COURSE CODE: MLS 211
COURSE TITLE: INTRODUCTION TO MEDICAL LABORATORY SCIENCE
NUMBER OF UNITS: 2 UNITS
COURSE DURATION: TWO HOURS PER WEEK
MODULE 1: INTRODUCTION TO MEDICAL MICROBIOLOGY

COURSE LECTURER: **BANKOLE HENRY OLADEINDE**

INTENDED LEARNING OUTCOMES

At the end of this class, students should be able to:

1. Define Medical Laboratory Science and explain its relevance as a discipline.
2. Define Medical Microbiology and list its sub- specialties.
3. Define micro-organism and highlight the differences between Prokaryotes and Eukaryotes.
4. Differentiate between infection and infectious disease.
5. List and explain the modes of transmission of infectious agents.
6. List and explain the different methods of diagnosis of infectious diseases

COURSE DETAILS:

Week 1-3: *General introduction to Medical Laboratory Science (Medical Microbiology, Clinical Chemistry, Haemtology and Blood Transfusion Science, , Histopathology and Immunology)*
Week 4-5: *Specimen collection procedure; specimen collection bottles; reception and registration of specimen; storage and disposal of specimen*
Week 6-7: *Safety precautions in pathology laboratories against chemical, biological, electrical, materials and irradiation hazards.*
Week 8-9: *Techniques and principles of chemical sterilization and physical methods*
Week 10-11: *glassware cleaning, care and maintenance; breeding of laboratory animals*
Week 12: *Revision*

RESOURCES

• **Lecturer's Office Hours:**
• Mr. Henry Bankole Oladeinde: Wednesdays: 1:00-2:00pm.
• **Course lecture Notes:**

•**Books:**
Jawetz, Melnick and Adelbergs Medical Microbiology 26th Edition by Brooks JF, Morse SA, Caroll KC, Mietzner TA, Butel JSMcgraw Hill 2013ISBN: 978-0-07-181578-9

Sherris Medical Microbiology 4th Edition by Kenneth J.Ryan and George C. Ray Mcgraw Hill 2004. ISBN: 0-07-150238-6

Journal
Oladeinde BH, Ekejindu IM, Omoregie, Aguh OD. (2015). Awareness and knowledge of ergonomics among medical laboratory scientists in Nigeria. Annals of Medical and Health Science Research 5(6): 423-427.

Project:
• Homeworks + Project: ~ 30% of final grade.
• **Exams:**
• Final, comprehensive (according to university schedule): ~ 70% of final grade

Assignments & Grading
• **Academic Honesty:** All classwork should be done independently, unless explicitly stated otherwise on the assignment handout.
• You may discuss general solution strategies, but must write up the solutions yourself.
• If you discuss any problem with anyone else, you must write their name at the top of your assignment, labeling them "collaborators".
• **NO LATE HOMEWORKS ACCEPTED**
• Turn in what you have at the time it's due.
• All homeworks are due at the start of class.
• If you will be away, turn in the homework early.
• Late Assignments (projects) will not be accepted, but penalized accordingto the percentages given on the syllabus.

PREAMBLE:

A major threat to the existence of mankind is disease. Disease outcome can be fatal, leading to death in many cases. Man over the years has sought different ways of combating this threat, recording successes in many areas. However, one element that is relevant in the fight against a disease is the knowledge of the cause of the disease, as one can hardly contend with what is unknown.

Medical Laboratory Science is concerned with the analysis of clinical specimen (urine, blood, stool, peritoneal fluid, synovial fluid e.t.c) with the aim of identifying the cause/s of disease conditions. It is pivotal to the effective management of diseases as reports shows that over 60 percent of decision relating to hospital admissions, prescribed medicals and discharge of patients depends on laboratory data. Medical laboratory science as a discipline is thus a fulcrum for practice of modern day medicine. One trained to perform the function above is regarded as a Medical Laboratory Scientist or a Clinical Laboratory Scientist.

