Semester – I
4H – 4C

17MBU101 INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

Instruction Hours / week: L: 4 T: 0 P: 0 **Marks:** Internal: **40** External: **60** Total: **100**
End Semester Exam: 3 Hours

SCOPE:

Microbiology has played a central role in all aspects of biological sciences, including morphogenesis, genetics, developmental biology, physiology, biochemistry and cell biology. An understanding of microbiology is thus basics to biological research. So this paper was designed to make the students familiarized with fundamental knowledge on history of microbiology and the diversity of microorganisms.

OBJECTIVE:

- To provide a strong, fundamental foundation in microbiology for advanced studies in biological sciences, particularly microbiology.

Unit I

Development of microbiology as a discipline, spontaneous generation Vs biogenesis. Contribution of Anton von Leewenhoek, Golden era of Microbiology Louis Pasteur, Robert Koch, Joseph Lister, Alexander Flemming. Role of microorganism in fermentation, Germ theory of disease, Establishment of fields of medical microbiology and immunology through the work of Paul Ehrlich, Ellie Metchnikoff, Edward Jenner. Microscopy Application in industries, Application in medicine, Application in agriculture, Application in biotechnology, Application in biology.

Unit II

Bergey's Manual, Binomial Nomenclature and Universal Phylogenetic tree. Classification system: Phenetic and Phylogenetic, Whittaker's Five Kingdom and Carl Woese's three kingdom classification system and their utility. Difference between prokaryotic and eukaryotic microorganism. Major diversity of microbial life. Bacteriology

Unit III

General characteristics of algae including algal cell ultra-structure. Classification of algae-Chlamydomonas, Volvox, Diatoms, red algae and brown algae). Application of Algae in agriculture, industry, environment and food.

Unit IV

General characteristics of fungi including habitat, distribution, nutritional requirements, fungal cell ultra-structure. Economic importance of fungi . Classification of fungi.

Unit V

General characteristics with special references with *Entameoba histolytica*, *Trichomonas*, *Giardia* and *Plasmodium*. Classification of viruses.

SUGGESTED READINGS

1. Tortora, G.J., Funke, B.R., and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.
2. Madigan, M.T., Martinko J.M., Dunlap, P.V., and Clark, D.P. (2014). Brock Biology of Microorganisms. 14th edition. Pearson International Edition.
3. Cappucino, J., and Sherman, N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education Limited.
4. Wiley, J.M., Sherwood, L.M., and Woolverton, C.J. (2013) Prescott's Microbiology. 9th edition. McGraw Hill International.
5. Atlas, R.M. (1997). Principles of Microbiology. 2nd edition. WM.T.Brown Publishers.
6. Pelczar, M.J., Chan, E.C.S., and Krieg, N.R. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
7. Stanier, R.Y., Ingraham, J.L., Wheelis, M.L., and Painter, P.R. (2005). General Microbiology. 5th edition. McMillan.8
8. Duby, R.C. (2014) Textbook of Microbiology. 5th edition. S. Chand Publishing.

DEPARTMENT OF MICROBIOLOGY
KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act, 1956)

Eachanari Post, COIMBATORE - 641 021, INDIA

I-B.Sc., Microbiology (Batch 2017-2020)

Introduction to Microbiology and Microbial Diversity (Semester-I) (17MBU101)

LECTURE PLAN

UNIT1

Duration	Topic	Reference
01	Development of microbiology. Spontaneous generation Vs biogenesis.	R1:6-9
02	Contributions of Anton von Leewenhoek, Louis Pasteur, Robert Koch	R1: 9
03	Contributions of Joseph Lister, Alexander Flemming	R1: 10
04	Golden era of Microbiology. Role of microorganism in fermentation	R1: 11
05	Germ theory of disease	R1: 12
06	Contributions of Paul Ehrlich, Ellie Metchnikoff, Edward Jenner	R1: 13
07	Microscopy	R2: 990-995
08	Application of microbes in industries, medicine and biology.	R2: 9-13
09	Application of microbes in agriculture and biotechnology.	R2: 14-17
10	Unit revision and possible questions	
	Total hours: 10	

R1: Tortora, G.J., Funke, B.R., and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

R2: Duby, R.C. (2014) Textbook of Microbiology. 5th edition. S. Chand Publishing.

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Department of Microbiology

2017

Introduction to microbiology and Microbial diversity

Unit I notes

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2017

Unit 1 History and development of microbiology

Microbes in our Lives

- Microbiology is the study of living organisms that are too small to be seen with the unaided eye.
- Microorganisms (microbes) are organisms that are too small to be seen with the unaided eye.
- "Germ" refers to a rapidly growing cell.

Microorganisms are important in the maintenance of an ecological balance on Earth.Some microorganisms live in humans and other animals and are needed to maintain the animal's health. Some microorganisms are used to produce foods and chemicals.Some microorganisms cause disease.

Naming and Classifying Microorganisms

In a nomenclature system designed by **Carolus Linnaeus (1735),** each living organism is assigned two names.
The two names consist of a genus and a specific epithet, both of which are underlined or italicized.

Types of Microorganisms

Bacteria Bacteria are unicellular organisms. Because they have no nucleus, the cells are described as prokaryotic.
The three major basic shapes of bacteria are bacillus, coccus, and spiral.Most bacteria have a peptidoglycan cell wall; they divide by binary fission; and they may possess flagella.Bacteria can use a wide range of chemical substances for their nutrition.

Archaea Archaea have prokaryotic cells; they lack peptidoglycan in their cell walls. Archaea include methanogens, halophiles, and extreme thermophiles.

Fungi Fungi (mushroom, molds, and yeasts) have eukaryotic cells (with a true nucleus).Most fungi are multicellular.Fungi obtain nutrients by absorbing organic material from their environment.

Protozoa Protozoa are unicellular eukaryotes.Protozoa obtain nourishment by absorption or ingestion through specialized structures.

Algae Algae are unicellular or multicellular eukaryotes that obtain nourishment by photosynthesis.Algae produce oxygen and carbohydrates that are used by other organisms.

Viruses Viruses are non cellular entities that are parasites of cells.Viruses consist of a nucleic acid core (DNA or RNA) surrounded by a protein coat. An envelope may surround the coat.

Multicellular Animal Parasites

The principal groups of multicellular animal parasites are flatworms and roundworms, collectively called helminths. The microscopic stages in the life cycle of helminths are identified by traditional microbiological procedures.

Classification of Microorganisms. All organisms are classified into the Domains Bacteria, Archaea, and Eukarya. Eukarya includes Protists, Fungi, Plants, and Animals.

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A Brief History of Microbiology

General information

1. Scientists have studied microorganisms for more than 400 years
2. Their study has been enhanced by the invention of such instruments as the microscope
3. From the 16th century to the present, many theories have been developed about the growth and control of microorganisms

The First Observations

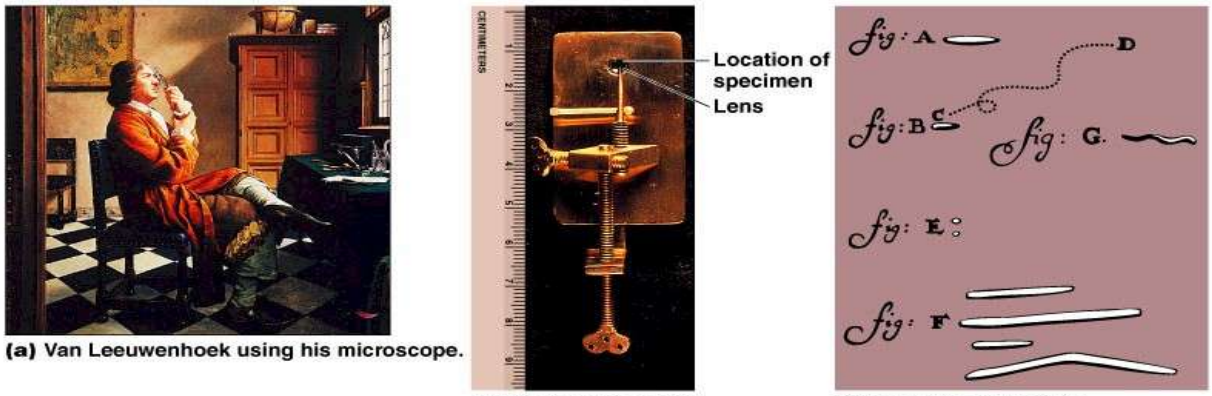
Aristotle (384 - 322 BC) Proposed the theory of spontaneous generation. Also called abiogenesis. Idea that living things can arise from nonliving matter.Idea lasted almost 2000 years. In the first century AD glass had been invented and the **Romans** (naturally) experimented with lenses. They found that making lenses that were thick in the middle and thin at the edges produced a magnifying effect. By the end of the 13th century spectacle makers were using lenses to make glasses.

16th century

1. In 1546, **Girolamo Fracastoro** proposed the theory of contagious diseases
a. He believed that diseases were spread through contact between individuals
b. He developed this theory while treating cases of syphilis
2. In 1590, **Johannes and Zacharias Janssen** invented the first compound microscope (one having two sets of lenses)
a. The Janssens used sunlight to illuminate the object under study
b. Their microscope achieved magnifications of 10 to 100 times the object's actual size

Robert Hooke, using a microscope with a magnification of about 30X, observed that plant material was composed of "little boxes"; he introduced the term cell (1665). Hooke's observations laid the groundwork for development of the cell theory, the concept that all living things are composed of cells (in 1838 Matthias Schleiden made the bold statement that plants are multicellular organisms, and in 1839 Theodor Schwann said the same thing about animals, thus gaining credit for cell theory).

Anton van Leeuwenhoek



(a) Van Leeuwenhoek using his microscope. (b) Microscope replica (c) Drawings of bacteria

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Anton van Leeuwenhoek started messing around with magnifying glasses when he worked in a dry goods store (he used them to count threads in bolts of cloth).Being a do-it-himself kind of guy he insisted on learning to grind his own lenses. It wasn't long before he developed a microscope with a magnification of about 270X, and using this instrument, looked at just about everything he could think of. Imagine his surprise when he observed a drop of water - and saw tiny little "**animalcules**". Van Leeuwenhoek was the first to observe microorganisms (first protozoa and then bacteria). He became more and more interested in science, and between 1673 and 1723 and published numerous papers on his observations.

The Debate Over Spontaneous Generation

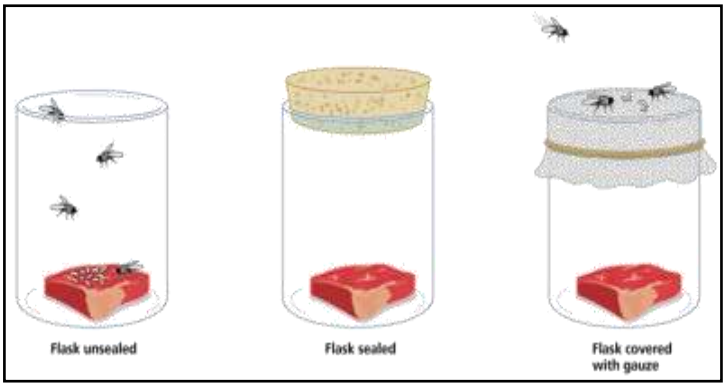
Until the mid-1880s, many people believed in spontaneous generation, the idea that living organisms could arise from nonliving matter. **Francesco Redi** demonstrated that maggots appear on decaying meat only when flies are able to lay eggs on the meat (1668). This was the first real example of modern experimentation with both experimental and control groups. Even though Redi thought he had disproved spontaneous generation, for maggots anyway, he still believed it occurred in some cases. Everybody was aware that you could put hay in water and in a few days you'd have a bunch of those animalcules that van Leeuwenhoek kept talking about, so for years people continued to believe that microorganisms at least arose via spontaneous generation.

Redi's Experiment (1626-1697)

- Redi used open & closed flasks which contained meat.
- His *hypothesis* was that rotten meat does not turn into flies.
- He observed these flasks to see in which one(s) maggots would develop.
- He found that if a flask was closed with a lid so adult flies could not get in, no maggots developed on the rotting meat within.
- In a flask without a lid, maggots soon were seen in the meat because adult flies had laid eggs and more adult flies soon appeared.

Evidence against spontaneous generation:

1.Unsealed–maggots on meat
2.Sealed–no maggots on meat
3. Gauze – few maggots on gauze, none on meat



In **1745 John Needham** claimed to show that microorganisms could arise spontaneously from heated nutrient broth. Everyone was aware that boiling animalcules would kill them, so Needham boiled broth, sealed the flasks, and got growth. He claimed that these results supported the idea of spontaneous generation.

In **1765 Lazzaro Spallanzani** repeated Needham's experiments and suggested that Needham's results were due to microorganisms in the air entering his broth before he sealed the flasks.

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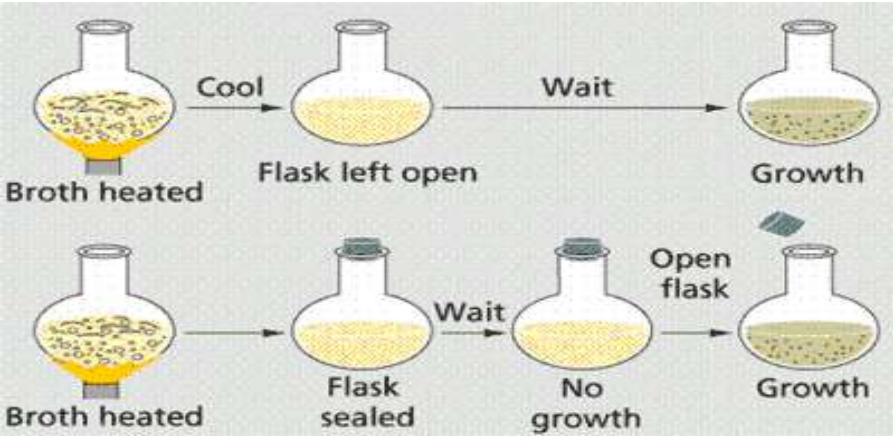
Spallanzani sealed the flasks, evacuated the air, and then boiled. When no growth occurred the conventional wisdom was that the "mysterious life force", which was required for spontaneous generation, was excluded.

Lazzaro Spallanzani experiment

- Boiled soups for almost an hour and sealed containers by melting the slender necks closed.
- The soups remained clear.
- Later, he broke the seals & the soups became cloudy with microbes.
- While that sounds like a bunch of hokum it was not far from the truth, at least in terms of the requirements for a number of living organisms. It was around this same time Laurent Lavoisier demonstrated the oxygen requirement of living organisms, and Spallanzani was back to square one.



In **1858 Rudolf Virchow** introduced the concept of biogenesis: living cells can arise only from preexisting cells ("Life from life").

Louis Pasteur

He was a Professor of Chemistry at the University of Lille, France. He is considered as "**Father of Microbiology**", as his contribution led to the development of Microbiology as a separate scientific discipline. He proved the theory of "Biogenesis" and disproved the "Theory of spontaneous generation" (Abiogenesis), experimentally by using swan-necked flasks. He demonstrated that microorganisms are in the air everywhere and offered proof of biogenesis with a set of elegant experiments in **1861**. To allow air to enter the flasks and at the same time prevent air-borne bacteria from gaining entry, Pasteur bent the necks of his flasks after he added broth. He then boiled the broth, killing any microorganisms that were present. If the theory of biogenesis was valid there should be no growth in the sterilized broth. And sure enough, that's exactly what happened. As a matter of fact, some of the original flasks are still on display at the Pasteur Institute today. (The personnel in charge of the flasks did eventually seal them to prevent jokesters from trying to blow bubbles, plug the ends with their gum, etc.) Pasteur's discoveries led to the development of aseptic techniques used in laboratory and medical procedures to prevent contamination by microorganisms that are in the air.

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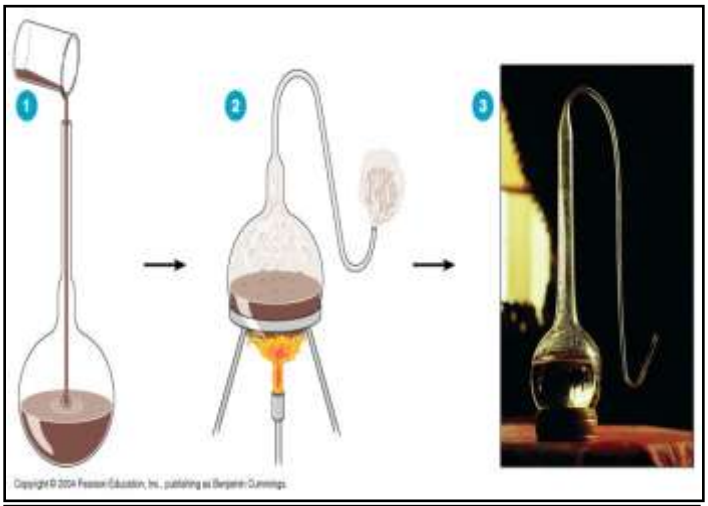
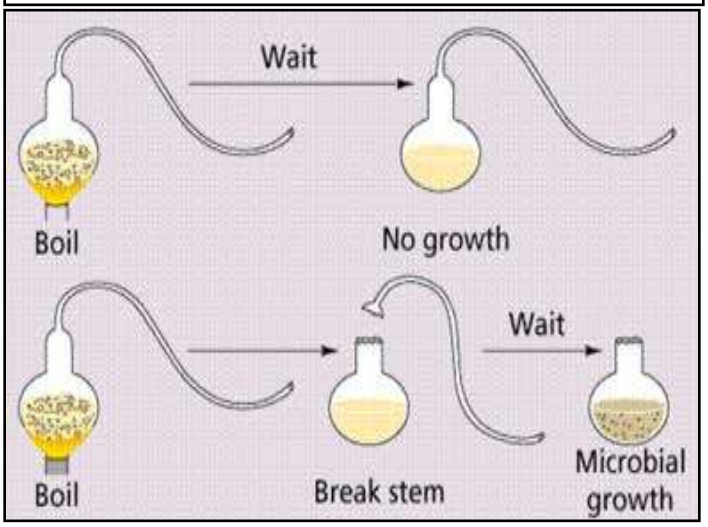
Pasteur worked on souring of wine and beer and found that this alcohol spoilage is due to the growth of undesirable organisms, while the desirable microorganisms produce alcohol by a chemical process called "**Fermentation**". He showed that wine did not spoil, if it is heated to 50-60°C for a few minutes. This method is called **"Pasteurization"**, now widely used in dairy units, to kill pathogenic microorganisms in milk.





Pasteur developed the process of **"attenuation"** during his work on "chicken cholera" in fowls. He found that cultures which had been stored in the laboratory for sometime would not kill the animals as fresh cultures did. This attenuation is now used in protective vaccination against diseases. Pasteur showed that the anthrax disease in cattle and sheep is caused by a bacterium. He cultivated anthrax organisms in sterile yeast water, and showed that these cultures can produce disease when inoculated in to healthy animals. He developed a live attenuated **anthrax vaccine**, by incubation at 40-42°C, which proved to be useful in protecting animals against anthrax. He also worked on swine erysipelas. Pasteur developed a **vaccine against rabies** (Hydrophobia), which made a greatest impact in medicine. He obtained the causative agent of rabies by serial intracerebral passage in rabbits and the vaccine was prepared by drying pieces of spinal chord. In 1888, Pasteur institute was established for

mass antirabic treatment.

Fermentation and Pasteurization

At that time, many scientists believed that air converted the sugars in beverages into alcohols.

- Pasteur found instead that microbes called yeasts convert the sugars to alcohols in the absence of air in a process called fermentation.
- Fermentation is the conversion of sugar to alcohol to make beer and wine.
- Souring and spoilage are caused by different MOs called bacteria.
- In the presence of air, bacteria change the alcohol in the beverage into vinegar (acetic acid).
- Pasteur's solution to the spoilage problem was to heat the beer and wine just enough to kill most of the bacteria that caused the spoilage in a process called pasteurization.
- Pasteurization is now commonly used to reduce spoilage and kill potentially harmful bacteria in milk as well as in some alcoholic drinks.
- Showing the connection between spoilage of food and MOs was a major step towards establishing the relationship between disease and microbes.
- Pasteur found that **yeast ferments sugars to alcohol** and that bacteria can oxidize the alcohol to acetic acid. He also developed a heating process (called **pasteurization**) that is used to kill bacteria in some alcoholic beverages and milk without altering their flavor.

The Germ Theory of Disease

- Until relatively recently, the fact that many kinds of diseases are related to MOs was unknown.Before the time of Pasteur, effective treatments for many diseases were discovered by trial and error, but the causes of the diseases were unknown.
- The realization that yeasts play a crucial role in fermentation was the first link between the activity of a MO and physical and chemical changes in organic materials. This discovery alerted scientists that MOs might have similar relationships with plants and animals- specially, that MOs might cause diseases. This idea was known as the germ theory of disease.
- Many people did not accept this theory at that time, because for centuries disease was believed to be punishment for individual's crimes and misdeeds.
- Most people in Pasteur's time found it inconceivable that "invisible" microbes could travel through the air to infect plants and animals, or remain on clothing and bedding to be transmitted from one person to another.
- 1835: **Agostino Bassi** showed that a silkworm disease was caused by a fungus.
- 1865: **Pasteur** found that another recent silkworm disease was caused by a protozoan.
- 1876: **Robert Koch** proved for the first time that a bacterium causes anthrax and provided the experimental steps, Koch's postulates, to prove that a specific microbe causes a specific disease.

- In course of **Pasteur** research, he discovered the importance of sterilization and discovered steam steri-lizer, autoclave and hot air oven. He also established the importance of cotton wool plugs for protection of culture media from aerial contamination. He differentiated between aerobic and anaerobic bacteria and coined the term "**anaerobic**" to refer to the organisms that do not require oxygen for growth.

Contributions of Louis Pasteur

- spontaneous generation (swan-neck flasks) 1859
- distribution of microbes in air
- fermentation
- pasteurization
- vaccines (chicken cholera/rabies)
- laid foundation for germ theory of disease

Contributions of Joseph Lister (1860's-70's): antisepsis , carbolic acid during surgery, wounds, bandages

ROBERT KOCH (1843-1912)

He was a German country Doctor who later became the Professor of hygiene and Director of institute of infective diseases at Berlin. He perfected many bacteriological techniques and known as "**Father of Practical Bacteriology**". He discovered rod shaped organisms in the blood of animals, that died of anthrax. He experimentally obtained the anthrax organisms in pure culture on a depression slide by inoculation of infected blood into the aqueous humour of a bullock's eye. He observed multiplication of bacteria and spore formation. He injected these spores into mice and reproduced the disease. He found that in certain conditions, the anthrax bacillus forms spores, that can survive on earth for years. He passed anthrax bacilli, from the blood of an infected animal, from one mouse to another through twenty generations, and found that they bred true. He worked out its life-history.

