antibody combining site to react with only one antigenic determinant or the ability of a population of antibody molecules to react with only one antigen. In general, there is a high degree of specificity in antigen-antibody reactions. Antibodies can distinguish differences in:

- The primary structure of an antigen
- Isomeric forms of an antigen
- Secondary and tertiary structure of an antigen

Cross reactivity

Cross reactivity refers to the ability of an individual antibody combining site to react with more than one antigenic determinant or the ability of a population of antibody molecules to react with more than one antigen. Cross reactions arise because the cross reacting antigen shares an epitope in common with the immunizing antigen or because it has an epitope which is structurally similar to one on the immunizing antigen (multispecificity).

Antigen

This is a substance that stimulates the production of antibody or reacts with them when introduced in the body.

Antibody

An **antibody** (Ab), also known as an **immunoglobulin** (Ig), is a large Y-shaped protein produced by B cells that is used by the immune system to identify and neutralize specific foreign objects such as bacteria and viruses. The antibody recognizes a unique part of the foreign target, called an antigen.

Structure of Antibody-Antigen Interaction

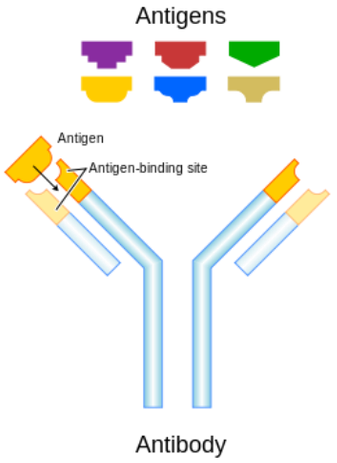

Figure 15: Structure of Antibody-Antigen Interaction

Explanation of the Antigen-antibody Reaction.

Each tip of the "Y" of an antibody contains a paratope (a structure analogous to a lock) that is specific for one particular epitope (similarly analogous to a key) on an antigen, allowing these two structures to bind together with precision. Using this binding mechanism, an antibody can *tag* a microbe or an infected cell for attack by other parts of the immune system, or can neutralize its target directly (for example, by blocking a part of a microbe that is essential for its invasion and survival). This is what is called antibody-antigen reaction.

The arms of the Y, for example, contain the sites that can bind two antigens and, therefore, recognize specific foreign objects. This region of the antibody is called the ***Fab (fragment, antigen binding) region*.** The base of the Y plays a role in modulating immune cell activity. This region is called the ***Fc (Fragment, crystallizable) region***, and is composed of two heavy chains that contribute two or three constant domains depending on the class of the antibody. The Fc region ensures that each antibody generates an appropriate immune response for a given antigen, by binding to a specific class of Fc receptors, and other immune molecules, such as complement proteins. By doing this, it mediates different physiological effects including recognition of opsonized particles, lysis of cells, and degranulation of mast cells, basophils and eosinophils

Classification of antibodies

Antibodies can come in different varieties known as isotypes or classes. In placental mammals there are five antibody isotypes known as IgA, IgD, IgE, IgG and IgM. They are each named with an "Ig" prefix that stands for immunoglobulin, another name for antibody,

and differ in their biological properties, functional locations and ability to deal with different antigens, as shown in the table below

Antibody isotypes of mammals

Name	Types	Description
IgA		Found in mucosal areas, such as the gut, respiratory tract and urogenital tract, and prevents colonization by pathogens. Also found in saliva, tears, and breast milk.
IgD		Functions mainly as an antigen receptor on B cells that have not been exposed to antigens. It has been shown to activate basophils and mast cells to produce antimicrobial factors.
IgE		Binds to allergens and triggers histamine release from mast cells and basophils, and is involved in allergy. Also protects against parasitic worms.
IgG		In its four forms, provides the majority of antibody-based immunity against invading pathogens. The only antibody capable of crossing the placenta to give passive immunity to the foetus.
IgM		Expressed on the surface of B cells (monomer) and in a secreted form (pentamer) with very high avidity. Eliminates pathogens in the early stages of B cell mediated (humoral) immunity before there is sufficient IgG.