Medical Laboratory Science has several specialties. They include Medical Microbiology, Chemical Pathology, Hematology and Blood transfusion, Histopathology and Immunology. Specialists in these areas work together and provide valuable data for management of patient.

Medical Microbiology is the study of micro-organisms, the diseases they cause and host response to these diseases. It is a branch of medical sciences that deals with the etiology, pathogenesis, laboratory diagnosis, treatment and control of infectious diseases. Micro-organisms are small (microscopic) organism that may exist in single or multicellular form. They are very small organism that cannot be seen with the naked eyes except with the use of magnifying equipment such as a Microscope. Indeed, the study of Microbiology began with the discovery of micro-organism by Antonie van Leeuwenhoek. He was the first person to observe bacteria and other microbes using his own self-designed microscope in 1676, and is thus generally referred to as the father of modern microbiology. Several other scientists such as Edward Jenner, Lious Pastuer, Robert Koch, Joseph Lister, Hans Christian Gram, Alexandra Flemming etc, made useful contributions to the study of Microbiology. Micro-organisms are ubiquitous and can be found everywhere and anywhere. They can be found in the air, soil, water, animals, and man. Some micro-organisms are known to cause disease conditions in man. These micro-organisms are termed pathogens.

Fig 1: Diagram of a Binocular Microscope

There are however some other microbes that do not naturally cause diseases. In fact, humans are inhabited by a group of micro-organisms that are term normal flora. These microbes are found in specific areas of the body where they play important and beneficial roles. An example of such micro-organism is a bacterium called *Lactobacillus acidophilus.* It is a harmless bacterium that resides in the intestine and helps in the digestion of food. As stated earlier several micro-organisms are associated with disease conditions. They belong to one of the classes of micro-organism, which include bacteria, viruses, fungi, protozoa and Algae.

CLASSIFICATION OF MICRO-ORGANISMS

The cell is the structural and functional unit of life. All living cells are divided into two groups, namely prokaryotes and eukaryotes based on their cellular structure. Micro-organisms are living cells and are also grouped into one of these classes. Examples of eukaryotic micro-organisms include fungi, simple algae and protozoa. Bacteria are prokaryotes. There are several differences between a prokaryotic and eukaryotic cell. The major differences are highlighted in the table below.

Table 1: Differences between eukaryotic and prokaryotic cells

Feature	Prokaryotes	Eukaryotes
Size	They are generally small in size	They have variable sizes, some measuring up to 40 um in diameter
Genetic material	Contains circular DNA present in cytosol	Contain DNA in the form of linear chromosome. They are present in well defined membrane nucleus
Genes	Have no introns	Posses introns
Organelles	They do not have membrane bound organelles	Posses membrane bound organelles with well defined functions.
Ribosome	Posses 70 sub-unit	Posses 80 sub-unit
Transcription and translation	Processes occur together	Transcription occur in nuclear and translation in cytosol
Histones	Have no histones	Posses histones

Bacteria: This is an extensive group of prokaryotic micro-organism, that are ubiquitous in nature. They have both DNA and RNA as nucleic acid. They are unicellular organisms which are free-living with size ranging from 2-5um. They have varied shapes and could range spherical, rod shaped or spiral shaped. Bacteria that are spherical are called cocci, while those that are rod shaped are called bacilli. Spiral shaped cells are spirochetes vibrones and spirilla, Bacteria can infect man causing an array of diseases. Examples of bacteria that cause diseases are *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeroginosa*, *Klebsiella pneumonia*, etc.