He introduced staining techniques. He prepared dried bacterial films (Smears) on glass slides and stained them with aniline dyes for producing a better contrast under microscope. He discovered tubercle bacillus (*Mycobacterium tuberculosis*) which is popularly called as **Koch's bacillus**. He injected tubercle bacilli into laboratory animals and reproduced the disease, satisfying all Koch's postulates. He discovered *Vibrio cholerae*, the causative agent of cholera disease. He developed pure culture techniques by introducing solid media. The use of agar-agar obtained from dried sea weeds (*Gelidium Sp.*) in the preparation of solid bacteriological media was first suggested by **Frau Hesse**, the wife of Koch' student. This agar-agar is totally inert with no nutritive value, solidifies at 45°C and melts at 90°C, and was found to be most suitable solidifying agent in the preparation of culture media. Koch isolated bacteria in pure cultures on these solid media. It revolutionized bacteriology.

He discovered "**Old Tuberculin**". Koch noted that when tubercle bacilli or its protein extract was injected into a Guinea-pig already infected with the bacillus, an exaggerated reaction took place and the reaction remain localized. This is popularly called **"Koch Phenomenon"** and it is a demostration of cell mediated immunity. The tuberculin test is based on Koch's

phenomenon. He erroneously thought that protein extracted from tubercle bacilli, called "Old tuberculin", could be used in the treatment of tuberculosis.

KOCH'S POSTULATES

Koch did a series of experiments to fulfill the criteria laid by his teacher Henle to establish the
causative role between a particular microorganism and a particular disease. They are popularly known as **Koch's postulates** (Henle-Koch's Posulates). They are :

1. A specific organism should be found constantly in association with the disease.
2. The organism should be isolated and grown in a pure culture in the laboratory.
3. The pure culture when inoculated into a healthy susceptible animal should produce symptoms/ lesions of the same disease.
4. From the inoculated animal, the microorganism should be isolated in pure culture.
5. An additional criterion introduced is that specific anitbodies to the causative organism should be demonstrable in patient's serum.

Contributions of Robert Koch (1870's)-"one disease-one organism"

- pure culture technique
- agar (red algae *Gelidium/Gracilaria*, w. Pacific Ocean); petri dish/agar plate
- Koch's postulates
- Discovered causative agents of anthrax -1876(*Bacillus anthracis*), tuberculosis-1882 (*Mycobacterium tuberculosis*), conjunctivitis-1883, cholera-1884 (*Vibrio cholera*).
- In 1905, he won the nobel prize in physiology/medicine.

EDWARD JENNER (1749-1823)

In a vaccination, immunity (resistance to a particular disease) is conferred by inoculation with a vaccine. Jenner was an English country physician, who discovered a safe and efficient vaccination against small pox. which ultimately led to the eradication of small pox (**Variola**). Jenner observed that dairy workers, exposed to occupational cowpox infection were immune to small pox. He proved experimentally that resistance to small pox can be induced by injecting cow pox material (**Vaccinia**) from disease pustules in to man (in 1796). Jenner claimed credit for the whole small pox/cow pox vaccination idea (even though he didn't call it vaccination at the time and the Chinese had been snorting powdered small pox scabs to generate immunity for hundreds of years prior to that). Pasteur gave the general term "**Vaccine**" (**Vacca = cow**) in honour of Jenner's cow pox vaccine,to various materials used to induce active immunity. Jenner published his findings in 1798 in a pamphlet "*An inquiry into the cause and effect of variole vaccine*".

Ignaz Semmelweiss-1840 need to wash hands after performing autopsies and before performing exam on patients. About 1880, Pasteur discovered that avirulent bacteria could be used as a vaccine for fowl cholera; he coined the word vaccine.

Modern vaccines are prepared from living avirulent microorganisms or killed pathogens, from isolated components of pathogens, and by recombinant DNA techniques.

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JOSEPH LISTER (1827-1912)

He is popularly known as **"Father of antiseptic surgery".** He was a professor of surgey at University of Glasgow and Edinburg and later at King's College, London. He was deeply interested in the prevention of post-operative sepsis. He was attracted by Pasteur's germ theory of disease and concluded that sepsis or wound infection may be due to microbial growth, derived from the atmosphere. He successfully prevented post-operative sepsis by introducing antiseptic techniques. He chose carbolic acid (Phenol) and used as spray on the wound or during surgery. He applied dressings soaked in carbolic acid on wounds. As a result, there was a marked reduction of post-operative sepsis, wound inflammation and suppuraton. It saved millions of lives from the jaws of death due to wound infections. Lister's antiseptic surgery later led to the development of aspetic surgery. He suffered many

criticism but never lose courage and followed his own ideas and revolutionzed the science of surgery by introducing antiseptic system in 1867. He knew about the work of Ignaz Semmelweis, who, in 1848, showed that puerperal fever was transmitted to patients by medical students, who didn't wash their hands between dissecting cadavers in anatomy lab and delivering babies.

The Birth of Modern Chemotherapy

- Treatment of disease by using chemical substances is called chemotherapy.
  - Chemotherapeutic agents prepared from chemicals in the laboratory are called synthetic drugs.
  - Chemotherapeutic agents produced naturally by bacteria and fungi to act against other MOs are called antibiotics.
  - The success of chemotherapy is based on the fact that some chemicals are more poisonous to MOs than to the hosts infected by the microbes.
  - Quinine from tree bark was long used to treat malaria.
  - 1910: Paul Ehrlich developed the first synthetic drug, Salvarsan, to treat syphilis. (the magic bullet!)
  - 1930s: Several other synthetic drugs derived from dyes that could destroy MOs were developed.
  - Sulfonamides (sulfa drugs) were synthesized at about the same time.
  - 1928: **Alexander Fleming** discovered the first antibiotic.
  - On a contaminated plate, around the mold (*Penicillium*) was a clear area where bacterial growth had been inhibited.
  - He observed that the *Penicillium* mold made an antibiotic, penicillin that killed *S. aureus.*
  - 1940s: Penicillin was tested clinically and mass produced.
  - Since then, thousands of antibiotics have been discovered.
  - Antibiotics and other chemotherapeutic drug faces many problem:
  - Toxicity to humans in practical use, specially antiviral drugs (why ?)
  - The emergence and spread of new varieties of MOs that are resistant to antibiotics due to bacterial enzymes that inactivate antibiotics, or prevention of Abt. From entering the microbe

PAUL EHRLICH (1854-1915)

- He was a German Bacteriologist, who pioneered the technique of chemotheraphy in medicine. From his discovery that certain tissues have a specific affinity, he reasoned that organisms causing diseases could be selectively killed with chemical drugs. This led him

to produce "**arsphenamine"** (**an arsenic compound**), **the first synthetic drug, which destroyed the syphilis microbe** in the body.

- Ehrlich observed that organic arsenicals killed trypanosomes in an infected animal, but, if smaller doses were administered, the trypanosomes acquired tolerance to the drug. Therefore, he aimed at "***therapia magna sterilans*****"** *i.e.,* the introduction into the blood of a single dose of chemotherapeutic agent sufficient to kill the parasite. He also observed that drug would undergo certain changes in the body after it would produce the desired action.

ALEXANDER FLEMMING (1881-1955)

- He was an English scientist worked at St. Mary's hospital in London.
- Flemming was associated with two major discoveries-**lysozyme** and **penicillin**. In 1922, he discovered lysozyme by demonstrating that the nasal secretion has the power of dissolving or lysing certain kinds of bacteria. Subsequently, he showed that lysozyme was present in many tissues of the body.
- In 1929, Flemming made an accidental discovery that the fungus ***Penicillium notatum*** produces an antibacterial substance which he called penicillin. Flemming was culturing Staphylococci in petridishes and some of his cultures were contaminated with a mold, subsquently indetified as *Penicillium notatum*. Around the mold colony, there were clear zones, where Staphylococci disappeared. Flemming attributed this to the production of an antibacterial susbstance by the mold. Flemming cultured the fungus
- *Penicilium notatum* in broth cultures, filtered the fungal mat and obtained the penicillin in soluble form in the culture filtrate.
- In 1940, Howard Florey and Ernst Chain demonstrated its antibacterial action *in vivo*. Working in U.S.A., they were able to produce large quantities of penicillin in pure form. In 1945, Flemming, Florey and Chain shared the nobel prize in physiology and medicine for the purifying penicillin and conducted clinical trials. Penicillin has been used clinically as an antibiotic since the 1940s. In 1939, Rene Dubous discovered two antibiotics produced by the bacterium *Bacillus*.

Gerhard Domagk-1935: discovers prontosil (sulfa drugs) inhibits bacteria

METCHNIKOFF (1845-1916)

- Elie Metchnikoff, the Russian-French biologist, discovered the phenomenon of phagocytosis, the cellular concept of immunity.
- In Italy, where he had gone on a research visit, he studied the transparent larvae of starfish and noticed some of their cells could engulf and digest foreign protein particles. These cell eaters are called "**Phagocytes**".
- He continued his work on phagocytic action, at Pasteur Institure, Paris and found that in human blood a large proportion of the leucocytes (White blood cells) are phagocytic and attack invading bacteria. This, in turn, results in increased numbers of leucocytes in the infected areas followed by the inflamed area becoming hot, red, swelled and painful due to dead phagocytes forming pus.
- He spent his last two decades on the study of human aging, since he believed that phagocytes eventually begin to digest the host cells aided by the effects of intestinal bacteria and that effectively combating them would increase the life span of human being.

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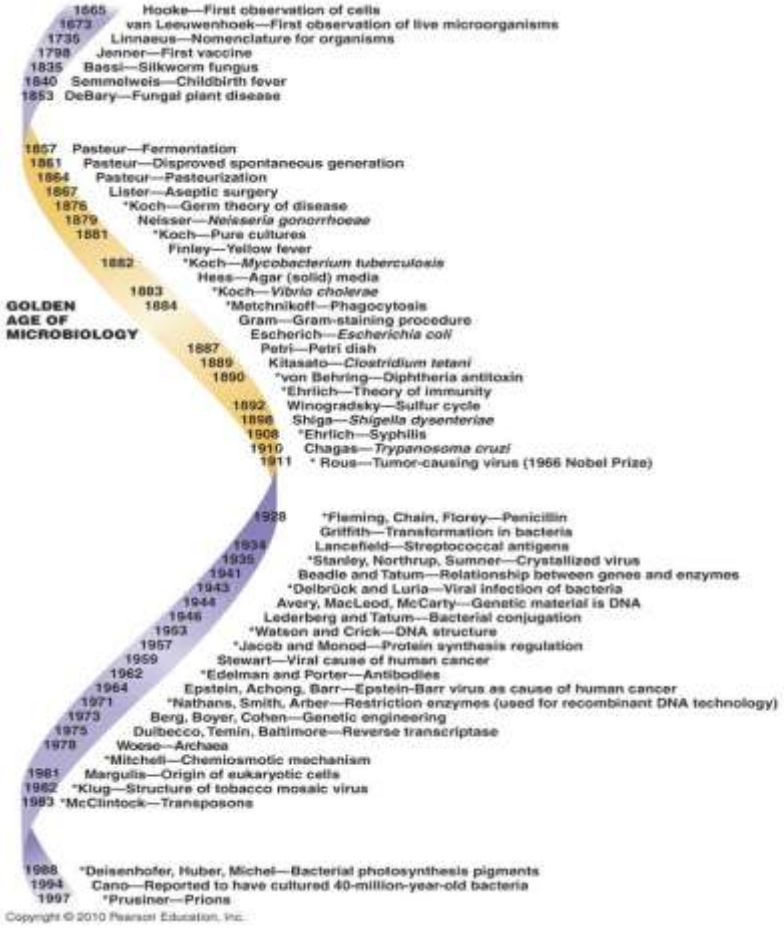
Modern Developments in Microbiology

- **Bacteriology** is the study of bacteria, mycology is the study of fungi, and parasitology is the study of parasitic protozoa and worms.Microbiologists are using genomics, the study of all of an organism's genes, to classify bacteria, fungi, and protozoa.
- The study of AIDS, analysis of interferon action, and the development of new vaccines are among the current research interests in immunology.New techniques in molecular biology and electron microscopy have provided tools for advancement of our knowledge of virology.The development of recombinant DNA technology has helped advance all areas of microbiology.

The Golden Age of Microbiology

- The period from 1857-1914, has been named the Golden Age of Microbiology.



Louis Pasteur (1822–1895)
Demonstrated that life did not arise spontaneously from nonliving matter.

Robert Koch (1843–1910)
Established experimental steps for directly linking a specific microbe to a specific disease.

Rebecca C. Lancefield (1895–1981)
Classified streptococci according to serotypes (variants within a species)

- During this period, rapid advances headed by Pasteur and Robert Koch, led to the establishment of microbiology as a science.
- Beginning with Pasteur's work, discoveries included

1. The agents of many diseases.
2. The role of immunity in the prevention and cure of diseases.

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3. The relationship between microbes and disease.
4. Antimicrobial drugs
5. Improved the techniques for microscopy and culturing microorganisms.
6. Development of vaccines and surgical techniques.
7. Studying the chemical activities of microorganisms.

Bacteriology is the study of bacteria. Began with the van Leeuwenhoek's first examination of tooth scrapings. New pathogenic bacteria are still discovered regularly. Many bacteriologists, look at the roles of bacteria in food and environment.

Mycology is the study of fungi Includes medical, agricultural, and ecological branches. Fungal infections accounting for 10% of hospital acquired infections.

Parasitology is the study of protozoa and parasitic worms. Recent advances in genomics, the study of all of an organism's genes, have provided new tools for classifying microorganisms. Previously these MOs were classified according to a limited number of visible characteristics.

Immunology is the study of immunity. Vaccines and interferons are being investigated to prevent and cure viral diseases. Vaccines are now available for numerous diseases, including measles, rubella (German measles), mumps, chickenpox, pneumococcal pneumonia, tetanus, tuberculosis, whooping coughs, polio, and hepatitis B. Smallpox was eradicated due to effective vaccination and polio is expected to. **Interferons**, substances produced by the body's own immune system, inhibit the replication of viruses and are used to treat viral diseases and cancer. The use of immunology to identify and classify some bacteria according to serotypes (variants within a species) based on certain components in the cell walls of the bacteria, was proposed by Rebecca **Lancefield** in 1933.

Virology is the study of viruses.In 1892, **Dimitri Iwanowski** reported that the organism that caused mosaic disease of tobacco was so small that is passed the bacterial filters. In 1935, **Wendell Stanely** demonstrated that the organism , called tobacco mosaic virus (TMV), was different from other microbes, so simple, and composed of only nucleic acid core and protein core. In 1940s, the development of electron microscope enabled the scientists to observe the structure and activity of viruses in detail.

Recombinant DNA Technology: In the 1960s, **Paul Berg** inserted animal DNA into bacterial DNA and the bacteria produced an animal protein. Recombinant DNA is DNA made from two different sources. Recombinant DNA technology, or genetic engineering, involves microbial genetics and molecular biology.

Using microbes

- **Beadle and Tatum** showed that genes encode a cell's enzymes (1942).
- **Avery, MacLeod, and McCarty** showed that DNA was the hereditary material (1944).

- **Lederberg and Tatum** discovered that genetic material could be transferred from one bacterium to another by conjugation (1946).
- **Watson and Crick** proposed a model for the structure of DNA (1953).
- **Jacob and Monod** discovered the role of mRNA in protein synthesis (1961).

Applications of Microbes

Everyone has microorganisms in and on the body; these make up the normal microbiota or flora.The disease-producing properties of a species of microbe and the host's resistance are important factors in determining whether a person will contract a disease.A n infectious disease is one in which pathogens invade a susceptible host. An emerging infectious disease (EID) is a new or changing disease, showing an increase in incidence in the recent past or a potential to increase in the near future. Only minority of all MOs are pathogenic. Microbes that cause food spoilage are also a minority. The vast majority of microbes benefit humans, other animals, and plants in many ways. Microorganisms degrade dead plants and animals and recycle chemical elements to be used by living plants and animals. Bacteria are used to decompose organic matter in sewage. Bioremediation processes use bacteria to clean up toxic wastes. Bacteria that cause diseases in insects are being used as biological controls of insect pests. Biological controls are specific for the pest and do not harm the environment. Using microbes to make products such as foods and chemicals is called biotechnology. Using recombinant DNA, bacteria can produce substances such as proteins, vaccines, and enzymes. In gene therapy, viruses are used to carry replacements for defective or missing genes into human cells. Genetic engineering is used in agriculture to protect plants from frost and insects and to improve the shelf life of produce.

Recycling vital elements

- In 1880s, **Beijerinck and Winogradsky** showed how bacteria help recycle vital elements between the soil and the atmosphere.
- Microbial ecology: the study of the relationship between microorganisms and their environment.
- Microorganisms recycle carbon, nitrogen, sulfur, oxygen, and phosphorus into forms that can be used by plants and animals.
- Bacteria and fungi, return CO2 to the atmosphere when decomposing organic wastes and dead plants and animals.
- Algae, cyanobacteria, and plants use CO2 to produce carbohydrates.

SEWAGE TREATMENT: Using microbes to recycle water.

- Recycling water and prevent the pollution of rivers and oceans
- Bacteria degrade organic matter in sewage (99% water), producing such by-products as carbon dioxide, nitrates, phosphates, sulfates, ammonia, hydrogen sulfide, and methane.

BIOREMEDIATION: Using microbes to clean up pollutants.

- In 1988, microbes began used to clean up pollutants and toxic wastes produced by various industrial processes.
- Bacteria degrade or detoxify pollutants such as oil and mercury.
- In addition, bacterial enzymes are used in drain cleaners to remove clogs
- Such bioremedial microbes are *Pseudomonas* and *Bacillus*, their enzymes used in household detergents.

Microbes and Human Welfare

INSECT PEST CONTROL BY MOs

- Insect pest control is important for both agriculture and the prevention of human diseases.
- *Bacillus thuringiensis* infections are fatal for many insects but harmless to other animals, including humans, and to plants.
- The bacteria produce protein crystals that are toxic to the digestive systems of the insects.
- The toxin gene has been inserted into some plants to make them insect resistant.
- Microbes that are pathogenic to insects are alternatives to chemical pesticides in preventing insect damage to agricultural crops, disease transmission, and avoid harming the environment.

MODERN BIOTECHNOLOGY AND RECOMBINANT DNA TECHNOLOGY

- **Biotechnology**, the use of microbes to produce foods and chemicals, is centuries old.
- **Genetic engineering** is a new technique for biotechnology. Through genetic engineering, bacteria and fungi can produce a variety of proteins including vaccines and enzymes.
- Recombinant DNA techniques have been used to produce a number of natural proteins, vaccines, and enzymes.
- The very exciting and important outcome of recombinant DNA techniques is **Gene Therapy**: inserting a missing gene or replacing a defective one in human cells by using a harmless virus to carry the missing or new gene into certain host cells.
- Genetically modified bacteria are used to protect crops from insects, from freezing, and to improve the appearance, flavor, and shelf life of fruits and vegetables. (more: Drought resistance and temperature tolerance)

Microscopy

Microscopy comprises of the tools that are used to see/image the microscopic objects and even macromolecules. There exists a wide variety of microscopic tools for studying the biomolecules and biological processes. Light microscopy is the simplest form of microscopy. It includes all forms of microscopic methods that use electromagnetic radiation to achieve magnification. In this lecture, we shall be discussing the principles of microscopy.

Geometrical optics

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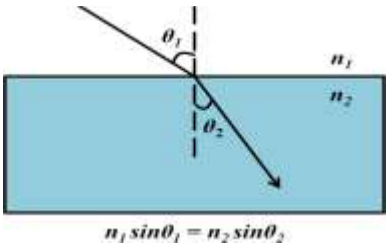
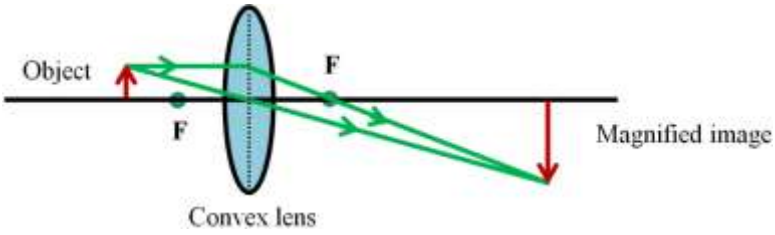
Light microscopy uses glass for bending and focusing the light. Refraction (bending) of light is the manifestation of different light velocities in different materials. Refractive index of a material is therefore a measure of the velocity of light in that material. The bending caused in the light beam when it enters from one material into another is given by the Snell's law

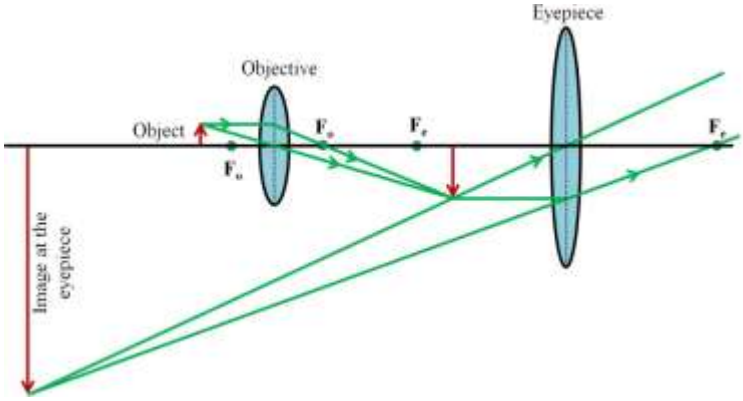


A convex lens is the simplest microscope. Figure 14.2 shows how a convex lens produces a magnified image of an object. A light ray parallel to the optical axis of the lens passes through the focus of the lens while a ray passing through the centre of the lens does not bend.