You have just covered the different types of antibodies/immunoglobulins, attempt the two questions below.

Self-Assessment Test

1. The antibodies that can bind to large parasites are_____

   A. IgA

   B. IgG

C. IgE

D. IgM

2. The antibodies found in mucus, saliva, and tears are_____

A. IgA

B. IgG

C. IgE

D. IgM

5.9 Defence mechanisms

Multicellular animals have dedicated cells or tissues to deal with the threat of infection. Some of these responses happen immediately so that an infecting agent can be quickly contained. Other responses are slower but are more tailored to the infecting agent. Collectively, these protections are known as the immune system. The human immune system is essential for survival in a world full of potentially dangerous microbes.

Its defences can be arranged into two groups. The Nonspecific defence mechanism (protects against invasion) and specific defence mechanism (checks the uncontrolled replication of microorganisms once in the body)

Non-specific host defence mechanisms (Innate Immunity) serve to protect the body from a variety of foreign substances or pathogens (first and second line of defence)

Specific host defence mechanisms are directed against a particular foreign substance or pathogen that has entered the body (third line of defence)

Body lines of Defence

The skin and mucous membranes

a. Skin

Both the skin and the mucous membranes form the first line of defence and belong to nonspecific defence mechanisms.

The intact skin provides a barrier through which most micro-organism cannot pass it provides a good defence against invasion. Most microorganisms enter the body through a break in the skin.

The secretions of the skin by sweat and sebaceous glands which are acidity and have chemicals which have anti-bacterial properties tend to eliminate pathogenic bacteria.

b. **Mucous Membranes/Surfaces**

Bacteria are removed mechanically from mucous membranes such as the nose, mouth and vagina as mucus secretions trap the organism bacteria in the respiratory tract are trapped in the sticky secretion on the surface (mucus) and then swept away by the action of cilia, minute hair-like ladies projecting from the cells lining the cavity.

2.Secretions:

All organs in the body which are in contact with the external environment produce secretions which act in 2 ways:

- **Mechanical action**: eg secretions of the bronchi entrap organisms and these are propelled away from the alveoli by the action of cilia in the bronchi and expelled tears by sneezing and coughing in the eye

- **Chemical action**

Secretions may be acidic like sweat and gastric juice or strongly alkaline like bile.

Microbial antagonism by indigenous micro flora; and overall nutritional status and good state of health.

Second line of defence:

- Transferrin and lactoferrin, are tie up iron, thereby preventing pathogens access to this essential mineral.

- Fever that augments host defence by stimulating leukocytes to deploy and destroy invaders, reducing available free plasma iron, and inducing the production of IL-1, which causes proliferation, maturation, and activation of lymphocytes in the immunologic response. Elevated body temperature also slow down the rate of growth of certain pathogens and can even kill some especially fastidious pathogens.

- Interferon's, are small, antiviral proteins that prevent viral multiplication in virus-infected cells and serve to limit viral infections.

- Inflammation, localized an infection prevent the spread of microbial invaders, neutralizes toxins, and aid in the repair of damaged tissue.

Phagocytosis.

The white blood cells, together with certain tissue cells move towards the bacteria and attempt to ingest them by a process known as *phagocytosis,* engulfment by phagocytes and ingestion by lysosomes. By surrounding the area of infection with plasma which often dots and with phagocytes, the infection may be prevented from spreading.

Flow of fluid away from the area of inflammation is largely by lymph vessels. Bacteria escaping from the area will usually enter the lymph and will be arrested at the nearest lymph node. Secondary inflammatory reaction may take place (lymphadenitis) but in many cases the infection will not become generalised. This inflammatory response of the tissues tends to restrict the spread of infection within the body and in many cases to overcome it at the cost of inner area damage. If for some reason the inflammatory response is deficient, the infection will tend to become systemic and much more serious

A. **Complement system**,

Involves approximately 30 different blood proteins that interact in a step-wise manner known as the complement cascade. Consequence of activation of the complement system:

- Initiation and amplification of inflammation.
- Attraction and activation of leukocytes.
- Lysis of bacteria and other foreign cells.
- Increased phagocytosis by phagocytic cells.