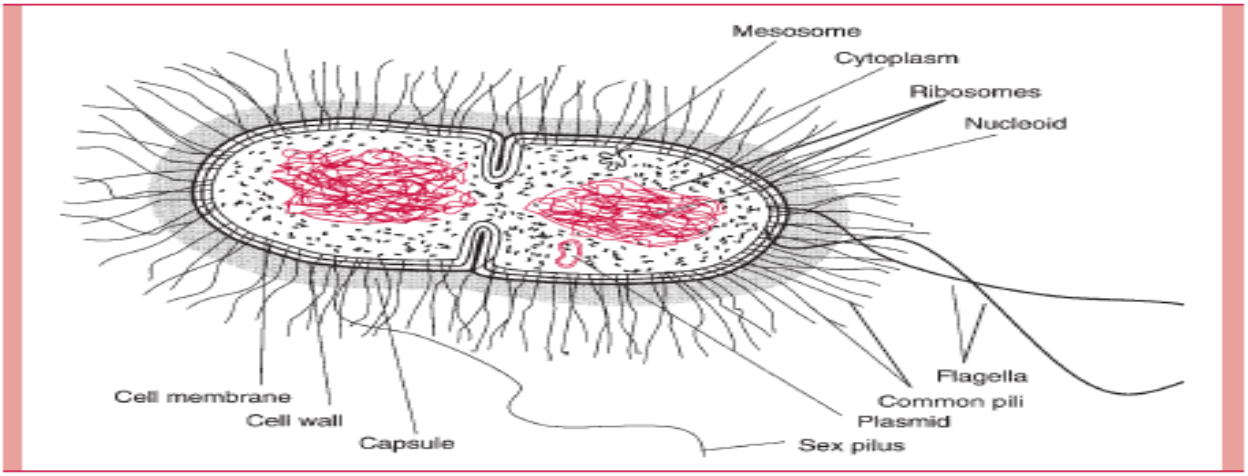

Fig 2: Diagram of a bacterium

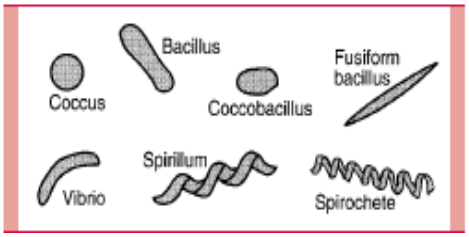

Fig 2a: Shapes of different bacteria

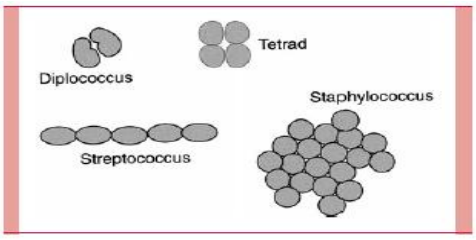

Fig 2b: Arrangement of spherical bacterial cells

Viruses

These are infectious agents that are composed of nucleic acid (DNA or RNA) a protein shell (capsid), and in some case an envelope. They are obligate

intracellular parasites. Viruses lack the ability to replicate and can only do so when they infect a susceptible cell. The viral nucleic acid contains information necessary for programming the infected host to synthesize virus specific macro-molecules. Examples of viruses that causes disease are Human Immunodeficiency Virus (HIV), adenovirus, Hepatitis B and C viruses, Lassa virus, Herpes simplex virus e.t.c