Magnification of an object by a convex lens

A microscope that uses two lenses to generate the magnified image of the object is called a compound microscope. The magnified image generated by one lens is further magnified by the second lens Magnification of a compound microscope is the product of the magnification caused by the objective and ocular (eyepiece) lenses:



Mfinal = Mobjective × Mocular

Ray optical diagram of a compound microscope

Resolution of microscope

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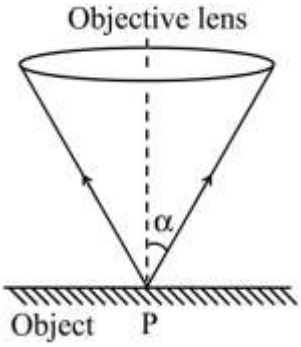
Resolution of a microscope is defined as $dmin = 1.22\ \lambda 2n\ sin\alpha = 1.22\ \lambda 2\ N.A. = 0.61\ \lambda N.A.$ ····· (14.1)

dmin = minimum distance between point objects that can be resolved

λ = wavelength of the light source used

n = refrective index of the medium between the objective lens and the specimen

α = half of the objective angular aperture

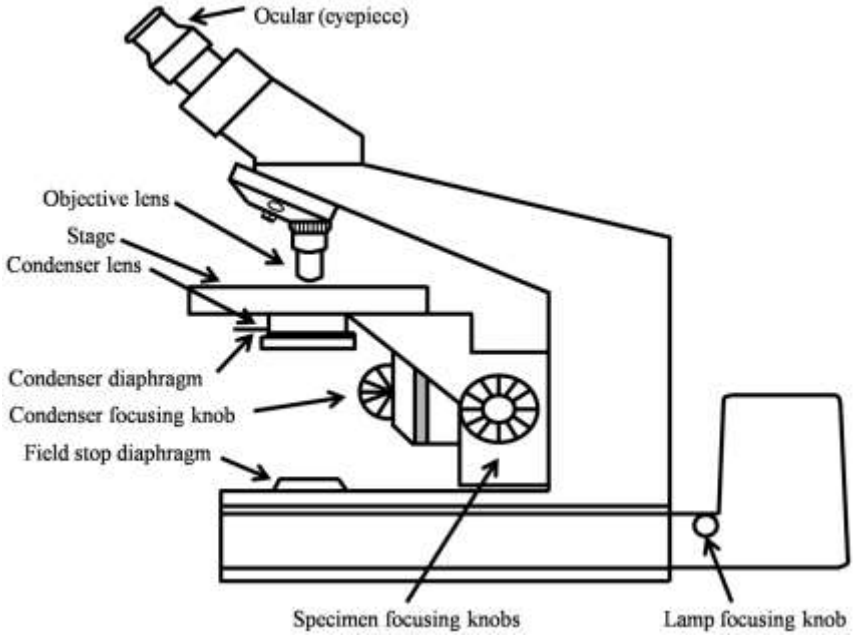


N. A. = numerical aperture = $n\ sin\alpha$

Resolution of a microscope

As is clear from the definition of resolution, lower *dmin* implies higher resolution. Resolution of a light microscope operating at the blue end of the visible spectrum will therefore be higher than that operating at the red end, assuming all other parameters remain same. The theoretical limit for *dmin* for a light microscope operating in high refractive index (typically, *nmax* = 1.4 for the oil used in microscopy) is ~ 0.17 μm (Assuming λ = 400 nm and $sin\alpha$ = 1). It is therefore an intrinsic limitation of a light microscope to resolve the particles closer than ~0.17 μm. It is evident that the resolution can be increased if the wavelength of the source radiation is reduced.

Parts of a light microscope



The light is produced by a lamp source and focused on the specimen by the condenser. The light diffracted by the sample is then collected by the objective lens that generates a real magnified image as shown in Figure 14.3. This image is further magnified by the eyepiece.

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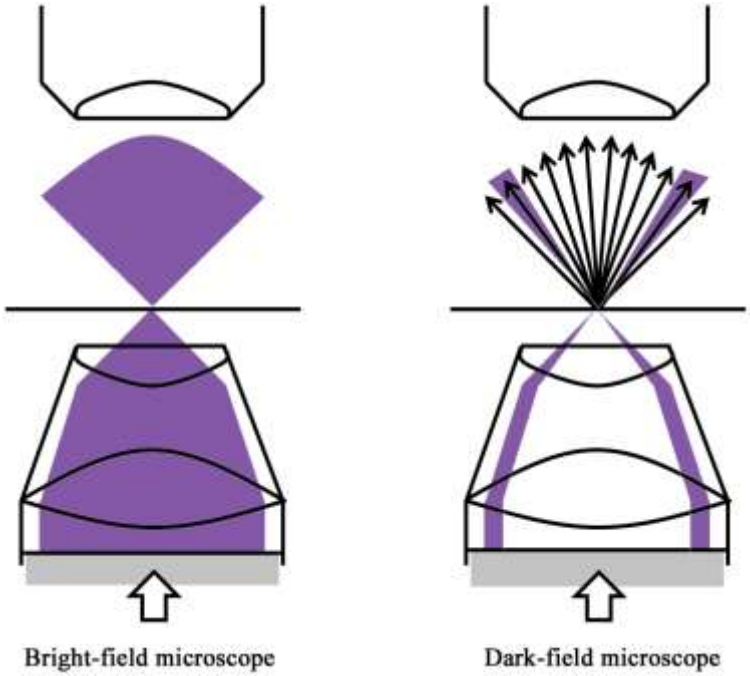
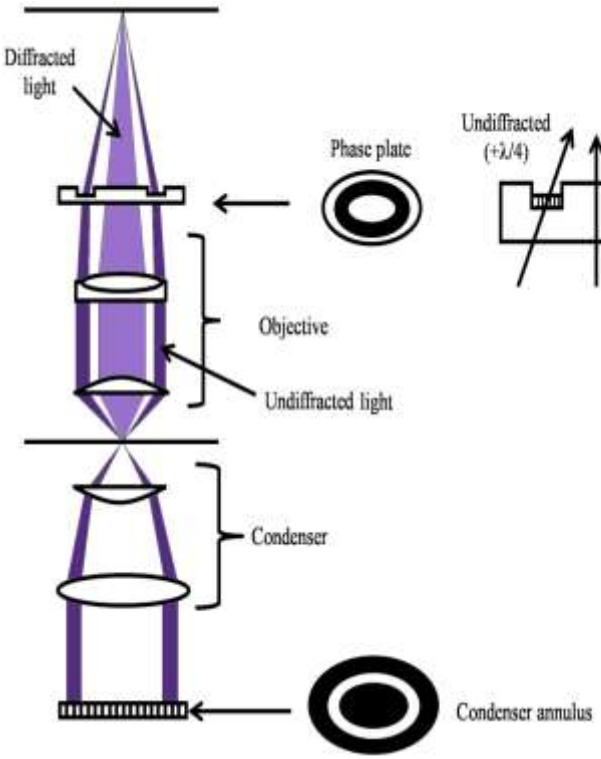
Bright-field microscopy

In a bright-field microscope, both diffracted (diffracted by the specimen) and undiffracted (light that transmits through the sample undeviated) lights are collected by the objective lens (Figure 14.6). The image of the specimen is therefore generated against a bright background, hence the name bright-field microscopy. Most biological samples are intrinsically transparent to the light resulting in poor contrast. To increase the contrast of the image, the specimens are therefore generally stained with the dyes. However, intrinsically colored samples such as erythrocytes can directly be observed using bright-field microscopy.

Dark-field microscopy



Dark-field microscopy increases the contrast of the image by eliminating the undiffracted light. The specimen is illuminated by the light coming from a ring at an oblique angle .If there is no specimen in the optics path, no light is collected by the objective lens. Presence of specimen results in the diffraction of light; the objective lens collects the diffracted light generating a bright image against a dark background.



Phase contrast microscopy

A phase contrast microscope provides very high contrast as compared to the bright-field and dark-field microscopic methods. The image in a phase contrast microscope is generated from both diffracted and undiffracted lights as shown in Figure 14.7. Like dark-field microscopy, the specimen is illuminated by the light coming from a ring, called a condenser annulus. The diffracted and the undiffracted lights are separated in space allowing

selective manipulation of their phases and intensities. The diffracted as well as the undiffracted light is collected by the objective lens. A phase plate is placed at the back side of the objective lens that increases the phase of the undiffracted light by $\lambda 4$ and decreases that of diffracted light by $\lambda 4$ as shown in Figure 14.7. A total phase difference of $\lambda 2$ is therefore obtained between the diffracted and the undiffracted light beams before they are focused on the image plane. As the intensity of the undiffracted light is very high, it is selectively reduced to ~30% of the initial intensity by a semi-transparent metallic film on the phase plate. Two waves that have $\lambda 2$ phase difference interfere destructively thereby diminishing the light intensity. Any phase change caused by the specimen is therefore converted into an amplitude signal by a phase contrast microscope thereby increasing the contrast.

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DEPARTMENT OF MICROBIOLOGY
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (17MBU101)

Unit I Question	Opt A	Opt B
Who demonstrated that open tubes of broth remained free c	Abbc Spallanzan	John Tyndall
The image obtained in a compound microscope is	Real	Virtual
Enzymes responsible for alcoholic fermentation	Ketolase	Zymase
Bacterial transformation was discovered by	Ederberg and Ta	Beadle and Tatu
Father of microbiology is	Louis Pasteur	Lister
The antiseptic method was first demonstrated BY	Lwanowski	Lord Lister
Small pox vaccine was first discovered by	Robert Koch	Louis Pasteur
The term mutation was coined by	Pasteur	Darwin
Compound microscope was discovered by	Antony von	Pasteur
Father of Medical Microbiology is	Pasteur	Jenner
Disease that affects many people at different countries is ter	Sporadic	Pandemic
Salt and sugar preserve foods because they	Make them acid	Produce a hypot
In a fluorescent microscope the objective lens is made of	Glass	Quartz
Direct microscopic count can be done with the aid of	Neuberg chambe	Anaerobic chami
In electron microscope, what material is used as an objectiv	Magnetic coils	Superfine glass
The main feature of prokaryotic organism is	Absence of locon	Absence of nucle
During conjunction the genetic material will be transferred f	Cell wall	Medium
Antiseptic surgery was discovered by	Joseph Lister	Ernest Abbe
Phagocytic phenomenon was discovered by	Louis Pasteur	Alexander Flemi
The minimum number of bacteria required to produce clinic	LD50	ID
In Electron Microscope source of electrons is from	Mercury lamp	Tungsten metal
Griffith (1928) reported the phenomenon of transformatior	*H. influenzae*	*Bacillus species*
The resolution power of the compound microscope is	0.2 micron	0.2 millimeter
The capacity of a given strain of microbial species to produc	Pathogen	Virulence
Monoclonal antibodies are associated with the name of	Burnet	Medwar
Lederberg and Tatum (1946) described the phenomena of	Conjunction	Transformation
Hanging drop method for motility study was first introduce	Robert Koch	Louis Pasteur
Electron microscope gives magnification upto	100 X	2000 X
Term vaccine was coined by	Robert Koch	Pasteur
The inventor of Microscope is	Galileo	Antony von
First Pasteur conducted fermentation experiments in	Milk	Food material
Modern concepts of chemotherapy was proposed by	Paul Ehrlich	Joseph Lister
The role of phagocytosis was discovered	Paul Ehrlich	Joseph lister
Eye cannot resolve any image less than	1ìm	2ìm
Compound Microscope was discovered by	A.V. Lewenhoek	Pasteur
Electron Microscope was discovered by	Prof. Fritz	Janssen and Han
Magnification range of light microscope is	1000x – 5000x	1000x – 2000x
Condensation of light in light Microscope is by	Objective	Condensor
Light gathering capacity of Microscope is by	Numerical apert	Angular apertur
If 10x and 40x objectives are used (air is the medium), the r	1.5	2

The ability of Microscope to distinguish two objects into two	Resolving power	Wave length
Source of light in fluorescence microscopy is from	Mercury lamp	Sunlight
The magnefication power of electron microscope developed	10,000x	12,000x
In electron microscope source of electrons is from	Mercury lamp	Tungsten metal
The electron passed out from the specimen are called	Primary electron	Secondary electr
The transfer of genetic material during transformation is pr	Avery Macleod &	Lederberg & Ta
Phagocytic theory was proposed by	Louis Pasteur	Elie Metchnikoff
E.coli was first isolated by	Louis Pasteur	Escherich
Mycobacterium tuberculosis was first discovered by	Robert Koch	Edward Jenner
Streptococcus pneumoniae was isolated by	Robert Koch	Edward Jenner
B.anthracis was isolated by	Louis Pasteur	Robert Koch
Staphylococcus aureus was isolated by	Rosenbach	Louis Pasteur
Pseudomonas aeruginosa was first named	Schroeter and Ge	Robert Koch
T. pallidum was discovered by	Robert Koch	Schaudinn and H
Neisseria gonorrhoeae was first described by	Neisser in 1879	Pasteur in 1878
Fluroscent substance used in fluorescent microscopy are	Quinine sulphate	Auramine
Who is considered as the "natural philosopher"	Anton van Leeuv	Francois Appert
The Swan necked flask was introduced by ____	Spallan Zani	Francois Appert
The word “Animacules” was first coined by	Joseph Lister	Beijerinck
Abiogenesis is otherwise known as ___	Spontaneous Ge	Biogenesis

Opt C	Opt D	Answer
Francisco Red	Pasteur	John Tyndall
Real inverted	Virtual inverted	Virtual
Peroxidase	Oxidase	Zymase
Griffith	None of these	Beadle and Tatum
A.V. Leeuwenhock	Robert Koch	A.V. Leeuwenhock
Edward Jenner	Beijerinck	Lord Lister
Lister	Edward Jenner	Edward Jenner
Hugo devries	Lamark	Hugo devries
Johnsen & Hans	None of these	Johnsen & Hans
Koch	A.L.Hock	Koch
Epidemic	Endemic	Pandemic
Deplete nutrients	d. Produce a hypertonic environment	d. Produce a hyperto
Polythene	None of these	Polythene
Mineral oil	Olive oil	Neuberg chamber
Aluminium foils	Electrons	Magnetic coils
Absence of nuclea	Absence of protein synthesis	Absence of nuclear e
Pili	Capsule	Pili
Pasteur	Beijerink	Joseph Lister
Metchnikof	Beijerink	Metchnikof
MLD	LD12	MLD
both a and b	None of these	Tungsten metal
Pneumococci	*E.coli*	*Pneumococci*
0.2 Angstrom uni	0.2 centimeter	0.2 micron
Infection	None of these	. Virulence
Milstein kohler	Owen	Burnet
Mutation	Plasmids	Conjunction
Jenner	Leeuwenhock	Leeuwenhock
50,000 X	2,00,000 X	2,00,000 X
Needham	None of these	Pasteur
Pasteur	Koch	Antony von
Fruit juices	Both a and c	Fruit juices
Elie Metchnikoff	None of these	Paul Ehrlich
Elie Metchnikoff	Pasteur	Elie Metchnikoff
7ìm	5ìm	5ìm
Janssen and Hans	None of these	Janssen and Hans
Knoll and Ruska	Pasteur	Knoll and Ruska
500x – 1000x	200-2000x	1000x – 2000x
Ocular	eye piece	Condensor
Both a and b	resolution	Numerical aperture

N.A	resolution	Resolving power
Both a and b	Electrons	Mercury lamp
15,000x	20,000x	12,000x
Both a and b	UV lamp	Tungsten metal
Tertiary electrons	quaternery electrons	Secondary electrons
Zinder & Lederbe	Watson & Crick	Avery Macleod & Mc
Behring	Widal	Elie Metchnikoff
Shiga	Koch	Escherich
Louis Pasteur	Lister	Robert Koch
Antony von Leew	Louis Pasteur	Louis Pasteur
Antony von Leew	Lister	Robert Koch
Passet	Sir Alexander Ogston	Louis Pasteur
Louis Pasteur	Edward Jenner	Schroeter and Gessa
Louis Pasteur	Edward Jenner	Schaudinn and Hoffi
Robert Koch	Escherich	Pasteur in 1878
Quinine sulphate	congo red	Quinine sulphate an
Louis Pasteur	Robert Koch	Anton van Leeuwenl
Louis Pasteur	Robert Koch	Louis Pasteur
Antony van Leeuv	Louis Pasteur	Antony van Leeuwer
Vaccination	Pasteurisation	Spontaneous Genera

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DEPARTMENT OF MICROBIOLOGY
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I-B.Sc., Microbiology (Batch 2017-2020)

Introduction to Microbiology and Microbial Diversity (Semester-I) (17MBU101)

LECTURE PLAN

UNIT II

Duration	Topic	Reference
01	Bergey's Manual	R1: 39-43
02	Binomial Nomenclature and Universal Phylogenetic tree	R1: 32-36
03	Classification system: Phenetic and Phylogenetic	R1: 37-39
04	Whittaker's Five Kingdom classification system	R2: 10-11
05	Carl Woese's three kingdom classification system	R3: 283-285
06	Difference between prokaryotic and eukaryotic microorganisms	R2: 8-10
07	Major diversity of microbial life	R2: 15-16
08	Bacteriology	R2: 23-25
09	Unit revision and possible questions	
	Total hours: 9	

R1: Duby, R.C. (2014) Textbook of Microbiology. 5th edition. S. Chand Publishing.

R2: Pelczar, M.J., Chan, E.C.S., and Krieg, N.R. (1993). Microbiology. 5th edition. McGraw Hill Book Company.

R3: Tortora, G.J., Funke, B.R., and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

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2017

Introduction to microbiology and Microbial diversity

Unit II notes

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Unit II: Diversity of microbial world

Scientific Nomenclature

• Carolus Linnaeus

• Binomial nomenclature: genus + species – italicized or underlined. – genus is capitalized – specific epithet (species) is lower case.

• "Latinized" • used worldwide

• Naming bacteria – Names can describe characteristics or honor pioneer in field – Rules established by International Committee on Systemic Bacteriology = Bacteriological Code – Bergey's Manual contains description and rules

• Compiled from publications in International Journal of Systemic Bacteriology

• Change as new techniques disclose similarities and differences

Examples • *Staphylococcus aureus* – Describes the clustered arrangement of the cells (staphylo-) and the golden color of the colonies (aur-). • *Escherichia coli* – Honors the discoverer, Theodor Escherich, and describes the bacterium's habitat–the large intestine or colon. • After first use, can be abbreviated as: "*S. aureus*" and "*E. coli*"

Scientific names

Scientific Binomial	Source of Genus Name	Source of Specific Epithet
Klebsiella pneumoniae	Honors Edwin Klebs	The disease
Pfiesteria piscicida	Honors Lois Pfiester	Disease in fish
Salmonella typhimurium	Honors Daniel Salmon	Stupor (*typh-*) in mice (*muri-*)
Streptococcus pyogenes	Chains of cells (*strepto-*)	Forms pus (*pyo-*)
Penicillium chrysogenum	Tuftlike (*penicill-*)	Produces a yellow (*chryso-*) pigment
Trypanosoma cruzi	Corkscrew-like (*trypano-*, borer; *soma-*, body)	Honors Oswaldo Cruz

Taxonomic hierarchy

• Kingdom
• Phylum or Division
• Class
• Order
• Family
• Genus
• Species

What is a species?

• **Eukaryotic species**: A group of closely related organisms that breed among themselves

• **Prokaryotic species**: A population of cells with similar characteristics – Clone: Population of cells derived from a single cell – Strain: Genetically different cells within a clone

• **Viral species**: Population of viruses with similar characteristics that occupies a particular ecological niche

How to determine phylogenetic heirarchy

• Generally determined by fossil records for higher organisms

• Not available for most microbes with following exceptions – White Cliffs of Dover in England

• Fossilized remains of marine protists – Stromalites

• Fossilized microbial communities up to 2 billion years old – Cyanobacterial fossils

• Found in Australia • 3-3.5 billion years old

Classifying bacteria: Bergey's Manual of Systematic Bacteriology

• 4 divisions – Distinguished by cell wall structure

• 7 classes – 3 eubacterial – 4 archaeobacterial

• Bacterial species – Population of cells with similar characteristics

• Strain – Variation within a species – Race, clade (ex) E. coli 0157:H7

Approx 1800 bacteria classified,<200 bacterial pathogens classified

Four volumes

– 1. Wall-less eubacteria and some gram-negative eubacteria

– 2. Gram positive eubacteria

– 3. Gram negative eubacteria

• Photosynthetic, chemolithotropic, sheathed, budding, appendaged, gliding, and fruiting bacteria

• archaeobacteria

– 4. Actinomycetes

Carolus Linnaeus/Carol von Linnae (1707-1778)

- Swedish physician and botanist
- sought to discover order in the diversity of life "for the greater glory of the Lord"
- divided life between plants and animals
- developed the two part or binomial system of naming organisms according to genus and species that is still used today

Robert H. Whittaker (1969)

- led a team of researcher from Cornell University.
- proposed a 5-kingdom system: Monera, Protista, Plantae, Fungi, and Animalia

Carl Woese (1977)

- added Archaea as a sixth kingdom
- redefined his classification to three domains in 1990: Bacteria, Archaea and Eukarya.

Linnaeus 1735	Haeckel 1866	Chatton 1925	Copeland 1938	Whittaker 1969	Woese et al. 1977	Woese et al. 1990	Cavalier-Smith 2004
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	6 kingdoms	3 domains	6 kingdoms
(not treated)	Protista	Prokaryota	Monera	Monera	Eubacteria	Bacteria	Bacteria
					Archaebacteria	Archaea	
		Eukaryota	Protoctista	Protista	Protista	Eukarya	Protozoa
							Chromista
Vegetabilia	Plantae			Fungi	Fungi		Fungi
			Plantae	Plantae	Plantae		Plantae
Animalia	Animalia		Animalia	Animalia	Animalia		Animalia

2 Types of cells

1. *Prokaryotes* – no nucleus and has single loop of DNA
2. *Eukaryotes* – has nucleus, DNA is longer and contain more information, has a lot of organelles

Bacteria/Eubacteria – Prokaryotes
- Rarely have organelles
- Often motile using pili or flagella
- Peptidoglycan (a kind of protein) in cell wall
- Can be found in many different shapes and sizes
- Can be found in almost any environment
- Ex. *E. coli*

Archaea – Prokaryotic organisms
- Mostly inhabit extreme environments (extremophiles)
- Archaean groups based on environmentsal criteria

1. *Methanogens* – obtain energy using CO2 to oxidize H2 producing methane; live mostly in swamps and marshes where there is little oxygen
2. *Halophiles* – live in saline places. Some just tolerate salinity while some require a degree of salt to be present to survive.
3. *Thermophiles* – thrive in hot environments
4. *Alkaliphiles/Acidophiles* – thrive in basic or acidic environments.

- ex. *Sulfulobulos*

Protists – mostly unicellular eukaryotes
- maybe several kingdoms within Domain Eukarya
- Some make food by photosynthesis (algae)
- Some are heterotrophic and eat bacteria and other protests
- Can be heterotrophic or autotrophic
- Some protests are fungus-like
- Ex. Amoeba, brown algae, Diatoms, *Trypanosoma*

Fungi – heterotrophic eukaryotes that digest their food externally and absorb externally and absorb the nutrients.
- usually consists of a mass of threadlike hyphae called a mycelium
- ex. Yeast, Button mushrooms, truffles

Plants – multicellular eukaryotes that make organic molecules by photosynthesize.
- have fortified cell well (lignin)
- obtain nutrients in two media (air and water)
- ex. Trees, shrubs, grasses

Animalia – are multicellular, heterophic and lack cell walls
- held together by extracellular structural proteins and by unique type of multicellular junctions
- reproduce sexually

Modes of Nutrition among Living organisms.