These defences operate against a variety of micro-organisms.

Specific defence mechanism

While healthy phagocytes are critical to good health, they are unable to address certain infectious threats. Specific immunity is a complement to the function of phagocytes and other elements of the innate immune system.

In contrast to innate immunity, specific immunity allows for a targeted response against a specific pathogen. Only vertebrates have specific immune responses.

Two types of white blood cells called lymphocytes are vital to the specific immune response. Lymphocytes are produced in the bone marrow, and mature into one of several subtypes. The two most common are T cells and B cells.

An antigen is a foreign material that triggers a response from T and B cells. The human body has B and T cells specific to millions of different antigens. We usually think of antigens as part of microbes, but antigens can be present in other settings. For example, if a person received a blood transfusion that did not match his blood type, it could trigger reactions from T and B cells.

A useful way to think of T cells and B cells is as follows: B cells have one property that is essential. They can mature and differentiate into plasma cells that produce a protein called an antibody. This protein is specifically targeted to a particular antigen. However, B cells alone are not very good at making antibody and rely on T cells to provide a signal that they should begin the process of maturation. When a properly informed B cell recognizes the antigen it is coded to respond to, it divides and produces many plasma cells. The plasma cells then secrete large numbers of antibodies, which fight specific antigens circulating in the blood.

T cells are activated when a particular phagocyte known as an antigen-presenting cell (APC) displays the antigen to which the T cell is specific. This blended cell (mostly human but displaying an antigen to the T cell) is a trigger for the various elements of the specific immune response.

A subtype of T cell known as a T helper cell performs a number of roles. T helper cells release chemicals to

- Help activate B cells to divide into plasma cells
- Call in phagocytes to destroy microbes
- Activate killer T cells

Once activated, killer T cells recognize infected body cells and destroy them.

Regulatory T cells (also called suppressor T cells) help to control the immune response. They recognize when a threat has been contained and then send out signals to stop the attack.

Organs and Tissues

The cells that make up the specific immune response circulate in the blood, but they are also found in a variety of organs. Within the organ, immune tissues allow for maturation of immune cells, trap pathogens and provide a place where immune cells can interact with one another and mount a specific response. Organs and tissues involved in the immune system include the thymus, bone marrow, lymph nodes, spleen, appendix, tonsils, and Peyer's patches (in the small intestine).

5.9.1 .Inflammation (inflammatory reaction/process)

Inflammation is the complex biological response of vascular tissues to harmful stimuli, such as pathogens, damaged cells, or irritants. It is a protective attempt by the organism to remove the injurious stimuli as well as initiate the healing process for the tissue. This is a general reaction of body tissues to a noxious agent such as chemical or physical in nature.

Following injury or entry of microorganisms into body tissues, a series of changes take place. The small blood vessels increase in diameter and the rate of blood flow increases, the area becomes redder and warmer than its surroundings. This causes swelling of the part.

5.9.2 The lymphatic system

The lymphatic system is part of the circulatory system, comprising a network of conduits called lymphatic vessels that carry a clear fluid called lymph directionally towards the heart., Lymphoid tissue is found include lymph nodes, lymphoid follicles associated with the digestive system such as the tonsils, the spleen, thymus and the bone marrow,

Lymphatic tissues play an important part in the immune system and their main functions include:

- returning plasma proteins to the bloodstream;
- Synthesis and maturation of B and T-cells which assist the body to build up an effective immunity to infectious diseases;
- lymph nodes filter out micro-organisms (such as bacteria) and foreign substances such as toxins, etc

5.9.3. Humoral Defence

The two types of immunity are;

a. Innate Immunity (natural) or non-specific immunity.

This is the natural or inborn type of immunity that is not acquired after birth. We are born with it.

b. Acquired (Specific/Adaptive) immunity.

This type of immunity occurs in response to infection. It is divided in to two components and these are;

Humoral immunity

Cell mediated immunity Innate Immunity (natural) or non-specific immunity

This prevents entry of micro-organisms into tissues or, once they have gained entry, eliminates them prior to the occurrence of disease

This includes a number of systems, which functions immediately or at short notice. They are referred to as non-specific because they respond to microorganisms equally and consistently.