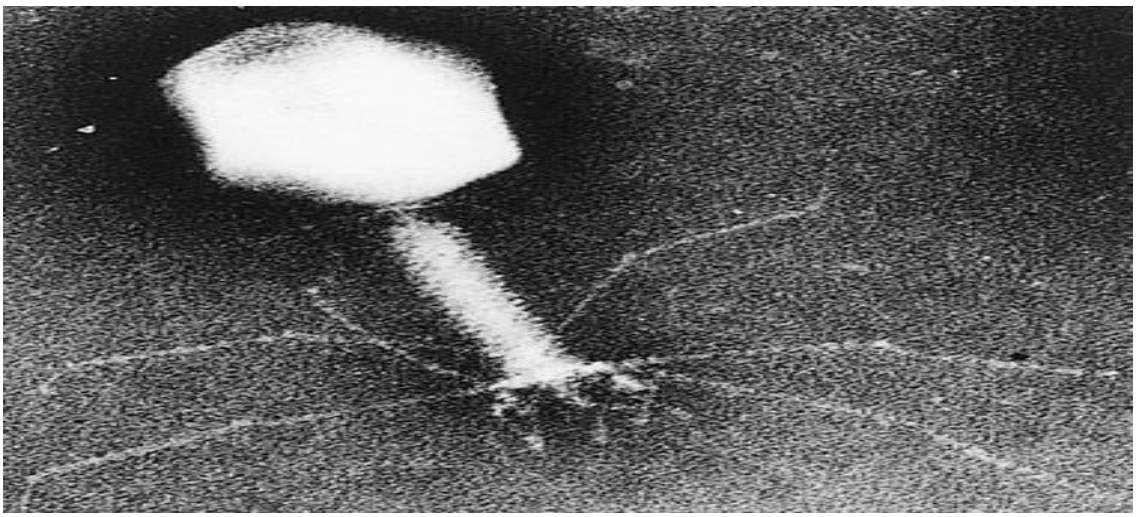

Fig 3: Bacteriophage T4

Fungi:

These are a group of non-photosynthetic micro-organism which lives as saprophytes in the soil and on dead organic matter. They can also be found as parasites of plants and man. Most fungi produce spores which they use as a mean of survival and propagation. They can exist in form of yeast or mould depending on the temperature of the environment in which they grow. They are non-responsive to antibiotics and some of them are known to cause diseases in man. such as athlete foot, vaginitis, thrush e.tc. Examples of medically important fungi include *Candida albicans*, *Histoplasma capsilatum*, *Epidemophyton flocucum*. *Paracoccidiodes brasiliensis* etc.

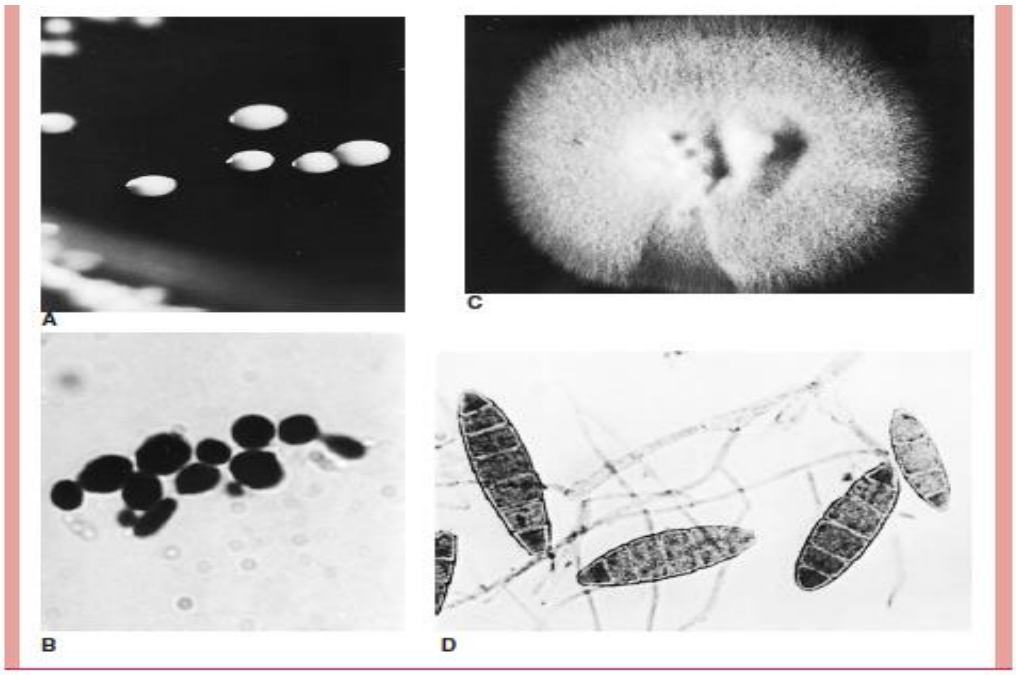

Fig 4: Showing different forms of fungi. A: Yeast cell colonies. B: Stained preparation of yeast cells viewed with the Microscope: A Mold. D: Appearance of molds under the Microscopic (note the presence of hyphae and conidia)