Mode of Nutrition	Energy Source	Carbon Source	Types of Organisms
Autotroph			
Photo-autotroph	Light	CO2	Photosynthetic prokaryotes including cyanobacteria; plants; ncertain protests (algae)
Chemo-autotroph	Inorganic chemicals	CO2	Certain prokaryotes (*Sulfolobus*)
Heterotroph			
Photo-heterotroph	Light	Organic compounds	Certain prokaryotes
Chemo-heterotroph	Organic compounds	Organic compounds	Many prokaryotes and protests; fungi; animals; some parasitic plants

Comparisons among the three domains

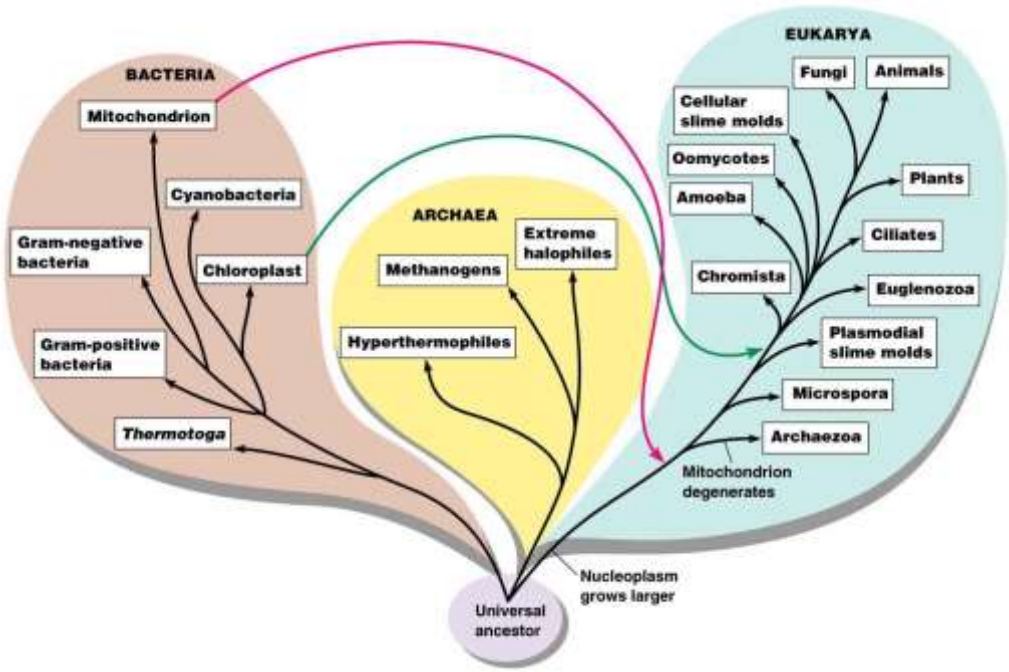
CHARACTERISTICS	DOMAIN		
	Bacteria	**Archaea**	**Eukarya**
Nuclear envelope	Absent	Absent	Present
Membrane-enclosed organelles	Absent	Absent	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Reproduction	Asexual	Asexual	Sexual/Asexual
Introns (noncoding parts of genes)	Rare	Present in some genes	Present
Response to the antibiotics streptomycin and chloramphenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present	Present
Circular chromosome	Present	Present	Absent
Ability to grow at temperatures >1000C	No	Some Species	No

The Three-Domain

TABLE 10.1 Some Characteristics of Archaea, Bacteria, and Eukarya

	Archaea	Bacteria	Eukarya
			
Cell Type	Prokaryotic	Prokaryotic	Eukaryotic
Cell Wall	Varies in composition; contains no peptidoglycan	Contains peptidoglycan	Varies in composition; contains carbohydrates
Membrane Lipids	Composed of branched carbon chains attached to glycerol by ether linkage	Composed of straight carbon chains attached to glycerol by ester linkage	Composed of straight carbon chains attached to glycerol by ester linkage
First Amino Acid in Protein Synthesis	Methionine	Formylmethionine	Methionine
Antibiotic Sensitivity	No	Yes	No
rRNA Loop*	Lacking	Present	Lacking
Common Arm of tRNA†	Lacking	Present	Present

*Binds to ribosomal protein; found in all bacteria.
†A sequence of bases in tRNA found in all eukaryotes and bacteria: guanine-thymine-pseudouridine-cytosine-guanine.



Five Kingdom System of RH-Whittaker (1969)

- Kingdom Prokaryotae/Monera
- Kingdom Protista

• Kingdom Fungi
• Kingdom Plantae
• Kingdom Animalia

Kingdom Bacteria
• Prokaryotes
• Peptidoglycan cell walls
• Binary fission
• Energy source: organic chemicals, inorganic chemicals, or photosynthesis

Kingdom Archaea
• Extreme living conditions
• Unusual metabolism
• No peptidoglycan in cell walls
• Examples – Methanogens – Halophiles – thermoacidophiles

Kingdom Protista
• Primarily unicellular eukaryotes
• Protozoa, algae, slime molds, water molds

Kingdom Fungi
• Unicellular yeasts
• Multicellular molds
• Mushrooms
• Saprophytes with hyphae

Kingdom Plantae
• Some alga, mosses, ferns, conifers, flowering plants
• Multicellular • Photosynthetic (autotrophs)

Kingdom Animalia
• Sponges, worms, insects, chordates
• Heterotrophic • multicellular

Algae
• Some unicellular, some multicellular
• Kingdom Protista, Kingdom Archaea, and Kingdom Plantae!
• photoautotrophs

Viruses
• Acellular • DNA or RNA, not both at same time
• Protein capsid • Some have envelope and other external structures • Obligate intracellular parasites

Three Domain System of Carl Woese (1978)

• Based on molecular biology and recognition that ribosomal differences suggest two types of prokaryotes

• Eukarya, prokarya, archaea

• Sometimes organized as empires or domains = a category above kingdom

Kingdoms in three domain system

• Recent discoveries in molecular biology have suggested division in Kingdom Protista

• New classification scheme – Domain Bacteria

• Kingdom Bacteria – Domain Archaea

• Kingdom Archaea – Domain Eukarya

• Kingdom Archaezoa Kingdom Plantae

• Kingdom Euglenazoa Kingdom Fungi

• Kingdom Alveolata Kingdom Animalia

• Kingdom Stramenopila

• Kingdom Rhodophyta

Classification of Microorganisms

I. Microbial Diversity

- Evolution → large number of bacterial, archaeal and eukaryotic species
- Tree of life (Figure 10.1)
- >1.8 million species have been identified.

Group	No. species described	Estimated total No. species
Prokaryotic	7,000	400,000 to 4,000,000
Fungi	100,000	1,500,000
Protozoa	40,000	200,000
Algae	40,000	400,000
Plants	290,000	350,000
Insects	950,000	8,000,000
Vertebrates	52,000	52,000

II. Classification of microorganisms

Why study diversity?

Taxonomy - the science of biological classification; the grouping of organisms according to their mutual similarities (i.e., establishing relationships between one group of organisms and another; to differentiate one group of organisms from another).

Systematics - The study of biodiversity in an evolutionary context (i.e., the study of the evolutionary history of organisms)

1. Principles of classification

- organisms exist as real, separate groups
- natural ordering into the groups
- reflect genetic relationships
- established by evolutionary processes (phylogeny - evolutionary history = evolutionary relatedness of organisms)

How do we determine what is a "species" in microbiology?

i) Phenetic Classification
- Classification according to phenotypic characteristics
- Group **analogously similar** organisms

The Phenetic approach is problematic
- taxa are often polyphyletic, i.e., contain organisms with different evolutionary histories (i.e., homologously dissimilar organisms are grouped together)

Phenetic Classification Parameters

a. Morphology
- cell shape and size, arrangement of cells, arrangement of flagella, capsule, endospores, mechanism of motility
- staining properties – e.g., **Gram stain reaction** and acid-fast stain reaction

b. Nutrition and physiology
- Modes of metabolism (phototroph, chemoorganotroph, chemolithotroph); energy sources, carbon, nitrogen and sulfur sources, fermentation products, growth factor requirements; Temperature range and optima, pH tolerance range, osmotic tolerance, salt requirements and tolerance, secondary metabolites formed, storage inclusions…
- Many different biochemical tests are used to assess a microbes nutrition and physiology
- Serotyping – Identifying a microorganism based on its reaction to particular antibodies. The antibodies are used to identify microorganisms carrying particular antigens. Techniques like the Western blot or Enzyme Linked Immunosorbent Assay (ELISA)
- Phage typing – determines the susceptibility of a bacterium to a particular phage type. Highly specialized and usually restricted to the species level and lower.

c. Ecological Characteristics
- The ability of a microorganism to colonize a particular environment
- Life cycle patterns, the nature of symbiotic relationships, the ability to cause disease in a particular host, habitat preferences (e.g., requirements for temperature, pH, oxygen, osmotic concentration)

d. Genetic analysis – the study of chromosomal gene exchange through transformation, conjugation and transduction is sometimes useful for classification.

Application of Phenotypes in Taxonomy and Systematics

a. Development of diagnostic keys for identification
(e.g. Dichotomous key in Microbiology lab manual)

b. Many commercial systems have been developed for microbial identification
- API – biochemical test profiling – often carbon source use but may also include enzymatic activities and other attributes
- Enterotube – biochemical test profiling
- Biolog – tests usage of 95 different carbon sources and compares results to a database of characterized bacteria
- FAME – fatty acid methyl ester – this techniques determines the cellular fatty acid profile and compares it to a database of characterized bacteria

The above approaches are useful but you must be able to grow the organism!

ii) Phylogenetic Classification
- Hereditary molecules provide insight into relatedness
- Hierarchies established on the basis of phylogeny
- Group **homologously similar** organisms

Molecular taxonomy techniques

i) Nucleic acid base composition
- G + C content = the percent of G + C in the DNA
- Can be determined by hydrolysis of DNA and HPLC analysis of the resulting bases or by melting temperature (T_m) determination
- Organisms with that differ in their G + C content by more than 10% are likely to have quite different base sequences

ii) DNA:DNA hybridization – genomic DNA from one organisms is labeled and hybridized with the genomic DNA from another organism. This technique measures the similarity between the two DNAs. Does not work well for comparing distantly related microorganisms.

- DNA chip technology has made it possible to "print" many different species specific probes (> 10,000) onto a glass slide (i.e., the "chip"). Genomic DNA is extracted from an unknown organism and labeled with a fluorochrome. The labeled genomic DNA is hybridized with the probes on the chip. Hybridization reactions fluoresce and can be identified by reading the DNA chip with an instrument known as a DNA chip reader

iii) Ribosomal RNA sequence analysis – rRNA genes (i.e., rDNA) from an unknown is isolated, sequenced and compared to database entries. The rDNA can easily be isolated by using rDNA specific primers and PCR. The amplified rDNA gene fragments are sequenced and compared to database entries (e.g., GenBank or Ribosomal Database project)

Species level
> 70% DNA re-association (DNA hybridization)
> 97% similarity between 16S rRNA sequences

Genus level
> 20% - 30% DNA re-association (DNA hybridization)
93% - 95% similarity in 16S rRNA sequences

Families
89 - 93 % similarity in 16S rRNA sequences

Family taxon is usually the highest level taxon used for prokaryotes

iv) Ribotyping – a technique used for bacterial identification.
- Genomic DNA is digested with restriction enzymes and then probed with an rRNA probe
- Banding pattern is compared to a database
- This technique is also known as molecular fingerprinting because a unique banding pattern appears for virtually any organism.

v) Multilocus Sequence Typing (MLST)

- This technique involves the sequencing fragments from 6 to 7 genes (often housekeeping genes) from an organism and comparing these with the same gene set from different strains of the same organism
- Can distinguish between closely related strains
- While rRNA gene sequence analysis is capable of identifying organisms to the genus level, MLST is useful for identifying organisms to the species level and below. MLST is not useful above the species level because is it too sensitive
- This technique has been used in epidemiological studies to track virulent strains of bacteria as well as differentiating strains of a particular pathogen

Disagreements between the phenetic and phylogenetic systems.

Groupings established by phenetic and phylogenetic systems do not always agree. Some notable examples are listed below.

- Proteobacteria contain photosynthetic bacteria such as *Chromatium* and heterotrophs such as *Escherichia*
- *Phytophthora infestans* once thought to be a fungus is actually more closely related to diatoms

III. Methods for determining evolutionary relationships

- Phylogeny is the study of evolutionary relationships
- Hereditary molecules provide insight into relatedness
- Hierarchies have been established on the basis of phylogeny

How are evolutionary relationships determined?

Study the sequences of evolutionary (molecular) chronometers

- Evolutionary time is embedded within informational molecules and the degree of similarity (homology) is a function of evolutionary distance

e.g.	nucleic acids	rRNA
		hsp genes – *cpn60*
	proteins	ATPase
		DNA & RNA polymerases
		Cytochromes & ferrodoxins

- The molecular chronometers are more reliable and objective tools for determining phylogeny than past phenetic approaches. Bacterial phylogeny used to be largely intuitive.

Criteria for molecular chronometers

The molecule must be:

- universally distributed across the study group
- functionally homologous in each organism
- have regions of sequence conservation for aligning the sequences for analysis
- should reflect evolutionary change in the organism as a whole

Ribosomal RNA as Evolutionary Chronometers

- Carl Woese – early 1970's - initiated the study of rRNA
- 16S rRNA (Bacteria and Archaea) and 18S rRNA (Eukaryotes)
- rRNA molecules are among the most evolutionarily conserved macromolecules in all living systems
- Large portions of their sequences are well conserved

Analysis of 16S rRNA and 18S rRNA

- Nucleotide sequence analysis followed by comparison to other sequences in databases
- Ribosomal Database Project > 800,000 16S rRNA (RDPII - http://rdp.cme.msu.edu/)
- GenBank (USA), EMBL (Germany), DDBS (Japan)

❖ Evolutionary distances can be determined through comparison of genetic similarity
  - Align sequences
  - Generate trees using treeing algorithm – calculates evolutionary distances

- These techniques have identified taxa specific sequences or **signature sequences**. These sequences are used to produce phylogenetic probes and primers

16S rRNA and 18S rRNA make excellent molecular chronometers

- Universal
- Functionally similar [part of ribosome small subunit (SSU) in both prokaryote and eukaryotes]
- Long highly conserved regions useful for looking at distant relationships
- Sufficient variable regions to assess close relationships
- Not prone to rapid sequence change i.e., central functional component in gene expression
- Large enough to provide enough information for comparison and small enough to conveniently analyze (~1500 nt for 16S and ~2300 for 18S)
- Large amounts of these macromolecules are produced in cells

Application of 16S/18S rRNA Sequences

a) Microbial ecology/Clinical diagnostics
- Signature sequences are used to construct phylogenetic probes and primers in order to identify organisms from different groups

  Universal probes vs more specific probes

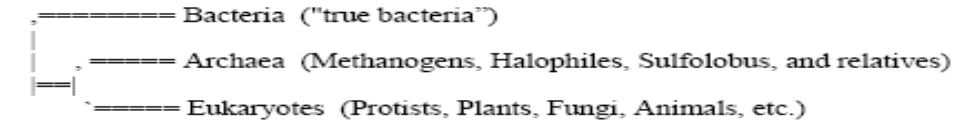
Fluorescent in situ hybridization (FISH)
- fluorescently labelled probes can enter permeabilized cells
- applied directly to cells in culture or a natural environment
- useful for nonculturable cells

Microbial community analysis
- extraction of community nucleic acids
- PCR amplify 16S/18S rRNA genes → rDNA clones
- Sequence rDNA clones and generate phylogenetic tree
- Can use quantitative PCR to determine relative abundance of specific organisms or groups

IV. Microbial Evolution

- Research by Woese and others suggests that life on earth evolved along three evolutionary lineages called domains: Bacteria, Archaea and Eukarya

- Phylogenetic information along with other taxonomic information has been used to construct the **Universal Phylogenetic Tree** or Tree of Life (Figure 10.1)



Where do viruses fit in?

Universal Phylogenetic Tree
- Depicts the evolutionary history of life and clearly reveals the three domains
- rRNA sequence analysis has made a significant contribution to constructing the universal phylogenetic tree
- Genome sequencing projects have provided clues about the nature of the universal ancestor
- Genome sequencing projects have also revealed that
  a) a large number of unique genes for every organism sequenced (up to 30%)
  b) many genes are shared among species in all three domains!!!!

Should it be a Universal phylogenetic net?

Phenotypic Characteristics of the Domains of Life
- In addition to genetic criteria, the domains of life can also be characterized by certain phenotypic properties

i) Cells Walls
Evolution of peptidoglycan cell walls is important to bacterial evolution.
- Unique feature of virtually all bacteria – few exceptions – *Mycoplasma* – *Chlamydia* and *Planctomyces* – *Pirella* groups
- Peptidoglycan is a signature molecules for species of bacteria
- Gram negative cell wall evolved first - Gram-positive cell wall evolved later.

ii) Lipids
- Archaeal lipids consist of ether-linked molecules in contrast to the ester linked lipids of Bacteria and Eukarya. A few Bacteria have ether linked lipids but no Archaea have ester linked lipids

iii) RNA polymerase

- Bacteria possess a RNA polymerase with a relatively simple structure (5 polypeptides)
- Archaeal RNA polymerases contain 8 or more polypeptides, more closely resembling eukaryotic RNA polymerases consisting of 10 to 12 polypeptides

iv) Protein Synthesis

- Bacteria and Archaea have a 70S ribosome compared to the 80S eukaryotic ribosome but several steps of archaeal protein synthesis more closely resemble those in eukaryotes (e.g., bacterial initiator tRNA carries modified methionine residue; tRNA carries unmodified methionine in Archaea and Eukarya)
- Diphtheria toxin inhibits Archaeal and Eukaryotic but not bacteria protein synthesis
- Antibiotics that specifically affect protein synthesis in bacteria do not affect archaeal or eukaryotic protein synthesis

Numerical Taxonomy

A method used in taxonomy to determine and numerically express the degree of similarity of every strain of prokaryotes is referred as numerical taxonomy.

$$\% \text{ similarity} = \frac{\text{No. of characters similar}}{\text{No. of characters similar} + \text{No. of characters not similar}}$$

Identification & Classification

- Many schemes were there for identification of bacteria before 1923.
- 1916-1918 - Robert Buchanan was the first to prepare a comprehensive scheme
- For the classification of bacteria
- 1920 - American Society for Microbiology submitted a report on various schemes which was the beginning of new outline for bacterial classification

Bergey's manual of systemic bacteriology

- David .H.Bergey, published a first edition of **Bergey's manual of determintive bacteriology** from the Society of American Bacteriologists in 1923.
- Second edition was published in 1925, third edition in 1930 and subsequently five editions appeared.
- In 1974, 8th edition was published with international contributions.
- In,1984 major change occurred and the manual was prepared with information dealing with ecology, enrichment, isolation, preservation, characteristics of bacteria concerned with classification and identification.
- Then the manual came with rename as **Bergey's manual of systematic bacteriology.**

Bergey's Manual of systematic bacteriology

- It is a compendium of standard and molecular informations about the available prokaryotes.

IDENTIFYING **BACTERIA**: STANDARD REFERENCE IS **BERGEY'S MANUAL OF DETERMINATIVE BACTERIOLOGY**

A. Morphological Characteristics
B. Differential Staining
C. Biochemical Testing
D. Serology
E. DNA Probes (Nucleic Acid Hybridization)
F. PCR (Polymerase Chain Reaction)

First edition consists of 4 volumes

- Vol 1. Gram positive bacteria
- Vol 2. Gram negative bacteria
- Vol 3. Bacteria with unusual properties including archaea
- Vol 4. Filamentous bacteria
- This system does not have much phylogenic information andf hence the second edition came
- The second edition of the Bergey's manual provides much clear information about the genetic relationship among the organisms.

The second edition was divided into 5 volumes

- Vol 1. Archaea, cyanobacteria, phototrophs and deeply branched genera
- Vol 2. Proteobacteria
- Vol 3. Low G+C gram positives
- Vol 4. High G+C gram positives
- Vol 5. Planctomycetes, Spirochetes, Bacteroides, Fusobacteria

Vol 1. Archaea, cyanobacteria, phototrophs and deeply branched genera

This volume has 3 important groups out of which, one is in different domain (Domain – archaea).

a. Hyperthermophiles - Ex. *Thermococcus, Sulfolobus, Thermosphaera*
b. Methanogens - Ex. *Methanobacterium, Methanococcus, Methanosarcina*
c. Halobacteria - Ex. *Halobacterium, Halococcus, Natronomonas*
d. Thermoplasma - Ex. *Thermoplasma*

2. Cyanobacteria

- Filamentous, oxygenic photosynthetic bacteria. They have special cells called heterocyst in which nitrogenase enzyme is present. The nitrogenase enzyme is responsible for fixing atmospheric N_2 into ammonia.
- Cyanbobacteria exist in three forms,
  - Single celled - *Chrococcus, Gleotheca, Gleocapsa*
  - Filamentous non-heterocystous - *Oscillatoria, Lyngbya*
  - Filamentous heterocystous - *Anabaena, Nostoc, Tolypothrix*

3. Anoxygenic phototrophs

Single celled, sulphur required bacteria. They use H_2S as electron donor. Ex. Green sulphur bacterium *Chlorobium*

Vol 2. Proteobacteria

- This volume has gram negative bacteria. They were further divided into 5 subgroups as α, β, γ, δ and ε.
- They contain medically, industrially and agriculturally important bacteria.