Characteristics

- Present from birth.
- Non-specific - acts on many organisms and does not show specificity.
- Does not become more efficient on subsequent exposure to same organisms

Prevention of entry of organisms

1. Mechanical barriers at body surfaces skin through desquamation, mucous membranes - disruption leads to infection.
2. Antibacterial substances in secretions, lysozyme (found in tears, saliva, vaginal and seminal secretions) lactoferrin, low pH of stomach contents.
3. Prevention of stasis.

- Peristalsis/flow of urine/upward movement of secretions in bronchial tree.
- Clinical relevance; urinary infection with urinary obstruction; decreased bronchial
- Ciliary activity – nasal hairs act as filters and the respiratory tract is lined with cilia to propel the mucous and trapped microorganisms out
- Coughing; cough reflex helps to clear the microorganisms or foreign body trapped in the airway.

- Mechanism of respiration if functioning properly effectively protect host against many air borne pollutants
- Vomiting
- Wax formation in the ears

Non-specific elimination of micro-organisms

1. Phagocytosis –this is the ingestion and killing of microorganisms by specialised cells (phagocytes). Phagocytes - polymorphonuclear leukocytes (neutrophils) - mononuclear phagocytes (monocytes, macrophages).
2. Opsonisation - the process of coating microorganisms with some of the proteins found in plasma, to make them more easily phagocytosable. An OPSONIN is a plasma protein binding to bacteria. This promotes adhesion between the opsonised bacteria and macrophages because the opsonin binds to receptors on phagocyte membrane e.g. complement with complement receptors and phagocytes. Opsonisation and phagocytosis are more efficient in immune individuals.

5.9.4 Normal body flora

Introduction

1. The term "normal microbial flora" denotes the population of microorganisms that inhabit the skin and mucous membranes of healthy normal persons. It is doubtful whether a normal viral flora exists in humans.
2. The skin and mucous membranes always harbor a variety of microorganisms that can be arranged into two groups:
3. (1) The resident flora consists of relatively fixed types of microorganisms regularly found in a given area at a given age; if disturbed, it promptly reestablishes itself.
4. (2) The transient flora consists of nonpathogenic or potentially pathogenic microorganisms that inhabit the skin or mucous membranes for hours, days, or weeks; it is derived from the environment, does not produce disease, and does not establish itself permanently on the surface. Members of the transient flora are generally of little significance so long as the normal resident flora remains intact. However, if the resident flora is disturbed, transient microorganisms may colonize, proliferate, and produce disease

Definition:

Normal body flora is organisms which are found in specific sites of the body or are microorganisms that are well established on the external and internal surfaces of the body without producing disease.

Normal flora's Relationship to the Body

The normal human body has a profuse normal flora. These relationships of micro-organism with the body may be on the following basis:

A. **Symbiosis**: micro-organisms live harmoniously with the body (host) and with other micro-organisms where both benefit. Eg the content of the alimentary canal nourish the flora living there and in turn the flora synthesise vitamin K which the body needs but cannot provide for itself.

B. **Commensalism**: this is the relation between two different kinds of organisms when one receives benefits from the other without damaging it

C. **Mutualism:** The relation between two different species of organisms that are interdependent; each gains benefits from the other

D. **Parasitism:** The relation between two different kinds of organisms in which one receives benefits from the other by causing damage to it (usually not fatal damage)

E. **Obligatory**: this is where the microorganism is completely dependent on the host

Antibiosis: An association between organisms that is harmful to one of them or between organisms and a metabolic product of another. This has led to development of antibiotics. An antibiotic is a chemical agent which one organism produces to inhibit or kill another.

Types of normal flora

A. Resident flora; these are organisms constantly found in a particulars site of the body e.g staphylococci albus which lives in the poles of health or damaged skin without causing disease.