Protozoa

They are a diverse group of unicellular heterotrophic eukaryotic microbes. They are non-phototrophic cells void of cell wall. Unlike the bacteria, protozoa possess several intracellular organelles which perform varied functions and tasks. Indeed some species of protozoa have structures that are analogous to the mouth gastro intestinal tract and the mouth. Most protozoa have a cyst stage which is highly resistant to unfavorable environmental conditions. There are four classes of protozoa namely

(a) Flagellates: These are protozoans that possess one or more whip-like locomotive appendage called flagella. Examples of flagellates are *Gardia lamdia* and *Trichomonas vaginalis*
(b) Amebae: These are generally amoeboid (lacking a definite shape) and they use pseudopodia or protoplasmic flow to migrate. A typical example is the *Entameoba histolytica*
(c) Sporozoa: These have a somewhat complex life cycle with alternating sexual and asexual reproductive phases. The human parasite

Cryptosporidium parvum, Toxoplasma gondi, and Plasmodium falciparium are examples of sporozoa

(d) Cillites: These are complex protozoa that bears cilia distributed in rows or patches with two kinds of nuclei in each individual.The protozoa *Balantiduim coli* falls into this group

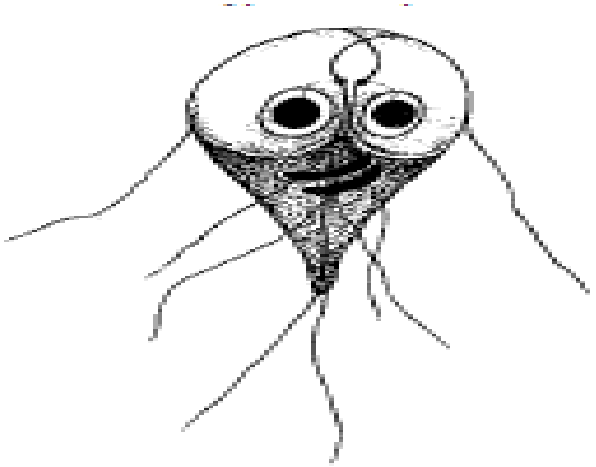

Fig 5: Diagram of *Gardia lamblia*

SUB- SPECIALTIES OF MEDICAL MICROBIOLOGY

There are four sub-specialties in the field of Medical Microbiology that are related to the study of specific micro-organism that causes diseases in man. These sub-specialties are:

1.**Medical Virology**: Focuses on the study of viruses and the diseases they cause in man.

2. **Medical Bacteriology**: Focuses on the study of bacteria and the diseases they cause in man

3. **Medical Mycology**: This focuses on the study of fungi that causes disease in man.

4. **Medical Parasitology**: Focuses on the study of parasitic diseases in man

A fifth sub-specialty is Immunology and this is concerned with the study of host response to infectious diseases.

INFECTION AND INFECTIOUS DISEASE

It is important to note that there is a difference between the term "infection" and "infectious disease". Infection is the invasion of a tissue by micro-organisms (bacteria, viruses, fungi etc). An infectious disease is a disorder resulting from the invasion and colonization of tissue by micro-organism (bacteria, fungi, viruses etc). One with an infectious disease typically presents with signs and symptoms of illness. Not all infection leads to infectious disease. Once a micro-organism enters an immuno-competent host, innate and adaptive immune responses are initiated against the invading microbe to halt its multiplication and facilitate its clearance from the body. When this happens, the invading micro-organism is unable to cause damage and no disease ensues.