S.No.	Important Bacteria	Characters	Example
α Proteobacteria			
1.	Purple bacteria	Anoxygenic Photosynthetic – sulphur bacteria	*Rhodospirillum, Rhodobacter,*

2.	Associative Nitrogen fixing bacteria	These bacteria present in the rhizosphere of graminaceous plants and symbiotically fix atmospheric nitrogen.	*Azospirillum*
3.	Symbiotic Nitrogen fixing bacteria	Form nodules in legume roots and fix atmospheric nitrogen.	*Rhizobium, Bradyrhizobium,*
		Some form galls in the roots	*Agrobacterium*
4.	Free living Nitrogen fixing bacteria	Present in the soil as heterotrophs – use verity of carbon sources in soil and fix atmospheric nitrogen	*Azotobacter, Beijerinkia*
5.	Pseudomonas group	Some are Plant Growth Promoting Rhizobacteria	*Pseudomonas*
		Some are pathogens	*Xanthomonas*
		Some produce alcohol	*Zymomonas*
6.	Rickettsia	Endoparasites	*Rickettsia*
7.	Sulphur oxidizing bacteria	Uses S as electron donor – Chemolithotrophs – Strict aerobes	*Thiobacillus*
8.	Acetic acid producing bacteria	Fermentative bacteria	*Acetobacter, Gluconobacter*
9.	Budding bacteria	Reproduction by budding like yeast	*Caulobacter*
10.	Hydrogen bacteria	Hydrogen producing bacteria	*Alkaligenes*
β Proteobacteria			
1.	Nitrifying bacteria	Chemolithotroph – strict aerobe – soil bacteria – important form N cycle	*Ammonia to nitrite – Nitrosomonas Nitrite to nitrate – Nitrobacter*
2.	Neisseria & relatives		Neisseria
3.	Spirillum	Aerobes & facultative aerobes	*Spirillum sp.*
4.	Sheathed bacteria		*Sphaerotilus*
γ Proteobacteria			
1.	Purple sulphur bacteria	Anoxygenic photosynthetic – sulphur bacteria	*Thiobacillus, Thiospirillum*
2.	Methylotrophs	Uses methane and methanol as carbon source	*Methylomonas, Methylobacter, methylococcus*
3.	Coliforms	Present in the intestinal track of mammals	*Escherichia, Salmonella*

2.	Neisseria & relatives		Neisseria
3.	Spirillum	Aerobes & facultative aerobes	*Spirillum sp.*
4.	Sheathed bacteria		*Sphaerotilus*
γ Proteobacteria			
1.	Purple sulphur bacteria	Anoxygenic photosynthetic – sulphur bacteria	*Thiobacillus, Thiospirillum*
2.	Methylotrophs	Uses methane and methanol as carbon source	*Methylomonas, Methylobacter, methylococcus*
3.	Coliforms	Present in the intestinal track of mammals	*Escherichia, Salmonella*
δ Proteobacteria			
1.	Sulphur reducing bacteria	Anaerobes – use S as terminal electron acceptor	*Desulfovibrio, Desulfomonas*
2.	Glding bacteria	Gliding movement	*Myxobacteria*
3.	Vibrio group	Most are pathogenic	*Vibrio, Erwinia*

δ Proteobacteria			
1.	Sulphur reducing bacteria	Anaerobes – use S as terminal electron acceptor	*Desulfovibrio, Desulfomonas*
2.	Glding bacteria	Gliding movement	*Myxobacteria*
3.	Vibrio group	Most are pathogenic	*Vibrio, Erwinia*

Vol 3. Low G+C gram positives

S.No	Group	Characters	Example
1.	Clostridia group	Strict anaerobes – mostly fermentative nutrition – few thermotolerant – endospore producers	*Clostridium, Thermoanaerobacteriu, Thermoanaerobium*
2.	Mycoplasma group	Absence of cell wall	*Mycoplasma, Mesoplasma, Spiroplasma*
3.	Bacilli and Lactobacilli group	Lactic acid producing bacteria – endospore producers – aerobes – aerotolerant – fermentative	*Leuconostoc, Lactococcus, Streptococcus*

Vol 4. High G+C gram positives

S.No	Group	Characters	Example
1.	Actinomycetes	Filamentous – sporangiospores – conidiospores – soil habitat – antibiotics producers	*Actinomyces, Nocardia, Sreptomyces*
		Symbiotic with *Casuarina* – form root nodules – N2 fixation	*Frankia*
2.	Mycobacterium	Presence of mycolic acid in the cell wall – acid fast staining – human pathogens	*Mycobacterium lepri*
3.	Corynebacterium	Human pathogens	*Corynebacterium diptheriaea*

Vol 5. Plancomycetes, Spirochetes, Bacteroides and Fusobacteria

S. No	Group	Characters	Example
1.	Chlamydia group	Obligate parasites to man, animal and birds	*Chlamydia*
2.	Bacteroides	Obligate anaerobes	*Bacteroides*
3.	Spirochete	Gram negative – flexile – endoflagella presence	*Spirocheta, Leptospira*

Modern Taxonomy:

CLASSIFICATION METHODS FOR BACTERIA

A. Differential Staining
B. PCR
C. DNA Base Composition

FAME- The fatty acid composition of prokaryotes give very high diversity. The fatty acid compositions especially the cell wall fatty acids analysis is used to identify the organisms.

D. DNA Probes (Nucleic Acid Hybridization

DNA:DNA hybridization - The DNA of one organism is subjected to hybridize with other organism and the degree of hybridization will vary with organisms depends upon their relativity. This variation will be used to identify and group the organism.

E. rRNA Sequencing

Ribosomal analysis - Among the cellular organelles, ribosome is present in all the living organisms; ancient molecule; functionally constant; universally distributed and well conserved.

"Ribotyping / Phylogenetic Classification"

Phylogeny-Ordering of species into higher taxa and construction of evolutionary tree based on the evolutionary relationship

2017

Differences between Prokaryotes and eukaryotes

PROKARYOTES	EUKARYOTES
ORGANISMAL GROUPS Archaeobacteria, Eubacteria	Protists (protozoa & algae), Fungi, Plants, Animals
CELL ORGANIZATION Simple, all cell functions take place within a single intracellular space bounded by a unit membrane. Cells (0.2-)0.5-2(-80) µm wide.	Intracellular space is compartmentalized into membrane-bounded organelles performing specialized functions. Cells (0.5-)10-50(-200,000) µm wide.
DEVELOPMENT Mostly unicellular and microscopic forms. Differentiation limited.	Uni- and multicellular, micro- and macroscopic forms. Differentiation can be extensive.
CELL WALL Contains peptidoglycan only in Eubacteria. Glycoproteins only in Archaeobacteria. Cell wall absent in mycoplasmas.	Contains chitin or cellulose. Glycoproteins common. Cell wall absent in protozoa and animals.
DNA A single molecule of DNA is in a closed-loop chromosome (nucleoid), attached to plasma membrane. Additional DNA in circular plasmids.	DNA distributed in several linear chromosomes, complexed with proteins (histones), within a membrane-bounded nucleus which also contains RNA.
SEXUAL SYSTEMS Absent or unidirectional (from donor to recipient). Genetic transfer and recombination by transformation, transduction, or conjugation	Regular, involving equal participation of both partners. Diploid and haploid forms alternate betweem fertilization and meiosis
RIBOSOMES All ribosomes with a sedimentation constant of 70S (Swedberg units, with subunits of 50S & 30S)	Ribosomes in cytoplasm with sedimentation constant of 80S (subunits 60S & 40S), those in mitochondria and plastids of 70S or variable
CELL DIVISION Cell division by fission, following DNA duplication and separation along plasma membrane.	Cell division by various forms of mitosis, involving microtubules and mitotic spindle in chromosome separation.
MOTILITY Simple, rotating bacterial flagella composed of flagellin protein. No cytoskeleton, intracellular motility or phagocytosis. Gliding motility common. Gas vesicles present in some forms.	Complex, flexing 9+2 flagella and cilia, composed of tubulin and other proteins. Cytoskeleton, amoeboid movement and phagocytosis based on actin-like proteins. Gliding motility common. Gas vesicles absent.
Endospores containing dipicolinic acid, heat-resistant. Actinospores, conidia, myxospores, akinetes.	Endospores absent. Various reproductive and resting spores following mitosis, meiosis, or fertilization (zygospores).
METABOLISM Extremely diverse. Obligately and facultatively anaerobic, microaerophilic, and aerobic forms.	Almost all are aerobic; exceptions are few and mostly secondary.
GLYCOLYSIS AND RESPIRATION Several glucose metabolism pathways. Respiration enzymes bound to plasma membrane or mesosomes. Not packaged separately.	Embden-Meyerhof glucose metabolism, followed by Krebs (CTA)-cycle, and cytochrom-based electron transport. Respiration enzymes packaged within mitochondria
PHOTOSYNTHESIS Anoxygenic and oxygenic photosyntheses, with one or two photosystems. Various electron donors including H_2O. Enzymes bound to plasma membrane, chromatophores, thylakoids or vesicles, not packaged separately.	Only oxygenic photosynthesis involving two photosystems. H_2O is used as electron donor. Enzymes for photosynthesis in thylakoids, packaged within membrane-bounded plastids.
LIPIDS AND SECONDARY PRODUCTS Vaccinic and oleic acids, and hopanes common. Archeobacterial lipids ether-linked. Steroids rare. Various antibiotics common.	Linoleic acid common, Steroids and alcaloids common.

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF MICROBIOLOGY
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (17MBU101)

Unit II Q	Opt A	Opt B	Opt C	Opt D	Answer
Who defi	Carl linna	Sneath &	Robert ko	Robert koch & Hooke	Sneath & Sokal
How man	10 to 20	20 to 30	50 to 70	60 to 70	50 to 70
Proportic	Sj	Ssm	Sn	Scx	Ssm
Which on	Sj	Ssm	Sn	Scx	Sj
Organism	phylum	phlogenet	Phytic	phenons	phenons
Which de	genus	Kingdom	family	Order	genus
Five King	Carl linna	Carl woos	Whittake	Charles	Whittaker
Example f	cell shape	cytoplasm	mitochon	ribosomes	cell shape
Example	cell shape	cellwall c	cell size	motility	cellwall constituents
plasmid a	phenotyp	phylogen	genetic tr	molecular traits	phenotypic traits
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Eight kin	Whittake	Sogin	Cavalier s	Carl woese	Cavalier smith
Who first	Whittake	Sogin	Cavalier s	Carl woese	Carl woese
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On five ki	Pigmenta	Environm	Nutrient T	Temperature	Nutrient Type
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Similarity	ab/a+b	a/a+b+c	a+b+c/a	a/abc	a/a+b+c
The study	Fossil	Evolution	Phylogen	Phenetic	Phylogeny
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Phenetic c	morpholo	shape	size	phylogenetic analysis	phylogenetic analys

Nomencla	Naming	Dividing	Segregati	Allocation	Naming
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DEPARTMENT OF MICROBIOLOGY
KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act, 1956)

Eachanari Post, COIMBATORE - 641 021, INDIA

I-B.Sc., Microbiology (Batch 2017-2020)

Introduction to Microbiology and Microbial Diversity (Semester-I) (17MBU101)

LECTURE PLAN

UNIT III

Duration	Topic	Reference
01	General characteristics of algae including algal cell ultra-structure.	R1: 553-557
02	*Chlamydomonas*	R2: 356-361
03	*Volvox*	R2: 357
04	Diatoms	R2: 358
05	Red algae	R2: 359
06	Brown algae	R2:360-361
07	Application of Algae in agriculture, industry	R3: 504-510
08	Application of Algae in environment and food.	R3: 511-518
09	Unit revision and possible questions	
	Total hours: 9	

R1: Presscott., Harley and Klein-Microbiology- sixth edition- Mc Graw Hill education. International edition.

R2: Tortora, G.J., Funke, B.R., and Case CL. (2008). Microbiology: An Introduction. 9th edition. Pearson Education.

R3: Robert Edward Lee-Phycology- Fourth edition. 2008. Cambridge University Press.

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2017

Introduction to microbiology and Microbial diversity

Unit III notes

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2017

Unit III: Algae

What are algae?

Algae is a group of chlorophyll containing thalloid plants which bear unicellular or multicellular sex organs and the sex organs are **NOT** protected in the sterile jacket cells. An undifferentiated plant body is known as *'thallus'*. In thalloid plants, there is no differentiation of plant body into true roots, stem and leaves.

The study of algae is known as **PHYCOLOGY.** The one who study algae is called Phycologist

General characters of algae

Ø Thalloid plant body

Ø In Eichler's system of classification, algae are placed in the **Division Thallophyta** along with Fungi and Lichens.

Ø Algae are autotrophs (synthesize food using light energy)

Ø Algae differ from fungi in:⊕. Presence of photosynthetic pigment – chlorophyll ⊕. Mode of nutrition (autotrophs)

Ø Majority of algae are in aquatic habitat (fresh water or marine), some algae are terrestrial also

Ø Algae are present in all parts of the world including Arctic and Antarctic regions (universal occurrence)

Ø Sex organs are unicellular or multicellular

Ø Sex organs lack jacket cells around them (naked sex organs)

Ø If jacket cells are present, they have different origin

Ø There is a progressive complexity in the reproduction of different algal groups

Ø Embryos is not formed after zygote formation

Ø Show distinct alternation of generation

Ø Cellular organization may be prokaryotic (blue green algae) or eukaryotic (all other algae)

Occurrence of algae:

Ø Found in a variety of habitats (Fresh water, marine, on rocks, with in plants or animals)

Ø Aquatic forms are most common

Ø On the basis of habitat, algae are classified into three groups

1. Aquatic forms

2. Terrestrial forms

3. Algae of unusual habitats

(1). Aquatic algae:

Ø Two types: Fresh water and marine forms

(a). Fresh water forms: Occurs in ponds, lakes, river etc. *(Spirogyra)*

(b). Marine water forms: Occurs in saline condition such as seas and oceans (Most of the Red and Brown algae such as *Polysiphonia* and *Sargassum)*

(2). Terrestrial Algae:

Ø Found in/on soil, rocks, moist wall, tree trunks etc.

Ø Example: *Vaucheria* and *Fritschiella* found on the surface of soil

(3). Algae of unusual habitat:

Halophytic algae: algae present in highly saline water (Example: *Dunaliella)*
Epiphytic algae: algae grown on the surface of other plants/algae (Example *Oedogonium)*
Epizoic algae: algae grown on animals such as snails and fishes (Example: *Cladophora* grows on the shells of snails)
Endozoic algae: algae growing inside the animals (Example: *Zoochlorella* grow inside *Hydra)*
Symbiotic algae: Symbiotic (mutual) association with fungi in lichen, in Bryophytes *(Anthoceros),* in Pteridophytes *(Azolla),* gymnosperms (corolloid roots of *Cycas)* and in angiosperms.
Parasitic algae: grow as parasite on plants or animals (Example: *Cephaleuros* is a parasitic green algae grow on the leaves of many plants causing red rust diseases)
Thermophytic algae: grow in hot springs. (Example: Heterohormogonium)
Fluviatile algae: algae found in rapidly running water such as water falls (Example: Ulothrix occurs in mountains water falls

Thallus diversity in algae:

Ø Wide range or thallus variation in algae
Ø Thallus may be unicellular to multicellular and microscopic to macroscopic
Ø Plant size range from few micron to several meters
Ø Example: *Chlamydomonas* is a single celled algae whereas *Macrocystis pyrifera,* a marine brown algae, is multicellular, parenchymatous and several meters long.
Ø On the basis of thallus organization algae are following five types:-

(1). Unicellular forms (Example:*Chlamydomonas, Chlorella)*
(2). Colonial forms *(Volvox, Pandorina)*
(3). Filamentous forms
(a). Un-branched filamentous *(Spirogyra, Oedogonium)*
(b). Branched filamentous *(Cladophora, Pithophora)*
(4). Siphonaceous forms *(Vaucheria)*
(5). Parenchymatous forms *(Sargassum, Laminaria)*

Pigmentation in algae:

Ø Algae also shows great diversity in pigmentation
Ø Different groups of algae have different pigment composition
Ø Distribution pattern of pigments has great taxonomic significance in algae
Ø The classification of algae by Fritsch is primarily based of the pigmentation in algae
Ø Pigments in algae belongs to three major categories:
(1). Chlorophylls
(2). Carotenoids
(3). Phycobilins
Ø All major algal groups have at least one characteristic pigment
Cyanophyceae (blue green algae): Phycocyanin
Chlorophyceae (green algae): Chlorophyll b
Pheophyceae (brown algae): Fucoxanthin

Rhodophyceae (red algae): Phycoerythrin
Chlorophyll a is universally present in all algal grous

Plastids in algae:

Ø Except in Cyanophyceae (blue green algae, BGA) pigments in algae are found in membrane bound organelles called plastids

Ø In BGA, plastids are absent, pigments located at peripheral cytoplasm called chromoplasm

Ø Plastids are two types:

(1). Leuoplast: – Colourless plastids

(2). Chromoplast: – Coloured plastids

Plastid forms in algae:

Ø Algae shows great diversity in plastid shape, Plstids may be:

Cup shaped: *Clamydomonas, Volvox*

Discoid: *Voucheria, Chara*

Girdle shaped: *Ulothrix*

Reticulate: *Oedogonium, Hydrodictyon, Cladophora*

Spiral: *Spirogyra*

Stellate (star shaped): *Zygnema*

Pyrenoids:

Ø They are proteinacious bodies present in chromatophores

Ø Considered as the organelle of synthesis and storage of starch

In some Chlorophyceae pyrenoids are surrounded by starch grains

Ø Pyrenoids arise de-novo or by the division of preexisting pyrenoids

Ø Pyrenoids absent in blue green algae

Reserved food materials in algae:

Ø It is also called as food reserve. It is the stored form of food in the cells for energy. Different algal groups have different types of reserved food materials. Similar to pigmentation in algae, the distributional difference in reserved food is also in the classification of different algal groups.

Cyanophyceae: cyanophycean starch
Chlorophyceae: Starch
Rhodophyceae: Floridean starch
Phaeophyceae: Laminarin, manitol and oil

Reproduction in algae:

Ø Algae reproduce by three methods:

(1). Vegetative reproduction: Cell division, fission, fragmentation, Hormogonia, formation of adventitious branches, tubers, buddings etc. are the important vegetative reproduction methods in algae.

(2). Asexual reproduction: By a variety of motile or non-motile spores. Zoospore, aplanospore, hypnospore, tetraspore, autospore, akinetes etc are the important spore types in algae

(3). Sexual reproduction: here the union of gametes are involved: Autogamy, hologamy, isogamy, anisogamy and oogamy are the different types of sexual reproduction algae.

Alternation of generation:

Ø Alternation of generations (also known as alternation of phases) is a term primarily used to describe the life cycle of plants

Ø Most algae have an alternation of many celled haploid gametophytic generation with many celled diploid sporophytic generation, which alternate regularly.

Life cycle in algae:

Ø The growth and development consists of a number of distinct morphological and cytological stages

Ø The sequence of these orderly changes is called life cycle

Ø Life cycle: sequence of all different phases or events through which an organism passes from zygote (diploid) of one generation to the zygote of the next generation through gametes (haploid)

Ø There are five types of life cycles in algae based on the number of haploid and diploid generation

Life cycle in algae:

(1). Haplontic: simple type, major stages in the life cycle are haploid, the diploid stage is represented by only the zygote. Zygote undergo meiosis to produce spores (Chlamydomonas, Ulothrix)

(2). Diplontic: Just reverse of the haplontic type. Major stages in the life cycle are diploid, the haploid stages are represented only by gametes. *(Sargassum, Codium)*

(3). Haplobiontic: Three phases in life cycle. Among three phases, two are haploid and one is diploid *(Batrachospermum, Coleochaete)*

(4). Diplobiontic: Three phases in life cycle, two are diploid and one is haploid. Majority of marine Red algae are this type *(Polysiphonia)*

Major Classes of Algae (algal systematics)

(1). Cyanophyta: Blue green algae (BGA), prokaryotes
(2). Euglenophyta: Motile, protozoan like algae lack true cell wall
(3). Crysophyta: Golden-brown algae = diatoms
(4). Pyrrophyta: Dinoflagellates
(5). Chlorphyta: Green algae
(6). Rhodophyta: Red algae
(7). Paeophyta: Brown algae

Ultrastructure of Eukaryotic Algal Cell:

Cell Wall of Eukaryotic Algal Cell:

The cell is bounded by a thin, cellulose cell wall. Cellulose layer is finely striated with parallel cellulose fibrils. In many species there is a pectose layer external to it which dissolves in water and forms a mucilaginous pectin layer. According to Roberts et. al. (1972), Hills (1973) the cell wall in C. Reinhardt consists of seven layers.

Plasma Lemma of Eukaryotic Algal Cell:

It is present just below the cell wall and consists of two opaque layers which remain separated by less opaque zone

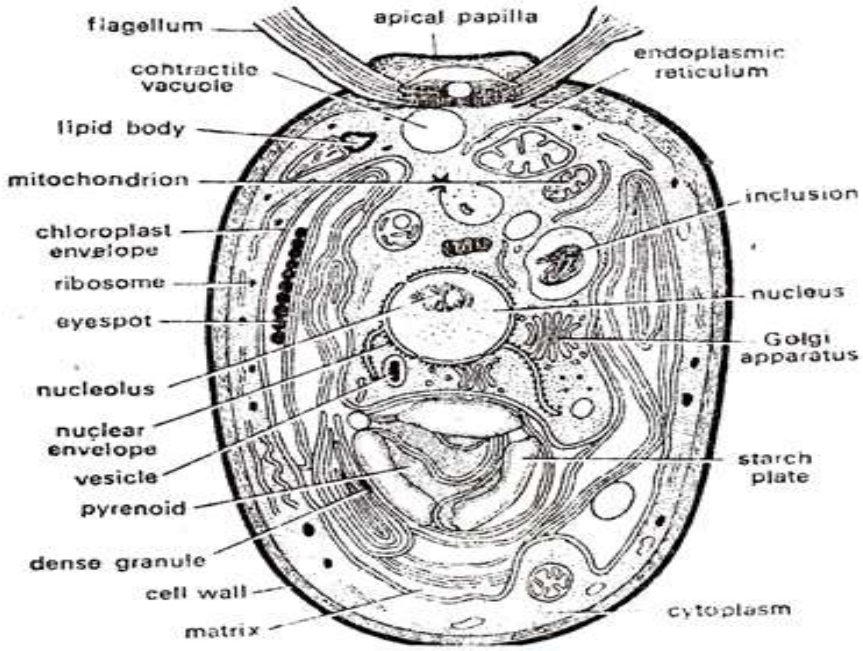


Fig. 1. *Chlamydomonas.* Ultrastructure of eukaryotic cell.

Protoplast of Eukaryotic Algal Cell:

It is bounded by plasma lemma. It is differentiated into cytoplasm, nucleus, chloroplast with one or more pyrenoids, mitochondria, Golgi bodies, two contractile vacuoles, a red eye spot and two flagella.

Chloroplast of Eukaryotic Algal Cell:

In majority of the species of Chlamydomonas, cytoplasm contains of a single, massive cup shaped chloroplast which almost fills the oral or pear shaped body of the cell. It is

surrounded by a double-layered unit membrane. It bears number of photosynthetic lamellae (disc or thylakoids).

The lamellae are lipo-proteinaceous in nature and remain dispersed in a homogeneous granular matrix (stroma). About 3-7 thylakoids bodies fuse to form grana like bodies. Matrix also contains ribosomes, plastoglobuli, microtubules and many crystals like bodies.

Flagella of Eukaryotic Algal Cell:

The anterior part of thallus bears two flagella. Both the flagella are whiplash or acronematic type, equal in size. Each flagellum originates from a basal granule or blepharoplast and comes out through a fine canal in cell wall. It shows a typical 9+ 2 arrangement. Fibrils remain surrounded by a peripheral fibril. According to Ringo (1907), 2 central ones are singlet fibrils and 9 peripheral ones are doublet fibrils (Fig. 2).

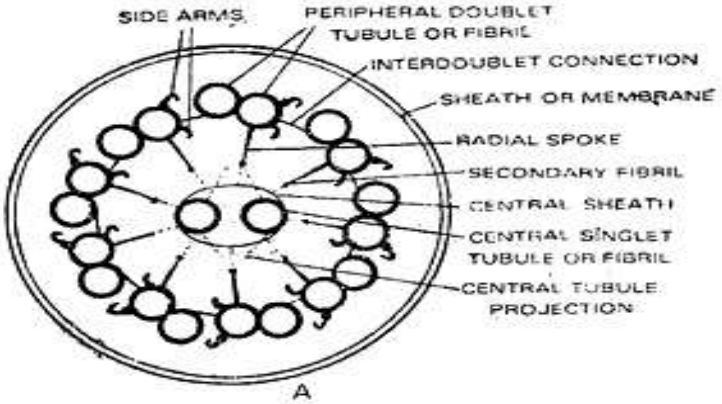


Fig. 2. Ultrastructure of flagellum of *Chlamydomonas*.