B. Transient flora; this is non-pathogenic or potentially pathogenic organism from the environment. They stay on the site from seconds to weeks but do not produce disease. (They inhabit the body sporadically)

The skin and mucous membrane always harbour normal floras because they are in contact with the environment. Some body parts have little or no normal flora:

These are:

- The lower respiratory tract. This is facilitated by micro ciliary bodies that propel organisms to external surface.
- The stomach due to the production of hydrochloric acid

- The blood and internal organs-because of leucocytes (phagoecytic action) and physical separation from external

Elements that alter the growth of normal flora

i. **Moisture**: it encourages growth of micro-organisms e.g axilla, between groins, between toes. These areas must be kept dry to avoid over growth of organisms

ii. **Antibiotics;** they may kill the normal flora e.g of the intestine and encourage the growth of other organisms.

iii. **Antiseptic;** regular use of antiseptics (soap) reduces the bacteria population by more than 95% which can lead to death of normal flora

Positive effects of normal flora

i. Prevent growth of pathogenic organism by means of competition or antagonism reaction.

ii. Allows motivation of the immune response

iii. May induce low antibodies that may cross react with pathogens.

Negative effects of normal flora

i. Normal flora may become opportunistic pathogen

ii. Some bowel flora acted upon by certain diets may form carcinogens

iii. Low grade toxaemia due to endotoxin of gastro intestinal flora is possible

iv. It may senergise/promote growth of pathogens in certain

Body sites and their normal flora

Micro-flora of the Skin

The skin has a rich resident of bacteria flora. It has 104/cm2. The anaerobic predominate in areas with sebacours gland in axillae and groin. Example of micro-organisms that present on the skin are:

Aerobic organisms:

- staphylococcal epidemidis
- Staphylococcol aureus

- Anaerobic organisms:
- Propionobacte
- Klebriella

Micococci

- Corynebacteria
- Coliform

Respiratory tract

The lower respiratory tract is sterile but the upper is colonised heavily. The mouth, nasal-pharynx and saliva has about 10 organisms/ml

- Dental plugue consists almost entirely of microorganisms

Nose: - staphylococco epidermidis

- Coryne bacteria
- Staphylococco aurevs

Oral pharyox:- Streptococco viridians

- Branhanella
- Corynebacteria
- Bacteroides
- Spirochaetes
- Lacfo bacilli
- Veriolla Actinornyles
- Streptococco pyogens
- Neisserin meningititis

Gastro-intestinal tract

The number increase as one moves down the tract and the flora becomes progressively more diverse and anaerobic.

The oesophagus: has a flora similar to that of the pharynx

The duodenum, jejunum and upper ileum the normal flora is scanty

Large intestine it is heavily colonised faeces contain enormous number of bacterium making up to of the weight. Many of these are anaerobic. The many bacteria account for gas that is expelled

Large intestine	**Less common**
- Bacteriodes	- Klebsiella
- Bifido bacteria	- Proteus
- Anacrobic cocci	- Enterobacter
- Escherichia coli (E.coli)	- Psevdomonas
- Streptococcal faecalis	
- Clostridia	
- Lactobacilli	

Genital urinary tract:

For anatomical reasons, the female genital tract has more micro-organisms (is much more heavily colonised) than that of the male. Normal vaginal secretion contains 10^8 organisms 1ml.

Female:

Vulva: Staphylococco epidermidis

- Coryne bacteria
- Coliforms
- Streptococco faecalis
- Yeasts

Vagina: Normal Flora of the vagina change with age and mostly under the influence of oestrogen during these phases, lacto-bacilli predominate, thus acting on the glycogen, converting it to lactic acid. This consequently reduces the vaginal PH to 3.8 – 4.7 where as in pre-puberty stage, it is slightly acidic normal flora include:

- Lacto bacilli

- Coliforms
- Streptococcal faecalis
- Yeasts
- Corynebacteria
- Bacteroides

Male and Female

Urinary bladder: is usually sterile though the distal /anterior urethra may contain

- Staphylococcal epidemides
- Corynebacteria
- Uareaplasma

External auditory meatus

- Staphylococcal epidemides
- Corynebacteria
- Acid fast bacteria in the wax- occasionally

Conjunctival sac

Microbial population are minimised by the mechanical flow of tears and presence of lysozymes organisms include:

- Corynebacteria
- Staphylococcal

We have come to the end of this sub-unit on the body reaction to infection. In this section, we discussed non-specific and specific body defence mechanism against infection. We also discussed the roles of inflammation, lymphatic system and normal flora in body defence mechanism. Thank you for your active participating.