Based on the place of acquisition of infection, it can be divided into two groups namely

1. **Nosocomial infection.** This is sometimes called Health-care associated infection. This is an infection that is acquired in a hospital or any other health care facility such as clinics, maternity homes, rehabilitation homes etc. Infection can be spread to a susceptible host in a clinical setting through contaminated equipment, beddings, health care staff, another patient, or even in some cases from the patient's own microbiota, particularly after surgery. Types of nosocomial infections include respiratory tract infections, urinary tract infections, gastroenteritis, tuberculosis etc. Micro-organism associated with nosocomial infection include *Staphylococcus aureus*, methicilin resistant *Staphylococcus aureus*, *Pseudomonas aeroginosa*, *Proteus mirabilis*, *Escherichia coli*, *Mycobateruim tuberculosis* etc.

2. **Community acquired infection**: This is any infection acquired outside a health care facility. It is also an infection present at the time of admission into a health care facility. Examples include malaria, tuberculosis, HIV/AIDS, wound and urinary tract infections

MODE OF TRANSMISION OF INFECTIOUS AGENTS

There are a number of ways through which infectious agents can be transmitted to cause disease. These are;

1. Human to human contact: This involves direct body contact with that of an infected person leading to transfer of infective agent. Direct contact can occur through skin to skin contact, kissing, and sexual intercourse. The Ebola virus, is an example of an organism that can be transmitted through direct contact with an infected host.

2. Feacal oral route: This involves the ingestion of materials (food, water) that have been contaminated with infective micro-organisms. Gastroenteritis are outcome of ingestion of contaminated food and water with infectious agents such as Salmonella spps, Hookworm ova, rotavirus, astrovirus, etc.

3. Vertical transmission: This refers to placenta transfer of infectious agents from mother to child. Micro-organisms such as Human Immunodeficiency Virus (HIV), Hepatitis B and C viruses, rubella virus, are common pathogens that can be transmitted from a mother to her unborn child.

4. Aerosol: Transmission can be through infective airborne droplets. Droplets are formed from infected persons during actions like coughing, sneezing and talking. Inhalation of these droplets that contain infective micro-organism by susceptible host can cause infection. Some micro-organism transmitted by air are legionella, *Mycobacteruim tuberculosis and* rubella virus.

5. Percutaneous Transmission: This is a principal means of transmission of many blood borne infectious agents such as HIV, Hepatitis B and C viruses

6. Vector borne transmission: This occurs when certain vectors such as mosquitoes, rats, fly etc, transmit infective micro-organism to susceptible host. The female Anopheles mosquito transmits malaria parasites from one person to another when taking a blood meal.

The route of transmission of an infectious agent greatly influences its rate of spread in any given population. Micro-organisms that are spread by air (e.g *Mycobacteruium tuberculosis*) have by far a greater potential of affecting more people than those spread through direct body to body contact. Transmission of infectious agents by air is facilitated by factors such as overcrowding, and poverty. Another important factor in the transmission of infectious agent is the time of survival of agent between host. Soon after leaving a host, some infectious agents loss their viability and ability to cause disease in a secondary host. Others however

have developed adaptive mechanisms to survive through unfavorable conditions outside their primary host to ensure their continued transmission. One of such mechanisms of survival is the development of cyst, which confers protection to the agent.