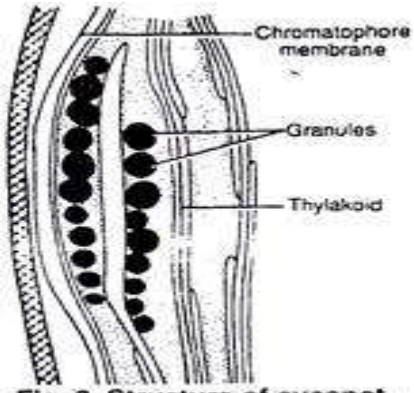


Fig. 3. Structure of eyespot.

Stigma or Eyespot of Eukaryotic Algal Cell:

The anterior side of the chloroplast contains a tiny spot of orange or reddish colour called stigma or eyespot. It is photoreceptive organ concerned with the direction of the movement of flagella. The eye spot is made of curved pigmented plate. The plate contains 2-3 parallel rows of droplets or granules containing carotenoids (Fig. 3). The other structures such as mitochondria, Golgi bodies, endoplasmic reticulum and nucleus are also bounded by double-layered unit membrane.

Chlamydomonas reinhardtii

2017

Taxonomic lineage

cellular organisms - Eukaryota - Viridiplantae - Chlorophyta - Chlorophyceae - Chlamydomonadales -Chlamydomonadaceae - Chlamydomonas - Chlamydomonas reinhardtii

Brief facts

- *Chlamydomonas* is haploid and has a controlled sexual cycle with the possibility of tetrad analysis.
- Its photosynthetic apparatus is closely related to that of vascular plants, and it is also a eukaryote, with photosynthesis genes encoded by both the nuclear and chloroplast genomes.
- Like a plant cell, the cell of *Chlamydomonas* has a cell wall.
- *Chlamydomonas* ability to grow heterotrophically allows the isolation of viable mutants that are unable to perform photosynthesis.
- Like animal sperm cells, *Chlamydomonas* has a flagellum, which enables it to carry out phototaxis, moving towards or away from light to maximize light perception for photosynthesis and minimizing photodamage.
- *Chlamydomonas* can adopt an anaerobic metabolism, producing hydrogen gas and metabolites such as formate and ethanol.
- *Chlamydomonas* is the only known eukaryote in which the nuclear, chloroplast and mitochondrial genomes can all be transformed.

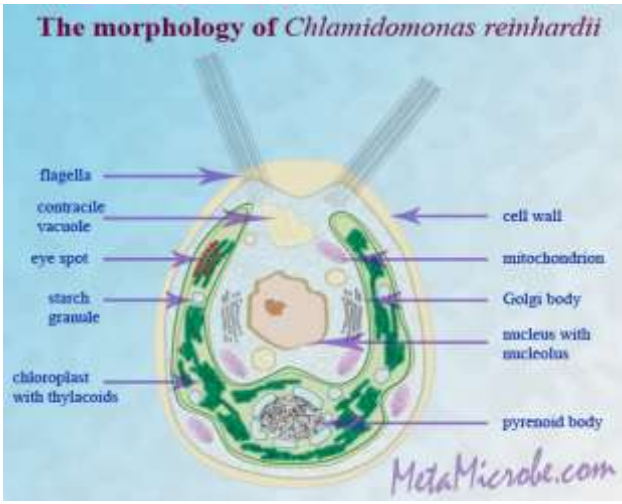
Thus, in some aspects, *Chlamydomonas* most closely models plant cells and in others, animal cells which makes it a powerful and versatile system for the study of a variety of molecular and cellular processes.

Life cycle: Generation time takes approximately 5 hours.

VEGETATIVE CELL Haploid cells reproduce asexually by fission: the protoplast dividing to form 4-8 zoospores similar to the parent.

GAMETOGENESIS

MeSHUnder conditions of nitrogen starvation vegetative cells develop into gametes of two mating types: mt+ and mt-. **ADHESION**Gametes of opposite mating types are attracted to each other and form aggregates. **GAMETE ACTIVATION**Release of cell walls; formation of mating structures. **FUSION**Fusion of mt+ fertilization tubule with mt- mating structure. **ZYGOTE** **MeSH**Complete cell fusion; zygote is not flagellated and serves as a dormant form of the species in the soil. **MEIOSIS** **MeSH**Zygote undergoes meiosis to form 4 haploid zoospores.



Mating type Mating can take place only between individuals of opposite mating types due to the interaction of cell surface components. The equivalent in lower organisms of the sexes in higher organisms; the mating types typically differ only physiologically and not in physical form.

Prepared by Dr. S. Ramalakshmi, Asst Prof, Dept of Microbiology, KAHE, CBE

MT+Activation of cells of mating type mt+ results in production of a long membrane-enclosed fetilization tubule covered with a glycoprotein, and containing polymerized actin filaments. **MT-** Cells of mating type mt- move membrane proteins to the specific region of the plasma membrane and produce a short-lived tubule with no microfilaments.

Volvox carteri

Taxonomic lineage

cellular organisms - **Eukaryota** - **Viridiplantae** - **Chlorophyta** - **Chlorophyceae** - **Chlamydomonadales** -**Volvocaceae** - **Volvox** - **Volvox carteri**

Phylogeny

The family *Volvocaceae* contains several genera of green flagellated algae that are intermediate in size and complexity between unicellular *Chlamydomonas* and *Volvox*. Molecular phylogenetic analysis indicates that the family is monophyletic, and shares common ancestor with *Chlamydomonas* that existed about 50-200 million years ago. Thus, these algae provide great opportunity to analyze evolutionary pathway leading from unicellularity to multicellularity with complete division of labor.

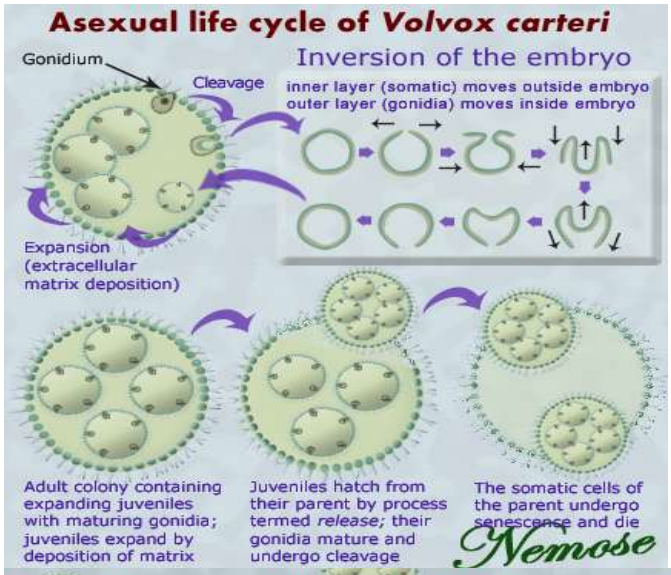
Genomes of *Chlamydomonas* and *Volvox* are remarkably similar: both genomes contain ~14,500 protein-coding genes, and the *Volvox* genome is slightly larger, 138-118 megabases, mostly because of its greater transposon/repetitive DNA content.

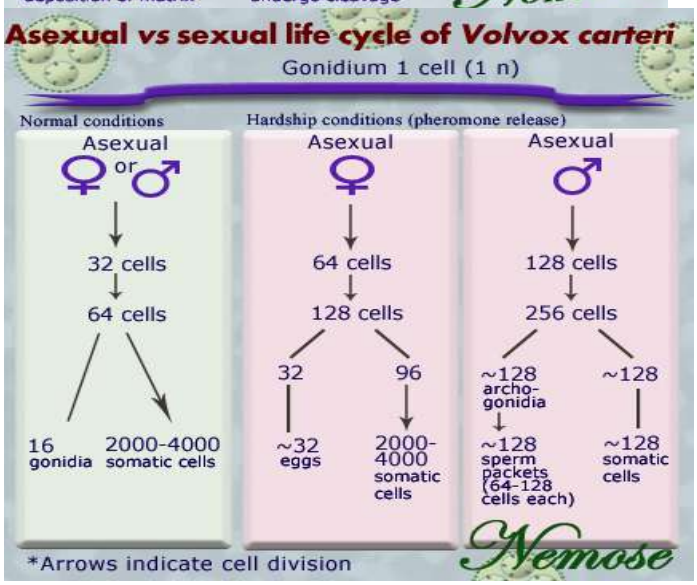
Over a relatively short period of time *Volvox* evolved:

- assymetric cell division, which generates large gonidial precursors;
- multicellularity with germ-soma division of labor;
- embryonic morphogenesis - a gastrulation-like process tha tflips the organism's polarity to position flagellar ends osomatic cells externally;
- complex extracellulaar matrix (ECM) ralated to *Chlamydomonas* cell wall;
- oogametic (egg/sperm) sexual program that is very different from the isogametic one (same-sized gametes).

Brief facts

- Volvox is a spherical multicellular green alga, which contains many small biflagellate somatic cells and a few large, non-motile reproductive cells called gonidia, and swims with a characteristic rolling motion with a distinct anterior and posterior.
- The name ***Volvox*** comes from the Latin *volvere*, to **roll**, and *-ox*, as in *atrox*,**fierce**.
- A medium in which the organism would thrive and reproduce in captivity was discovered only in the 1960s. Only after that it became possible to exploit Volvox as a laboratory model system.
- In nature Volovox is found in ponds and ditches.





Life cycle

Volvox has 2 modes of reproduction: sexual and asexual.

SEXUALIn nature *V. carteri* reproduces sexually at least once each year when temporary ponds where the mode of reproduction is known to be a sex-inducing pheromone, a 32-kDa glycoprotein triggers sexual development of gonidia at concentrations as low as 10(-16) M.

SEXUAL INDUCTION Gonidia that have been exposed to the sex-inducing pheromone for at least 6–8 h before the initiation of embryonic cleavages modify their developmental program and produce sexual progeny containing immotile eggs or motile sperm, depending on the genetic sex of the individual; the sexual cycle is initiated by a heat shock that causes the somatic cells of the asexual Volvox spheroid to produce the sex-inducing pheromone; the level of pheromone is then further amplified by the ability of sperm cells to produce more sex-inducing pheromone.

GAMETOGENESIS
MeSHThe 64–128 cell transition in sexual females, and the 128–256 cell transition in sexual males; in sexual males, somatic cells (smaller spheres) and androgonidia (larger spheres) arise in a 1:1 ratio; androgonidia undergo further cleavages to form sperm packets, each containing 64 or 128 sperm; when the gametes are mature, sperm packets are released into the surroundings.
ZYGOTE **MeSH**On contact with females, the sperm packets break up into individual sperm, which can fertilize the eggs. The resulting diploid zygotes have tough cell walls that can resist drying, heat and cold. When favourable conditions cause the zygotes to germinate, they undergo meiosis to produce haploid males and females that reproduce asexually until the sex-inducing pheromone induces the sexual cycle again.
ASEXUALMales and females are indistinguishable in their asexual form; under standard conditions, the asexual life cycle takes precisely 48 h and is synchronized by a 16 h light–8 h dark cycle.
EMBRYOGENESIS **CLEAVAGE**Embryogenesis takes ~8 hours; mature gonidia undergo a rapid series of cleavage divisions (11–12 divisions), some of which are asymmetric: the larger cells resulting from these unequal divisions will become the gonidia of the next generation, whereas the smaller cells will become part of the somatic cell population; at the end of cleavage, the embryo is inside out with respect to the adult configuration: its gonidia are on the outside and the flagella of its somatic cells are pointing towards the interior of the hollow sphere.
INVERSIONThe morphogenetic process of inversion taking place at the end of embryogenesis returns the embryo to its adult configuration through a series of cell movements that resemble the gastrulation of animal embryos. The cell-sheet bending occurs at a specific site known as the **phialopore**, a swastika-shaped opening found at the anterior pole of the embryo. To initiate inversion, cells at the edges of the phialopore adopt an asymetric flask-like shape.
EXPANSION The juveniles expand by deposition of extracellular matrix.
RELEASE Juveniles hatch from their parent spheroid.
JUVENILEOrganism with immature gonidia.
ADULTOrganism with mature gonidia.
SENESCENT **MeSH**The parent sphere devoid of gonidia and consisting only of somatic cells undergoes senescence and die. Somatic cells are specialized for motility and are destined to die when they are only about four days old.

Brown Algae

Brown Algae have about 1500 species and most of it is a marine brown-colored algae which is commonly known as seaweeds. Brown algae make up **Phylum Phaeophyta** in Protista kingdom. The name comes from the Greek word “Phaios” which means “brown” and “phykos” for seaweed and “Phyton” for the plant.Brown algae are known to be the largest of the algae. They are abundantly found in the tidal zones of temperate to polar seas and some do exist in Depth Ocean. An example of a giant brown algae includes:

- Giant Kelp

- Free-floating Sargassum weed

The brown pigment that is found in brown algae is called fucoxanthin, which along with other xanthophylls pigments covered the green pigment in the algal cells. Brown algae are made up of multicellular and have diverse structures that resembles to the roots, leaves and stalks of a true plant. Though they are quite different internally, their cell walls are made of cellulose that is likely the same in red algae. The outsides of the walls are covered by a gelatinous pectic compound called **algin**. Brown algae such as kelp are harvested for economic, medicinal and food purposes:

- Emulsion stabilizer,
- An ingredient of ice cream
- Fertilizer
- Vitamin-containing food such as iodine.

Brown algae store food in the form of the two carbohydrates known as ***mannitol*** and **laminarin.**

Red Algae

Red algae belong to **Phylum Rhodophyta**, a large group of aquatic algae that is about 6000 species and only two percent are freshwater species. The name comes from the Greek word "Rhodon" which means "rose", "Phykos" for "seaweed" and "Phyton" for the plant. Red algae are characterized by having reddish phycobilin pigments: Phycoerythrin and Phycocyanin. These pigments mask the color of the chlorophylls. Most red algae species thrive near tropical and subtropical shores below the low-tide mark and some are found in fresh water. They contain chlorophyll A and D. They store food in the form of carbohydrates known as "**floridean"** starch. The cell wall of red algae consists of cellulose and contains a gelatinous carbohydrate called **agar**. Most multicellular red algae are small to medium in size. Their bodies are relatively complex just like in kelps. The sexual and reproductive structure of red algae is very specialized. They vary in shapes:

- Platelike
- Coralline
- Crustlike L
- Leathery
- Feather-like

Diatoms

The diatoms are one of the largest and ecologically most significant groups of organisms on Earth. They are also one of the easiest to recognize, because of their unique cell structure, silicified cell wall and life cycle.

Characteristics

Diatoms share several characteristics with some or all other heterokont algae, including (see also van den Hoek et al. 1995):

- plastids that are enclosed by four membranes. The inner two are homologous with the two membranes surrounding the plastids of Rhodophyta, Chlorophyta and Glaucophyta. The outer two, often referred to as 'chloroplast endoplasmic reticulum' reflect the origin of the heterokontophyte plastid as a secondary endosymbiont, related to extant Rhodophyta.
- between the outer and inner chloroplast membranes, there is often a network of anastomosing tubules called the periplastidial reticulum.
- grouping of the thylakoids into stacks of three (lamellae) within the plastid.
- presence of a girdle lamella beneath the plastid membranes, surrounding all the other lamellae.
- chlorophylls a and c and fucoxanthin as the major light-harvesting pigments for photosynthesis.
- chloroplast DNA usually concentrated within a ring-shaped nucleoid at the periphery of the plastid (but there are exceptions in some diatoms!)
- a β-1,3-linked glucan as the main reserve polysaccharide.
- possession of special tripartite stiff hairs ('mastigonemes') on a flagellum.
- mitochondrial inner membrane developed into tubular invaginations.
- all species are unicellular or colonial coccoid algae. None are free-living flagellates.
- the only flagellate cells produced are the male gametes (= sperm, spermatozoids) of 'centric' diatoms. These have a single forward-pointing flagellum, which bears mastigonemes.
- the relative proportions of the chlorophylls and fucoxanthin produce a yellow-brown or greenish-brown colour in the plastids.
- most have a large central vacuole or pair of vacuoles.
- cells (especially during stationary-phase) often accumulate large quantities of lipids and fatty acids; polyphosphate bodies are also present and sometimes take the form of discrete spherical or complex 'volutin' granules, one per vacuole.
- secretion of extracellular polymeric material (usually polysaccharides) is common, as stalks, pads, capsules, tubes, chitin fibres, or trail material from locomotion.
- all cells (except the gametes and endosymbiotic diatoms) possess a bipartite cell wall comprising two overlapping halves.
- each half-wall itself consists of a large end-piece, the 'valve', and several or many narrow bands or segments, which together form the 'girdle'.
- the cell wall is almost always heavily silicified.
- cell wall elements (valves, girdle bands, and auxospore scales and bands) are formed intracellularly, in special membrane-bound 'silica deposition vesicles' associated very closely with the cell membrane; they are not secreted from the cell until they are complete.

- new wall elements are always produced *within* the confines of an existing cell wall. As a result, average cell size usually decreases with successive mitotic divisions during the life cycle.
- size is restored via the formation and expansion of a special cell, the auxospore, which is usually a zygote. The basic shape of each diatom species is largely created during the expansion of the auxospore, but is often modified during subsequent mitotic cell divisions.
- during vegetative mitoses, the nucleus always lies to one side of the cell immediately beneath the girdle, at the edge of the hypotheca.
- mitosis is open, the nuclear envelope breaking down before metaphase; the spindle is a narrow cylinder, persistent at telophase, consisting of two interdigitating half-spindles, each associated with a polar plate.
- the chromosomes bunch closely around the cylindrical spindle at metaphase, becoming impossible to separate and count.
- cytokinesis occurs through cleavage.
- the life cycle is strictly diplontic: as far as is known, all vegetative cells of all species are diploid, and all mitoses take place in the diploid phase. However, haploids have occasionally been grown in culture in a few species.
- they occur just about everywhere in aquatic and damp terrestrial habitats, providing that photosynthesis is possible!
- they are amazingly diverse, with hundreds of genera and perhaps 200,000 species (Mann & Droop 1996), of which only a tenth have been described so far.

Applications of algae

Humans use algae as food, for production of useful compounds, as biofilters to remove nutrients and other pollutants from wastewaters, to assay water quality, as indicators of environmental change, in space technology, and as laboratory research systems. Algae is commercially cultivated for Pharmaceuticals, Nutraceuticals, Cosmetics and Aquaculture purpose.

Fuel source

- Algae can be used to make Biodiesel, Bioethanol and biobutanol and by some estimates can produce vastly superior amounts of vegetable oil, compared to terrestrial crops grown for the same purpose.
- Algae can be grown to produce hydrogen. In 1939 a German researcher named Hans Gaffron, while working at the University of Chicago, observed that the algae he was studying, *Chlamydomonas reinhardtii* (a green-algae), would sometimes switch from the production of oxygen to the production of hydrogen.
- Algae can be grown to produce biomass, which can be burned to produce heat and electricity.

Food supplement:

1. It is a complete protein with essential amino acids (unlike most plant foods) that are involved in major metabolic processes such as energy and enzyme production.
2. It contains high amounts of simple and complex carbohydrates which provide the body with a source of additional fuel. In particular, the sulfated complex carbohydrates are thought to enhance the immune system's regulatory response.

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3. It contains an extensive fatty acid profile, including Omega 3 and Omega 6. These essential fatty acids also play a key role in the production of energy.
4. It has an abundance of vitamins, minerals, and trace elements in naturally-occurring synergistic design.

Stabilizing agent

Chondrus crispus, (probably confused with Mastocarpus stellatus, common name: Irish moss), is also used as "carrageen". It is an excellent stabiliser in milk products - it reacts with the milk protein caesin, other products include: petfoods, toothpaste, ice-creams and lotions etc.,Alginates in creams and lotions are absorbable through the skin.

Fertilizer

Algae are used by humans in many ways. They are used as fertilizers, soil conditioners and are a source of livestock feed. Because many species are aquatic and microscopic, they are cultured in clear tanks or ponds and either harvested or used to treat effluents pumped through the ponds

Role Of Algae in Pollution control

- Algae are used in Wastewater Treatment facilities, reducing the need for greater amounts of toxic chemicals than are already used.
- Algae can be used to capture fertilizers in runoff from farms. When subsequently harvested, the enriched algae itself can be used as fertilizer.
- Algae Bioreactors are used by some powerplants to reduce CO2 emissions. The CO2 can be pumped into a pond, or some kind of tank, on which the algae feed. Alternatively, the Bioreactor can be installed directly on top of a smokestack.

Red algae have economic importance too. Agar is used for:

- Preparing gelatin, locally called “gulaman” for dessert.
- Used as a nutrient medium for growing bacteria and fungi
- Used in the food and drug industries, is obtained mostly from *Gelidium* and*Gracilaria* species.
- Carrageenin, obtained from Irish moss (*Chondrus crispus*), and is used as a substitute for gelatin.
- Laver (*Porphyra*) is used as a food in Japan and the Philippines.