In the next section we shall look at nosocomial and opportunistic infections.

But just before that, here is an activity for you. Write the answers in your note book

Activity 3.1

1. Explain what is involved in the non-specific and specific body's response to infection

2. Explain the role of normal flora in the body's defence mechanism
3. Mention at least five (5) normal flora of the human body and where they are found

5.10 Nosocomial and opportunistic infections

We have discussed the body reaction to infection in relation to non-specific and specific body defence mechanism against infection. We also discussed the roles of inflammation, lymphatic system and normal flora in body defence mechanism. I hope you enjoyed it.

In this sub-unit, we will discuss the nosocomial and opportunistic infections as some of the emerging trends in nursing and medical science in general. By the end of this section, you are expected to define nosocomial and opportunistic infections, explain how they spread, give some examples of each and outline how they can prevented

Nosocomial infections

A nosocomial, or hospital-acquired, infection is defined as an infection that is identified at least forty-eight to seventy-two hours either following admission or discharge from health facility.

Methods of Transmission of Nosocomial Infection

Nosocomial infections are commonly transmitted when hospital officials become complacent and personnel do not practice correct hygiene regularly.

The first method by which a hospital acquired infection may be transmitted is direct contact. Direct contact is physical or actual touching of the infected person, animal, or other reservoir of infection. Infections are most commonly transferred through hands that come into contact with the infection. The second method of transmission is indirect contact. The physical presence of the infected host doesn't have to present for an infection to spread. The bedding, clothing, toys, handkerchiefs, and surgical instruments all can serve as vectors in the spread of infection. Another method of transmission is through droplet spread. An infected patient sneezing, coughing, singing, and sometimes even talking can spread the infection. Although these droplets typically don't travel more than a few feet away from the source, they are still a method of infection transmission. Inhalation of these infected particles can lead to a transmission. The last method of transmission is through vehicles, such as water, food, or biological products. This can occur through ingestion, inoculation, or by deposit on skin or of the mucous membrane. Part of the reason hospital acquired infections are very difficult to stop is because they have many mediums of being transferred. A hospital staff must be very diligent in the disinfection and sterilization of instruments and equipment process to avoid complications. Some examples of known nosocomial infections include Candida albicans, Tuberculosis, Urinary tract infection,

Prevention of nosocomial infections

Hand Washing

The most common way infections are spread is by staff members touching a patient or a contaminated piece of equipment with their hands, and then touching another patient without washing their hands. Hand washing is a simple, yet effective measure in the fight against infection prevention. Having a high workload, wearing gloves, disagreeing with guidelines, and forgetfulness are not valid excuses. Hand washing is a mandatory step in the fight against infection prevention.

Hygiene and Uniform

Healthcare workers must also be conscious of their personal hygiene and what they wear to work as it could help spread infection within the hospital. For example, employees must have good personal hygiene, maintain short and clean nails, and keep hair worn short or pinned up. Also, employees should utilize proper personal protective equipment (PPE), such as gloves, masks, head covers, marks and must obey special uniform rules. Clothing must also be easy to decontaminate and cleaned daily to keep at optimum conditions.

Equipment Safety

Another common mode of transmission of infection is through equipment and environmental causes. Though it may appeal to common sense, it is necessary that the hospital environment is thoroughly cleaned often. These areas must be cleaned with a detergent or antiseptic solution and different cleaning equipment must be used for different rooms. Another way to ensure equipment safety is sterilization, which is destruction of all microorganisms.

Point-of-Use Care

Effective instrument processing begins at the point of use i.e., during the surgical procedure. To prevent blood, soil, or any protein containing material from drying on instruments, and/or to soften and remove dried blood and soils, remove gross blood and debris from instruments immediately after use by wiping with a single use wipe that has been moistened with sterile water or enzymatic solution, **except if it is a sharp instrument**.