DIAGNOSIS OF INFECTIOUS DISEASES

Effective management of infectious diseases depends largely on the timely and accurate diagnosis of its etiologic agents. To achieve this goal, there must be effective collaboration between the clinician and the Medical Microbiologists. Based on the clinical examination of patients, the clinician should be able to select the appropriate test to be conducted, and where appropriate suggest the suspected agents to the laboratory worker. Laboratory test results depends largely on the collection of quality specimen, the timing and care with which it is collected and the proficiency of the laboratory personnel. The Medical Microbiologist should have the requisite knowledge to select method/s that will best demonstrate the probable cause of the disease condition, as the general approach to diagnosis varies with different microbes and infectious diseases. There are a number of methods the Medical microbiologist may employ in this light. They include:

Microscopy: This involves the use of the Microscope in viewing clinical specimen in other to reveal the presence of inherent micro-organism that may be the cause of disease. This involves the microscopic examination of stained and unstained preparation. It is quite a simple and inexpensive procedure, but has a drawback of not been too sensitive especially when the specimen does not contain much organism. Gram stained specimens can be examined with the Microscope for the presence of bacteria. Other procedures such as Ziehl nelson staining reaction for *Mycobacterium tuberculosis* can also be assessed with microscopy. Specimens such as stool, urine, sputum can be also be examined directly without staining for parasites. The Binocular light Microscope shown in figure 1 above is particularly useful in viewing most bacteria and fungi isolates. However for the bacteruim *Treponema palliduim* which causes syphilis, the conventional light Microspore may be inadequate for use. The dark field and fluorescent Microscope is the preffered choice of Microscope. Also Viruses cannot be visualized with the Binocular Microscope. To achieve this, the Electron Microscope is usually employed.

Serological Technique: Diagnostic Medical microbiology makes great use of the specificity of the binding between antigens and antibodies. Serological techniques entail procedures that detect specific antigens or antibodies of pathogens in clinical specimens of patients. Antigens of known specificity are used to detect their

homologous antigens in body fluids. Several methods such as precipitation, agglutination, immunodiffusion, neutralization, enzyme linked immunoassays (ELIZA), etc can be employed.

Cultural method: This employs the use of appropriate artificial culture media in growing suspected pathogens in the laboratory. There are different kinds of culture media for the isolation of pathogenic micro organism (bacteria, fungi, viruses) .The nutritional requirement of pathogens differ The nutritional value of culture media also varies, For successful isolation of a pathogen, the specimen containing the infectious agent must be inoculated onto an appropriate culture media, with nutrient adequate to support its growth. The organism must be given time to grow on the medium after other factors such as its gaseous , and temperature requirements have been satisfied. Most micro organism will grow within a day, with all growth factors been satisfied, but a few will require longer period of incubation. Once growth of achieved after incubation, it is important that the Medical Microbiologist confirm the identity as been truly a pathogen. In this wise the colonial characteristics and biochemical profile of the isolate will be helpful in designating the isolate as a pathogen. For strict intracellular microbes such as Rickettsia, Clamydia, and animal and human viruses will require cultures of living eukaryotic cells.

Biochemical tests: The ability to attack certain substances and produce specific metabolic products from them has been used to characterize laboratory isolates. Biochemical tests are used to confirm the identity of pathogens in the Laboratory. Common biochemical test used in the laboratory include citrate utilization test, coagulase, catalase, indole tests, urease test, oxidase tests and vogue-proskauer tests.

Nucleic acid detection (Polymerase Chain Reaction): The analysis of the Deoxyribonucleic (DNA) or Ribonucleic acid (RNA) of microorganisms is the newest ways of detecting infectious microbes. The polymerase Chain Reaction is an amplification technique that allows for the detection and selective replication of a targeted portion of a genome. It utilizes special DNA polymerase that uses alternate changes in test conditions such as temperature to initiate replication in either the 3` or 5` directions. The specificity is provided by primers that recognize a pair of sites on the chromosomes so that the DNA between them can be replicated by repetitive cycling of the test conditions. Basically, the procedure sets out to amplify small quantity of microbes into several million copies, followed by the detection of nucleic acid on a specialized medium. It is a very sensitive diagnostic method, and often regarded as gold standard for diagnosing several infectious diseases.

Assignment:

Discuss the contributions made by the following persons to the study of Microbiology.

(a). Lious Pasteur

(b).Robert Koch

(c). Edward Jenner

(d) Alexandra Flemmings