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INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (17MBU101)

UNIT III QUESTIONS	**Opt A**	**Opt B**	**Opt C**	**Opt D**
Pigment present in BGA is _____	Ph	Ph	Ph	Xanthophyll
The pigment present in red algae is	Rhodochr	Fucoxantl	Chlorophy	Chlorophyll + phyco
Algae means	Fresh wa	Sea weed	Fresh wa	None of these
The study of algae is known as	Algalogy	Phycology	Mycology	Bacteriology
The free floating algae are known as	Phytoplar	Benthons	Sea weed	photoalgae
The stain used to demonstrate fungus	Albert	Nigerosir	Lactophe	safranin
Sexual reproduction of algae is carried by	Isogamy	Anisogan	Oogamy	isogamy, anisogamy
In algae, advanced type of sexual reproducti	Isogamy	Anisogan	Oogamy	isogamy, anisogamy
Alginic acids and its salts are obtained from	Red algae	Brown alg	Green alg	Red and brown alga
Agar is obtained form	Brown alg	Red algae	Green alg	Blue-green algae
The principle light- trapping pigment molec	Chlorophy	Chlorophy	Porphyrir	Rhodapsin
_____ or alcology is the study of algae.	Phycology	Physiolog	Mycology	Zoology
The term algae was originally used to simple	Marine pl	Aquatic p	Fresh wat	Plants
Dinoflagellates have chlorophylls____	a & c	a & b	a, b &c	b&z
Diatom frustules are composed of crystallize	Calcium	Potassiun	Silica	Cadmium
Phycocyanin is a _____-	Red pigm	Blue pigm	Brown pi	Yellow pigment.
Agar, which is the solidifying agent in many	Chlorophy	Chrysoph	Pyrrophy	Rhodophyta
Red algae cell wall made up of _____.	Galactose	Glucose	Galactans	Glucan
Starch is an energy storage material charact	Chlorophy	Chrysoph	Phaeophy	Rhodophyta
Which algal division never produces motile,	Chlorophy	Chrysoph	Phaeophy	Rhodophyta
Rhodophyta is a _____	Red Algae	Brown alg	Blue algae	BGA
Red Algae contain _____	Phycoery	Elythesin	Elythrocy	Cynin
Blue pigment is known as _____	Phycocya	Pyocyami	Pyuredin	Cynin
The classical classification of algae on recog	Photosyn	Cell wall	Cell const	Reproduction
The chloroplast have membrane bound sac (	Thylakoic	Cell wall	Pyrenoids	Flagella
Starch synthesis in algae takes place in _____	Chlorobla	Vacuole	Contractil	Pyrenoids
Chloplast contain chlorophyll a and b toget	Carotenoi	Chlorophy	Chitin	Pyrenoids
Contractile vacuole which present in euglen	Osmotic p	Temperat	Light	Boiling point
Chlamydomonas is_____	Red algae	Blue algae	Blue algae	Brown algae
Chlamydomonas consist of _____ nucleu	Multi	Two	Single	Three
Algae reproduce asexually by producing____	Zoospore	Ascospor	Basidiosp	Myxospores
Example for non-mobile unicellular green al	Chollera	Diatoms	Cyanobac	Actinomycetes
Example of motile algae_____	Volvox	Tricoderm	Chrysoph	Rhodophyta
Euglenoids_____	Share wit	Share wit	Share wit	Share with the chlor
Chloroplast contain _____	Chlorophy	Chlorophy	Chlorophy	chorophyll z
The fossil deposit of diatoms in ocean is call	gaseous	spraceous	diatomac	plaster of Paris
Agar gelling property last by ----------	over chilli	over heat	over mixi	mild temperature.
Algae are rich in	Carbohyd	Proteins	Vitamins	carbohydrates, prot
A green algae prototheca moriformis causes	Blood pr	Prototheo	Uremia	Anorexia
Stonewarts appear as dense covering on the	Lakes	Ponds	Sea	Ocean

Fucoxanthin is a _____	Carotenoi	Chloroph	Enzyme	Food
Chlamydomonas consist of _____ nucleu	Multi	Two	Single	Three
Algae reproduce asexually by producing____	Zoospore	Ascospor	Basidiosp	Myxospores
Example for non-mobile unicellular green a	Chollera	Diatoms	Cyanobac	None of the above
Example of motile algae_____	Volvex	Tricoderi	Chrysoph	Rhodophyta
Example for stone worts_____	Calcium	Charophy	Chysophy	Cyanobacterium
Euglenoids_____	Share wit	Share wit	Share wit	Share with the chlo
Reproduction in euglenords is by _____	Mitotic	Meiosis	Binary	cytokinesis
The major carbohydreate reserve in the chr	Chrysola	Calbon	Amunioa	carbohydrates, prot
Eg for golden brown Algae _____	Chrysoph	Cryophyta	Rhodophy	carbohydrates, prot
Diatoms are _____	Photosyn	Non-phot	Photopho	algae
The color of these algae reflects the presenc	Fucoxant	Xanthin	Melami	None
_____ plays X role in building coral ree	Ca103	caso4	Ca chloric	Cap04
The storage product in brown algae is _____	Fucoxant	Laminarii	Pyrenoids	Xanthins
Dinoflagellates have chlorophylls_____	a & c	a & b	a, b &c	a, d
Diatom frustules are composed of crystallize	Calcium	Potassiur	Silica	Cadmium
Stoneworts are abundant in_____	Brackish	River wa	Ground w	waste water
Contractile vacuole which present in euglen	Osmotic p	Temperat	Both	pH
The chloroplast have membrane bound sac c	Thylakoi	Cell wall	Pyrenoids	Flagella
Paramylon is a polysaccharide composed of	b- 1,3 linl	b- 1,3 link	b- 1,3 link	b- 1,3 linked glucos
A green algae, *Prototheca moniform* is cause	Prostothe	Metanog	Protease	moniformosos

	Answer
	Phycocyanin
bilin	Chlorophyll + phycobilin
	Sea weeds
	Phycology
	Phytoplankins
	Lactophenol cotton blue
and ooga	isogamy, anisogamy and oogamy
and ooga	Oogamy
e	Brown algae
	Red algae
	Chlorophyll a
	Phycology
	Aquatic plants
	a & c
	Potassium
	Blue pigment
	Rhodophyta
	Galactose
	Rhodophyta
	Rhodophyta
	Red Algae
	Elythrocytin
	Pyocyami
	Photosynthetic pigments
	Thylakoids
	Pyrenoids
	Chlorophyll
	Osmotic pressure
	Blue algae
	Two
	Zoospores
	Chollera
	Volvox
ophyta &c	Share with the chlorophyta &charophyta
	Chlorophyll b
	diatomaceous earth
	over heating
eins and v	carbohydrates, proteins and vitamins
	Protothecosis
	Ponds

Carotenoid
Two
Zoospores
Chollera
Volvex
Charophyta
rophyta & Share with the chlorophyta &charophyta
Mitotic
eins and v Chrysolaminarin
eins and v Rhodophyta
algae
Melami
Cap04
Laminarin
a & c
Potassium
Brackish water
Osmotic pressure
Thylakoids
e heroes b- 1,3 linked glucose molecules
Prostothecosis

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I-B.Sc., Microbiology (Batch 2017-2020)

Introduction to Microbiology and Microbial Diversity (Semester-I) (17MBU101)

LECTURE PLAN

UNIT IV

Duration	Topic	Reference
01	General characteristics of fungi including habitat, distribution, nutritional requirements	R1: 537-546
02	Fungal cell ultra-structure	R1: 547-548
03	Economic importance of fungi with examples in agriculture, environment	R2: 126
04	Economic importance of fungi with examples in industry	R2: 127
05	Economic importance of fungi with examples in medicine and food	R2: 128-129
06	Biodeterioration	R2: 136-141
07	Mycotoxins	R2:148-151
08	Alexopoulos classification of fungi.	R3: 12-70
09	Unit revision and possible questions	
	Total hours: 9	

R1: Presscott., Harley and Klein-Microbiology- sixth edition- Mc Graw Hill education. International edition.
R2: Fungi-biology and applications-Kevin Kavanagh, John Wiley and sons Ltd, 2005.
R3: Michael J Carlile, Sarah C Wattinson, Graham, W. Gooday-The Fungi, 2001. Second edition. Academic press.

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2017

Introduction to microbiology and Microbial diversity

Unit IV notes

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Unit IV: Fungi and Actinomycetes

Definition

To give a precise definition of a fungus is difficult as fungi vary in forms, behaviour and life-cycles. Alexopoulos and Mims (1979) defined fungi as **"eukaryotic, spore-bearing, achlorophyllous organisms that generally reproduce sexually and asexually and whose usually filamentous, branched somatic structures are typically surrounded by cell walls containing chitin or cellulose, or both of these substances, together with many other complex organic molecules."** Fungi are **chemoheterophic organisms** that derive both carbon and energy from organic compounds that originate
from autotrophs and other heterotrophs.

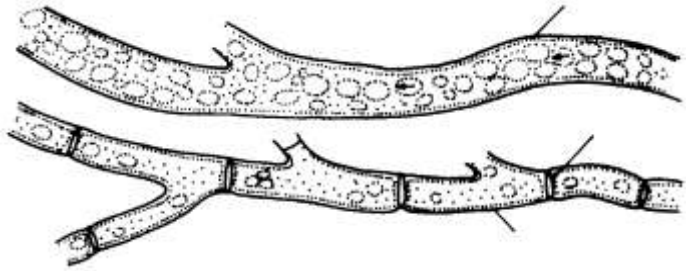
Recent studies indicate that members of kingdom *Fungi* are most closely related to animals not plants, possibly through a choanoflagellate like ancestor.Based on data presently available, Blackwell and Spatafora (2004) reported that the organisms studied by mycologist are **polyphyletic** (*i.e.,* developed from more than one ancestral type) and belong to two different kingdoms (*i*) kingdom ***Fungi*** that includes **true fungi** (*e.g., Chytridiomycota, Zygomycota, Ascomycota* and *Basidiomycota*)*;* (*ii*) kingdom ***Straminipila*** (*Oomycota, Hypochytriomycota, Labyrinthulales,* and *Thraustochytriales*) and a clade **slime molds** (*Plasmodiophorales, Myxomycota, Dictyosteliomycota, and Acrasiomycota*). Thus, the members of *Straminipila* and slime molds are, not fungi but considered as fungus-like organisms. The slime molds are placed in the kingdom ***Protozoa*** in the 9th edition of the *Dictionary of the Fungi* (Kirk *et al.*, 2001). The fungi and fungus-like organisms are eukaryotic and heterotrophic enveloped by cell walls and reproduce both sexually and asexually by spores. Currently **true fungi** are defined as **eukaryotic organisms lacking plastids, with absorptive nutrition, reproducing both sexually and asexually by spores and hyphae surrounded by cell walls containing chitin and β-glucans, and mitochondria with flattened cristae and peroxisomes.**

Thallus Organisation

Some fungi are unicellular, but the majority have a differentiated thallus consisting of threadlike, tubular filaments, the **hyphae** (sing. **hypha**, Gr. *hyphe* = web). In most fungi, the thallus is differentiated into a vegetative part which absorbs nutrients, and a reproductive part which forms reproductive structures. Such thalli are called **eucarpic** (Gr. *eu* = good + *karpos* = fruit). In some, however, the thallus does not show this differentiation and after a phase of vegetative growth, changes into one or more reproductive structures. Such thalli are called **holocarpic** (Gr. *holos* = entirely + *karpos* = fruit). The network of hyphae constituting the body (thallus, soma) of a fungus is called a **mycelium** (Gr. *mykes* = mushroom, fungus). A hypha is made up of a thin transparent, tubular filament, filled with a layer of cytoplasm varying in thickness. In the simpler filamentous fungi, septa are always formed at the base of reproductive organs and the vigorously growing hyphae are **coenoecytic** (Gr. *koinos* = common + *kytos* = a hollow vessel) which means they are **nonseptate** or **aseptate** with nuclei in a common matrix.

Paul Vuillemin in the year 1912 used the term **coenocyte** (adj. coenocytic) for a cell usually multinucleate and **apocyte** for one temporarily or secondarily multinucleate. When the mycelium contains genetically identical nuclei, it is called **homokaryotic** (Gr. *homo* = the same + *karyon* = nucleus), and when it contains two or more genetically different nuclei, the mycelium is said to be **heterokaryotic** (Gr. *Heteros* = other + *karyon* = nucleus). In the more complex groups, the hyphae are divided into compartments or cells by cross walls called **septa** (Fig. 1.1):

primary and adventitious. The **primary septa** are formed during nuclear divisions and are laid down between daughter nuclei. The **adventitious septa** are formed independently of nuclear division and are especially associated with changes in the concentration of the protoplasm as it moves from one part of the hypha to another.



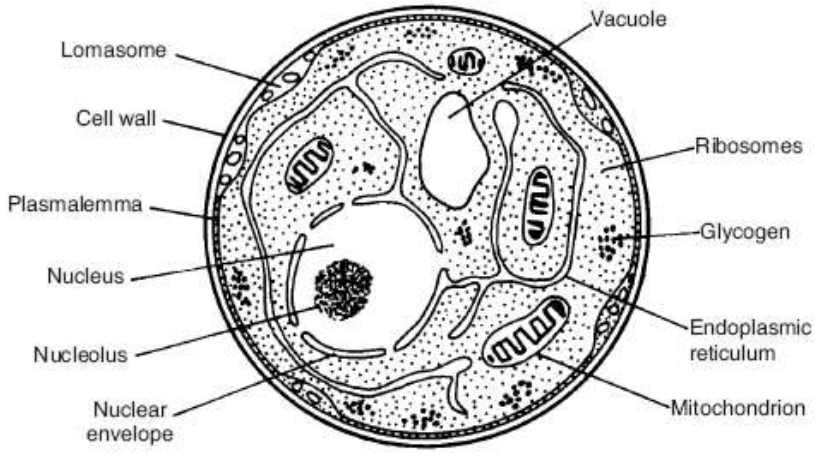
Dimorphism

Some fungi especially human and animal pathogens, can exist either in yeast form or in mycelial form and are said to be **dimorphic**. This phenomenon is termed as **dimorphism**. Common examples of human fungal pathogens showing dimorphism are *Histoplasma, Sporothrix* and *Blastomyces.* In infected tissues dimorphic fungi occur as single yeast-like cells that multiply by budding but become mycelial in their saprophytic growth in culture as in *Blastomyces (Ajellomyces) dermatitidis* (Fig.1.6) causing blastomycosis in humans. The dimorphism appears to be an inherent characteristic of a number of fungi. This phenomenon has also been observed in members of *Taphrinales* and *Ustilaginales,* which are mycelial in their plant hosts but yeast like in artificial culture.

Cell Structure

The cell structure of prokaryotes is simpler than that of eukaryotes. Cells of bacteria lack mitochondria, plastids, nuclear membranes, mitotic spindles, endoplasmic reticulum, Golgi apparatus, vacuoles, and advanced (9 + 2 strands) flagellar structure. These organelles are characteristic of the cells of plants, animals, and many other organisms such as algae (except blue green), fungi, protozoa and slime molds.

Fungal cells are typically **eukaryotic** and lack chloroplasts (Fig. 1.7). Recent studies indicate that the true fungi are most closely related to animals, not plants. Fungi are usually filamentous and multicellular; their nuclei, although small, can be demonstrated with relative ease; and their primary carbohydrate storage product is **glycogen.**



Cell Membrane

In fungal cells, as in other eukaryotic cells, the living protoplast is enclosed in a cell membrane, the **plasma membrane** or **plasmalemma**. It is a tripartite structure composed of two electron dense regions separated by a transparent region. Each layer measures approximately 25–30Å. This tripartite structure which occurs in many biological membranes is termed as **"unit membrane".** The plasmalemma is usually adpressed to the cell wall, but may become undulating or

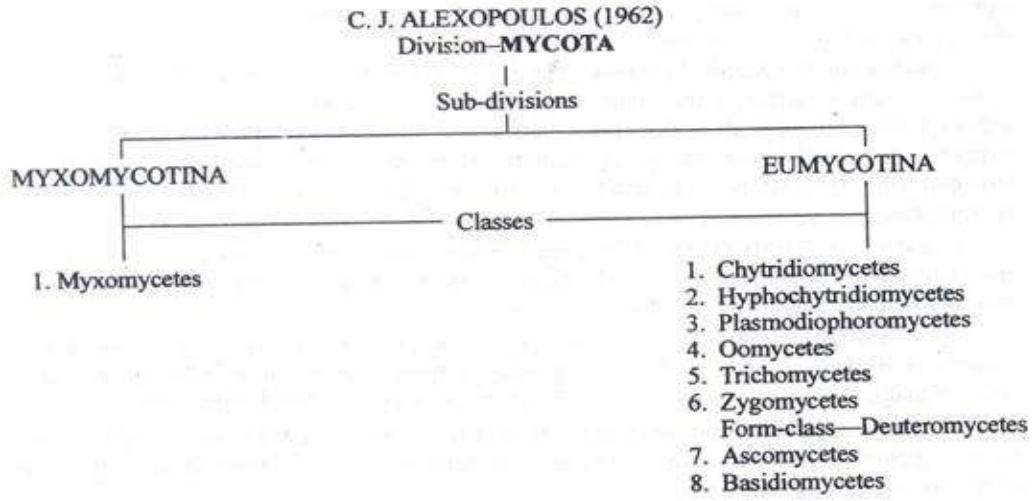
invaginated during certain developmental stages of some organisms or certain conditions. The principal components of the plasmalemma are **protein** and **lipids.** Glucosamine and glucose residues account for most of the carbohydrate, but appreciable amounts of mannose are also present.The cytoplasm of fungal hyphae resembles that of other eukryotic cell in the presence of such organelles as nucleus, mitochondria, microbodies, Golgi bodies, ribosomes, vacuoles, vesicles, endoplasmic recticulum.

Alexopolous method of algal classification

According to the recommendations of the Committee on International Rules of Botanical Nomenclature, the names of the divisions of fungi end in -mycota, of sub-divisions in -mycotina. of classes in -mycetes, sub-classes in -mycetidae, of orders in -ales and of families in -aceae. For example, Puccinia graminis may be classified as follows:

C. J. Alexopoulos (1962):

Kingdom	Plantae
Division	Mycota
Sub-division	Eumycotina
Class	Basidiomycetes
Sub-class	Heterobasidiomycetidae
Order	Uredinales
Family	Pucciniaceae
Genus	Puccinia
Species	Graminis



Division-Mycota (The Fungi):

Devoid of chlorophyll; the plant body varies from a microscopic unicell to an extensive mycelium; true nuclei with nuclear membranes, nucleoli present; cell walls contain chitin or cellulose, or a mixture of both, and other complex polysaccharides;

reproduction asexual and sexual; propagative units—spores, two sub-divisions—1. Myxomycotina and 2. Eumycotina.

Sub-division-Myxomycotina:

The definite cell walls are absent from their amoeba- like bodies; somatic structure, a free-living Plasmodium, i.e., a multinucleate mass of protoplasm without definite cell walls, the entire

Plasmodium whose nuclei are diploid (2n), is consumed in the formation of fructifications which bear haploid (n) spores resulting from meiosis; spores are provided with firm walls, flagellated cells are characteristically produced; single class— Myxomycetes.

Sub-division-Eumcotina:

They are true fungi, the organisms, only with few exceptions provided with cell walls and are typically filaments (some unicellular); reproduction-sexual and asexual; there are eight classes and one form-class.

1. Class-Chytridiomycetes:

They are posteriorly uniflagellate fungi, motile cells (zoospores or planogametes) produced, each with a single posterior, whiplash flagellum; various types of thalli; 3 orders-1. Chytridiales, 2. Blastocladiales and 3. Monoblepharidales.

2. Class-Hyphochytridiomycetes:

Aquatic fungi; motile cells possess a single anterior tinsel flagellum; parasitic on algae and fungi or saprobic on plant and insect debris in the water, single order-hypochytriales.

3. Class-Oomycetes:

Fungi with well-developed coenocytic mycelium; they reproduce asexually by means of flagellate zoospores, each bearing one tinsel flagellum directed forward and one whiplash flagellum directed backward; zoospores formed in sporangia of various types; perfect spores— oospores; 4 orders-1. Saprolegniales, 2. Leptomitales, 3. Lagenidiales and 4. Peronosporales.

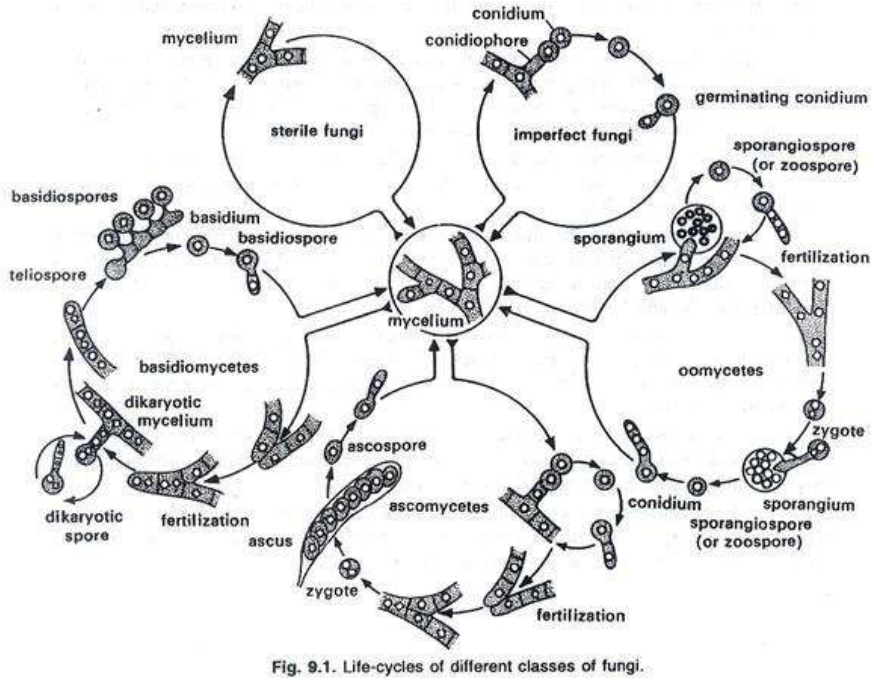


Fig. 9.1. Life-cycles of different classes of fungi.

4. Class-Plasmodiophoromycetes:

Obligate endoparasitic fungi of vascular plants, algae and fungi; non-cellular (without cell walls,) multinucleate thalli living in the cells of their hosts, motile cells possess two unequal, anterior whiplash-type flagella; resting spores produced in masses, but not in distinct fruiting bodies, single order—Plasmodiophorales.

5. Class-Trichomycetes:

Fungi possessing simple or branched filamentous coenocytic thallus, attached to the digestive track or the external cuticle of living arthropods; mycelium not immersed in host tissues; 5 orders.

6. Class-Zygomycetes:

Saprobic or parasitic fungi, well developed coencocytic or septate mycelium; sexual reproduction resulting in the formation of a resting spore formed by the fusion of two usually equal gametangia; no motile cells formed; 3 orders—1. Mucorales, 2. Entomophthorales and 3. Zoopagales.

7. Class-Ascomycetes:

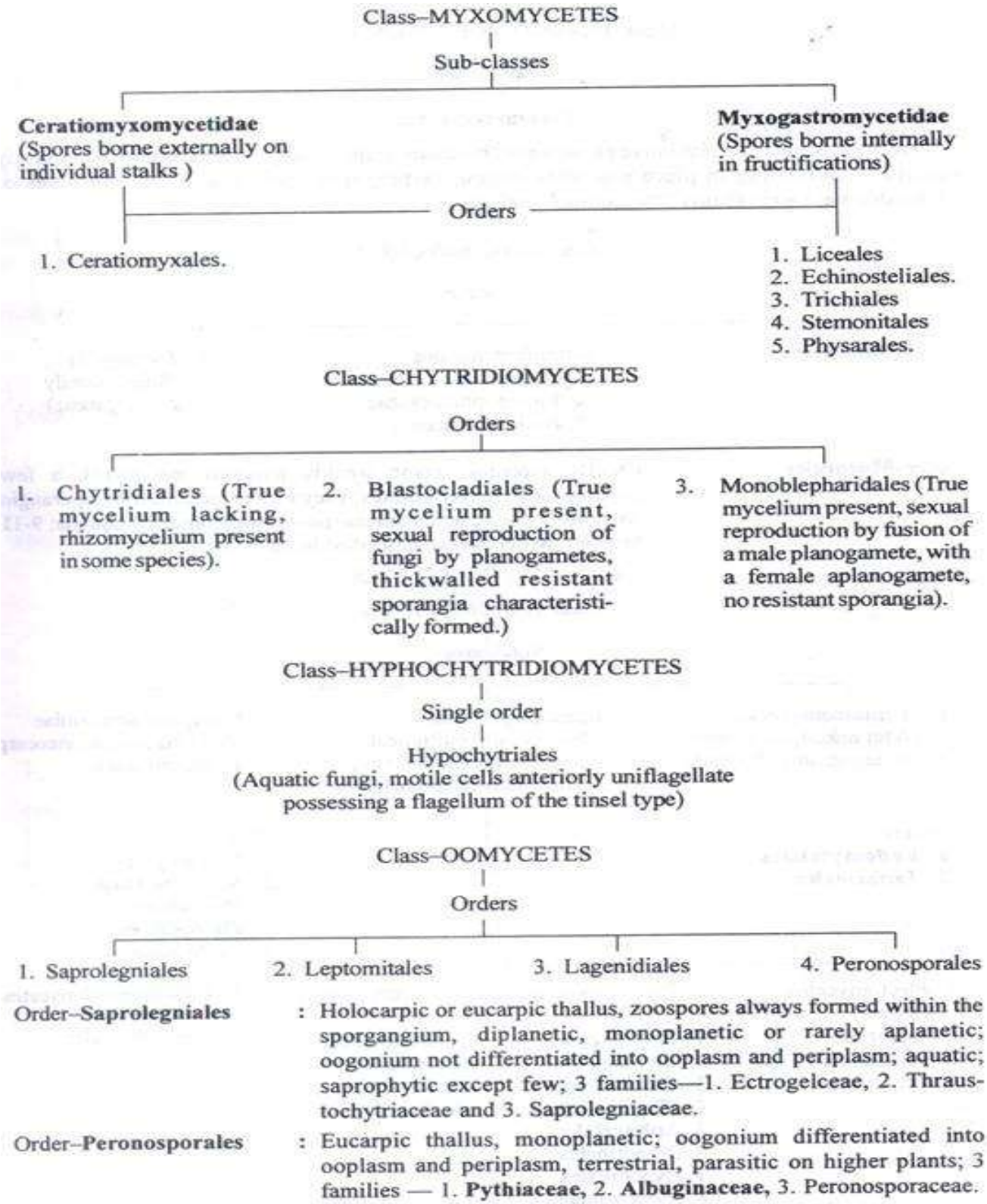
Somatic body consists of a septate mycelium, in some one-celled; never producing motile spores or gametes; sexually produced spores, ascospores formed inside sac-like structure, the ascus; 3 sub-classes—1. Hemiascomycetidae, 2. Euascomycetidae and 3. Loculoascomycetidae.