Cleaning/Decontamination

To prevent transfer of microorganisms from personnel to items being processed, personnel working on the clean side of the reprocessing department should wear clean scrub attire, durable shoes with nonskid soles, and a surgical type hair covering or hood; they should not wear jewellery. To protect themselves from pathogenic microorganisms that may be on the items they are processing, personnel who clean and decontaminate

surgical instruments must wear protective attire appropriate for the tasks they are performing.

Isolation

While all of the infection control methods deal with physical objects, isolation of the patient also plays a critical role in infection control. The isolation of an infected patient can often prevent the spread of disease and also protect the patient from acquisition of other infections.

Opportunistic infections

An opportunistic infection is an infection caused by pathogens, particularly opportunistic pathogens—those that take advantage of certain situations—such as bacterial, viral, fungal or protozoan infections that usually do not cause disease in a healthy host (one with a healthy immune system). A compromised immune system, however, presents an "opportunity" for the pathogen to infect

Immunodeficiency or immunosuppression or compromised immune system can be caused by:

- Malnutrition
- Fatigue/stress
- Recurrent infections
- Immunosuppressing agents for organ transplant recipients
- Advanced HIV infection
- Chemotherapy for cancer
- Genetic predisposition
- Skin damage
- Prolonged antibiotic treatment
- Pregnancy

The table below shows examples of common opportunistic infections and cancers and the body systems that they occur in. Examples of opportunistic infections are shown below:

Table 3: Examples of opportunistic infections

System	**Examples of Infection/Cancer**
Respiratory system	Pneumocystis jirovecii Pneumonia (PCP)

	Tuberculosis (TB) Kaposi's Sarcoma (KS)
Gastro-intestinal system	Cryptosporidiosis Candida Cytomegolavirus (CMV) Isosporiasis Kaposi's Sarcoma
Central/ peripheral Nervous system	Cytomegolavirus Toxoplasmosis Cryptococcosis Non Hodgkin's lymphoma Varicella Zoster Herpes simplex
Skin	Herpes simplex Kaposi's sarcoma Varicella Zoster

Self Assessment Questions

1. A 45 year old woman is admitted to the hospital with acute chest pain. On the second hospital day it is clear that she has had a myocardial infarction. Unfortunately, on the same day she develops acute diarrhea. A stool culture grows Salmonella. This infection is:
A. Hospital acquired
B. Nosocomial
C. Iatrogenic
D. Community acquired

2. An important means of preventing hospital acquired infections is:
A. For health care workers to wash their hands between patient contacts
B. For all patients to be placed in single rooms
C. For all patients to receive a single dose of antibiotics at the time of admission
D. An infection control program with one nurse for every 100 patients in the hospital

Summary

In this unit we have discussed in detail the subject of infection, mode of transmission, the body reaction and one's immunity.

The sources of infections are:

- Excretions: These include faeces, urine, pus, sputum
- Secretions: They include nasal digalets e.g sneezing, cough droplets and saliva.
- Contaminated food, water, milk etc
- Infected farm animal
- Unwashed hands
- Contaminated air, soil, dust and plants

Human beingWe have discussed the mode of entry as being**:**

- Inhalation
- Ingestion

- Inoculation
- Trans-placental

Finally we discussed immunity and defined Immunity as a system of biological structures and processes within an organism that protects against disease by identifying and killing pathogens and tumour cells. It detects a wide variety of agents, from viruses to parasitic worms, and needs to distinguish them from the organism's own healthy cells and tissues in order to function properly. It is composed of leucocytes (white blood cells), tissue macrophages and lymphoid tissues.

B. Types of immunity

III Natural acquired immunity

- Natural passive acquired immunity
- Natural active acquired immunity

IV **Artificial acquired immunity**

- Artificial passive acquired immunity
- Artificial Active acquired immunity

We also discussed defence mechanisms such as:

- Inflammation
- Lymphatic System
- Humoral defence
- Normal flora

Finally we discussed Nosocomial infections and to prevent it.

5.11 References

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