8. Class-Basidiomycetes:

Sexually produced spores, basidiospores, formed exogenously on a specialized organ, the basidium, in which karyogamy and meiosis occur; 2. sub-classes — 1. Heterobasidiomycetidae. 2. Homobasidiomycetidae.

Form-Class-Deuteromycetes:

This form-class is also known as Fungi Imperfecti; sexual reproduction lacking; a parasexual cycle may be present; 4 orders—1. Sphaeropsidales 2. Melanconiales, 3 Moniliales and 4. Mycelia Sterilia.



Order–**Saprolegniales** : Holocarpic or eucarpic thallus, zoospores always formed within the sporgangium, diplanetic, monoplanetic or rarely aplanetic; oogonium not differentiated into ooplasm and periplasm; aquatic; saprophytic except few; 3 families—1. Ectrogelceae, 2. Thraustochytriaceae and 3. Saprolegniaceae.

Order–**Peronosporales** : Eucarpic thallus, monoplanetic; oogonium differentiated into ooplasm and periplasm, terrestrial, parasitic on higher plants; 3 families — 1. **Pythiaceae,** 2. **Albuginaceae,** 3. Peronosporaceae.

2017

Class–PLASMODIOPHOROMYCETES

Single order

Plasmodiophorales

Always parasitic assimilative phase a multinucleate thallus within host cells of plants (mostly vascular); sporulating in place and often causing hypertrophy, both flagella of zoospores of whiplash type, single family Plasmodiophoraceae.

Class–ZYGOMYCETES

Orders

1. Mucorales
2. Entomophthorales (Two families : 1. Entomophthoraceae 2. Basidiobolaceae)
3. Zoopagales (Single family Zoopagaceae)

Order–**Mucorales** : Chiefly saprobic, some weakly parasitic on plants, a few endoparasitic in vertebrates; asexual reproduction by sporangia containing one to many aplanospores, sometimes by conidia; 9-11 families, **Mucoraceae** described in the text.

Class–TRICHOMYCETES

Class–ASCOMYCETES

Sub–classes

1. Hemiascomycetidae (Asci naked; no ascocarps; no ascogenous hyphae).
2. Euascomycetidae (Asci usually unitunicate; borne in a cleistothecium, perithecium or apothecium).
3. Loculoascomycetidae (Asci bitunicate; ascocarp an ascostroma).

Orders :
1. **Endomycetales**
2. **Taphrinales**

Series

Orders :
1. Myriangiales
2. Microthyriales
3. Hysteriales
4. Pleosporales
5. Dothideales

1. Plectomycetes
   Orders–
   1. **Eurotiales**
   2. Microascles
   3. Onygenales
2. Pyrenomycetes
   1. Erysiphales
   2. Meliolales
   3. Chaetomiales
   4. Clavicipitales
   5. **Sphaeriales**
   6. Diaporthales
   7. Hypocreales
   8. Coryneliales
   9. Coronophorales
3. Discomycetes
   1. Ostropales
   2. Helotiales
   3. **Pezizales**
   4. Tuberales
4. Laboulobeniomycetes
   1. Laboulbeniales

Order-Endomycetales:
Asci arising directly from zygotes each derived from the copulation of two cells, or parthenogenetically from single cells; 4 families — 1. Ascoideaceae; 2. Endomycetaceae; 3. Spermophthoraceae and 4. Saccharomycetaceae.

Order-Taphrinales: Product of sexuality a dikaryotic thallus; asci arising directly from cells of this thallus; single many family—Taphrinaceae. Ascocarp sessile and without an ostiole; 3 families — 1. Ascosphaeriaceae, 2. Gymnoascaceae 3. Eurotiaceae.

Order-Eurotiales:

Ascocarp closed (cleistothecium), typically black or dark coloured, wall appendaged, mycelium largely superficial, single family — Erysiphaceae.

Order-Clavicipitales

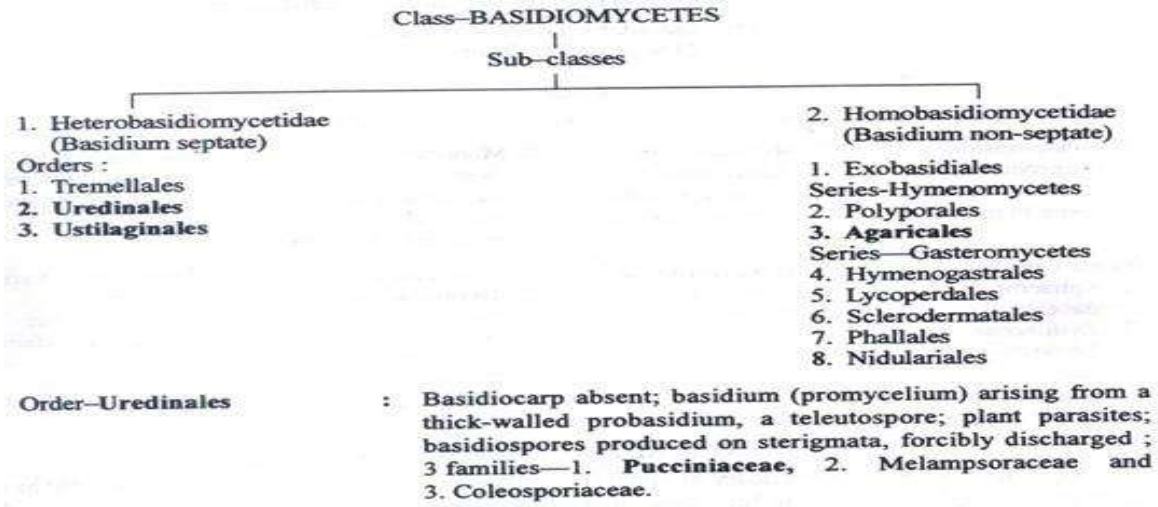
Asci persistent; ascospores thread-like; ascocarp a perithecium with an ostiole; periphyses present; asci with enlarged thickened by apical cap penetrated by a narrow thread-like apical pore; single family — Clavicipitaceae.

Order-Sphaeriales:

Ascocarps and stromata, if present, dark, membranous or carbonous; perithecia, typically white to bright coloured; periphyses and apical paraphyses present; mature asci attached to the inner perithecial wall; 4 families — 1. Sordariaceae, 2. Phyllachoraceae, 3. Diatrypaceae and 4. Xylariaceae.

Order-Pezizales:

Ascocarp an open apothecium or a modified form of it; apothecia above ground (epigeous); asci operculate or sub- operculate; 3. families — 1. Sarcoscyphaceae, 2. Pezizaceae and 3. Helvellaceae.



Order-Ustilaginales:

Basidiocarp lacking; mostly parasitic on vascular plants; teleutospores formed in a manner similar to that of chlamydospores; basidiospores sessile, not forcibly discharged, 3 families—1. Ustilaginaceae, 2. Tilletiaceae and 3. Graphiolaceae.

Series-Hymenomycetes:

Basidiocarp present; hymenium present and exposed before the spores are mature.

Order-Polyporales:

Basidiocarp present; hymenium present; hymenium gymonocarpic texture of basidiocarp not soft and putrescent; 6 families—1. The lephoraceae, 2. Clavariaceae, 3. Cantha- rellaceae 4. Hydnaceae, 5. Meruliaceae and 6. Polyporaceae.

Order-Agaricales:

Basidiocarp present; hymenium borne on lamellae (gills), or if lining the interior of pores then basidiocarp soft and putrescent; 5 families—1. Boletaceae, 2. Paxillaceae, 3. Russulaceae, 4. Hygrophoraceae and 5. Agaricaceae.

Series-Gasteromycetes:

Hymenium present or absent, basidiocarps remaining closed at least until the spores have been released from the basidia (i.e.,angiocarpic).

Order-Lycoperdales:

Gleba powdery; glebal chambers not separating from peridium; hymenium present in early stages; spores mostly light coloured, small; 3 families- 1. Arachniaceae, 2. Lycoperdaceae and 3. Geastraceae.

Order-Nidulariales:

Gleba waxy; glebal chambers forming waxy peridioles, or entire gleba separating as a unit from the peridium; 2 families — 1. Sphaerobolaceae and 2. Nidulariaceae.

Economic importance of fungi

Fungi are one of the most important groups of organisms on the planet. This is easy to overlook, given their largely hidden, unseen actions and growth. They are important in an enormous variety of ways.

- *Recycling.* Fungi, together with bacteria, are responsible for most of the recycling which returns dead material to the soil in a form in which it can be reused. Without fungi, these recycling activities would be seriously reduced. We would effectively be lost under piles many metres thick, of dead plant and animal remains.
- *Mycorrhizae and plant growth*. Fungi are vitally important for the good growth of most plants, including crops, through the development of mycorrhizal associations. As plants are at the base of most food chains, if their growth was limited, all animal life, including human, would be seriously reduced through starvation.
- *Food*. Fungi are also important directly as food for humans. Many mushrooms are edible and different species are cultivated for sale worldwide. While this is a very small proportion of the actual food that we eat, fungi are also widely used in the production of many foods and drinks. These include cheeses, beer and wine, bread, some cakes, and some soya bean products.
  While a great many wild fungi are edible, it can be difficult to correctly identify them. Some mushrooms are deadly if they are eaten. Fungi with names such as 'Destroying Angel' and 'Death Cap' give us some indication that it would not be a terribly good idea to eat them! In some countries, collecting wild mushrooms to eat is a popular activity. It is always wise to be totally sure that what you have collected is edible and not a poisonous look-a-like.
- *Medicines* Penicillin, perhaps the most famous of all antibiotic drugs, is derived from a common fungus called *Penicillium.* Many other fungi also produce antibiotic substances, which are now widely used to control diseases in human and animal populations. The discovery of antibiotics revolutionized health care worldwide. Some fungi which parasitise caterpillars have also been traditionally used as medicines. The Chinese have used a particular caterpillar fungus as a tonic for hundreds of years. Certain chemical compounds isolated from the fungus may prove to be useful treatments for certain types

of cancer. A fungus which parasitises Rye crops causes a disease known as Ergot. The fungus can occur on a variety of grasses. It produces small hard structures, known as sclerotia. These sclerotia can cause poisoning in humans and animals which have eaten infected material. However, these same sclerotia are also the source of a powerful and important drug which has uses in childbirth.

- *Biocontrol*. Fungi such as the Chinese caterpillar fungus, which parasitise insects, can be extremely useful for controlling insect pests of crops. The spores of the fungi are sprayed on the crop pests. Fungi have been used to control Colorado potato beetles, which can devastate potato crops. Spittlebugs, leaf hoppers and citrus rust mites are some of the other insect pests which have been controlled using fungi. This method is generally cheaper and less damaging to the environment than using chemical pesticides.
- *Crop Diseases*. Fungal parasites may be useful in biocontrol, but they can also have enormous negative consequences for crop production. Some fungi are parasites of plants. Most of our common crop plants are susceptible to fungal attack of one kind or another. Spore production and dispersal is enormously efficient in fungi and plants of the same species crowded together in fields are ripe for attack. Fungal diseases can on occasion result in the loss of entire crops if they are not treated with antifungal agents.
- *Animal Disease.* Fungi can also parasitise domestic animals causing diseases, but this is not usually a major economic problem. A wide range of fungi also live on and in humans, but most coexist harmlessly. Athletes foot and Candida infections are examples of human fungal infections.
- *Food Spoilage*. It has already been noted that fungi play a major role in recycling organic material. The fungi which make our bread and jam go mouldy are only recycling organic matter, even though in this case, we would prefer that it didn't happen! Fungal damage can be responsible for large losses of stored food, particularly food which contains any moisture. Dry grains can usually be stored successfully, but the minute they become damp, moulds are likely to render them inedible. This is obviously a problem where large quantities of food are being produced seasonally and then require storage until they are needed.

Mycotoxin

A **mycotoxin** is a toxic secondary metabolite produced by organisms of the fungus kingdom, commonly known as molds. The term 'mycotoxin' is usually reserved for the toxic chemical products produced by fungi that readily colonize crops. One mold species may produce many different mycotoxins, and several species may produce the same mycotoxin.

Production

Most fungi are aerobic (use oxygen) and are found almost everywhere in extremely small quantities due to the minute size of their spores. They consume organic matter wherever humidity and temperature are sufficient. Where conditions are right, fungi proliferate into colonies and mycotoxin levels become high. The reason for the production of mycotoxins is not yet known; they are not necessary for the growth or the development of the fungi. Because mycotoxins weaken the receiving host, the fungus may use them as a strategy to better the environment for further fungal proliferation. The production of toxins depends on the surrounding intrinsic and extrinsic environments and these substances vary greatly in their

toxicity, depending on the organism infected and its susceptibility, metabolism, and defense mechanisms.

Major groups

Aflatoxins are a type of mycotoxin produced by Aspergillus species of fungi, such as A. flavus and A. parasiticus. The umbrella term aflatoxin refers to four different types of mycotoxins produced, which are B_1, B_2, G_1, and G_2. Aflatoxin B_1, the most toxic, is a potent carcinogen and has been directly correlated to adverse health effects, such as liver cancer, in many animal species. Aflatoxins are largely associated with commodities produced in the tropics and subtropics, such ascotton, peanuts, spices, pistachios, and maize.

Ochratoxin is a mycotoxin that comes in three secondary metabolite forms, A, B, and C. All are produced by *Penicillium*and *Aspergillus* species. The three forms differ in that Ochratoxin B (OTB) is a nonchlorinated form of Ochratoxin A (OTA) and that Ochratoxin C (OTC) is an ethyl ester form Ochratoxin A.*Aspergillus ochraceus* is found as a contaminant of a wide range of commodities including beverages such as beer and wine. *Aspergillus carbonarius* is the main species found on vine fruit, which releases its toxin during the juice making process. OTA has been labeled as a carcinogen and a nephrotoxin, and has been linked to tumors in the human urinary tract, although research in humans is limited byconfounding factors.

Citrinin is a toxin that was first isolated from *Penicillium citrinum*, but has been identified in over a dozen species of*Penicillium* and several species of Aspergillus. Some of these species are used to produce human foodstuffs such as cheese (*Penicillium camemberti*), sake, miso, and soy sauce (Aspergillus oryzae). Citrinin is associated with yellowed ricedisease in Japan and acts as a nephrotoxin in all animal species tested. Although it is associated with many human foods (wheat, rice, corn, barley, oats, rye, and food colored with Monascus pigment) its full significance for human health is unknown. Citrinin can also act synergistically with Ochratoxin A to depress RNA synthesis in murine kidneys.

Ergot **Alkaloids** are compounds produced as a toxic mixture of alkaloids in the sclerotia of species of *Claviceps*, which are common pathogens of various grass species. The ingestion of ergot sclerotia from infected cereals, commonly in the form of bread produced from contaminated flour, cause ergotism the human disease historically known as St. Anthony's Fire. There are two forms of ergotism: gangrenous, affecting blood supply to extremities, and convulsive, affecting the central nervous system. Modern methods of grain cleaning have significantly reduced ergotism as a human disease, however it is still an important veterinary problem. Ergot alkaloids have been used pharmaceutically.

Patulin is a toxin produced by the P. expansum, *Aspergillus*, *Penicillium*, and Paecilomyces fungal species. *P. expansum* is especially associated with a range of moldy fruits and vegetables, in particular rotting apples and figs. It is destroyed by the fermentation process and so is not found in apple beverages, such as cider. Although patulin has not been shown to be carcinogenic, it has been reported to damage the immune system in animals. In 2004, the European Community set limits to the concentrations of patulin in food products. They currently stand at 50 µg/kg in all fruit juice concentrations, at 25 µg/kg in solid apple products used for direct consumption, and at 10 µg/kg for children's apple products, including apple juice.

Fusarium toxins are produced by over 50 species of *Fusarium* and have a history of infecting the grain of developing cereals such as wheat and maize.They include a range of mycotoxins, such as: the fumonisins, which affect the nervous systems of horses and may cause cancer in rodents; the trichothecenes, which are most strongly associated with chronic and fatal toxic effects in animals and humans; and zearalenone, which is not correlated to any fatal toxic effects in animals or humans. Some of the other major types of *Fusarium* toxins include: beauvercin and enniatins, butenolide, equisetin, and fusarins.

Health effects

Some of the health effects found in animals and humans include death, identifiable diseases or health problems, weakened immune systems without specificity to a toxin, and as allergens or irritants. Some mycotoxins are harmful to other micro-organisms such as other fungi or even bacteria; penicillin is one example. It has been suggested that mycotoxins in stored animal feed are the cause of rare phenotypical sex changes in hens that causes them to look and act male.

In humans

Mycotoxicosis is the term used for poisoning associated with exposures to mycotoxins. The symptoms of mycotoxicosis depend on the type of mycotoxin; the concentration and length of exposure; as well as age, health, and sex of the exposed individual. The synergistic effects associated with several other factors such as genetics, diet, and interactions with other toxins have been poorly studied. Therefore, it is possible that vitamin deficiency, caloric deprivation, alcohol abuse, and infectious disease status can all have compounded effects with mycotoxins. In turn, mycotoxins have the potential for both acute and chronic health effects via ingestion, skin contact, and inhalation. These toxins can enter the blood stream and lymphatic system; they inhibit protein synthesis, damage macrophage systems, inhibit particle clearance of the lung, and increase sensitivity to bacterial endotoxin.

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF MICROBIOLOGY
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (17MBU101)

Unit IV QUESTIONS	**Opt A**	**Opt B**	**Opt C**
Which of them lacks sexual reproduction_____?	Zygomyce	Ascomyce	Deuterom
Spores of actinomycetes are very sensitive, killed at room ten	52oC for 3	65oC for	70oC for 3
Culture media for fungi are	Potato de	Sabourau	Czapekdo
Which type of spores are produced sexually?	Conidia	Sporangic	Ascospor
Fixation of atmospheric nitrogen is by	Biological	Lightining	Ultraviole
Which one of the following fungi is the most serious threat in	Candida a	Aspergillu	Blastomy
Fungi with known sexual stages are called _____	Pathogen	Rreprodu	Perfect fu
The wonder drug of second world war is produced by	Algae	Fungi	Bacteria
The fungal disease that affect the internal organs and spread t	Mycose	Systemic	Mycotoxi
Those fungi which do not have a sexual stage are classified as	Phycomy	Ascomyce	Basidiom
Fungi differs with bacteria in that it –	Contain r	Are eukar	Have no r
The molds obtained nutrition from dead and decaying matter	Saphroph	Parasites	Commens
Most molds are capable of growing in the temperature range	0o – 25o	0o – 35oC	10o – 25o
Examples for actinomycetes	Streptom	Spirilla	mushroor
The branch of microbiology that deals with the study of fungi	parasitolo	mycology	myology
The study and effect of fungal toxins and their effects is called	Mycoses	Mycotoxi	Mycotoxi
A character that promotes the pathogenic potential of fungus	toxin	enzyme	byproduc
A disease caused by a fungus is called _____	mycolysis	virulence	mycosis
Fungi is _____	eukayotes	prokaryot	archae
Fungi are	aerobic	obligate a	obligate a
Basidium with basidiospores is called ____	Basidiom	Zygomyce	Ascomyce
Fungi differ from the other eukaryotic microbes in having	flagella	ergostero	chloropla
Which of the following is not a member of the division Ascom	Aspergillu	Claviceps	Penicilliu
Mycorrhizae are mutualistic associations between fungi and	bacteria	protozoa	unicellula
Which of the following structures would not be associated wit	Mitochon	Cell walls	Chloropla
Fungi posses a cell membrane that contains _____	lipids	Protein	Fat
Ascospores are produced and enclosed in a sac like structure	basidium	zygus	ascus
Basidiospores are borne in a specialised stalk called____	basidium	zygus	ascus
Give an example for yeast like fungi___	Cryptoco	Candida a	Aspergillu
Give an example for thermally dimorphic fungi____	Cryptoco	Candida a	Aspergillu
Give an example for filamentous fungi_____	Cryptoco	Candida a	Aspergillu
Sporangium with sporangiospores is called ___	Basidiom	Zygomyce	Ascomyce
Ascus with ascospores is called _____	Basidiom	Zygomyce	Ascomyce
Specific media for the isolation of fungi is	brain hea	sabourau	nutrient a
Aspergillus flavus &Aspergillus parasiticus secretes ____	verotoxin	endotoxir	exotoxin
Which of the following does not represent a human disease ca	Ringworn	Cryptoco	Malaria
Specific media for the isolation of fungi is	brain hea	sabourau	nutrient a
Mechanism of pyrimidine	binds to s	inhibit er	inhibit DN
Primary infection for coccidioidomycosis is _____	UTI	pulmanar	skin infec
Fungi are important in the production of all of the following c	bread	beer	cheese

Most fungi are soil _____	Parasites	Obligate F	Saprophy
Pebrane is a disease of_____.	Honeybee	Rat	silkworm
Fungi are widely distributed and are found where ever ------	Moisture	Enzymes	Plants
The slime molds and water molds resemble the fungi only in _	Cellular o	Reproduc	Appearan
The endophytic fungi affect plant _____ and patability to he	Reproduc	Growth	Feeding
Fungi also play a major role in the production of some organic	Hydrochl	Sulphuric	Gallic aci
The example for immunosuppressive drug_____	Cyclospor	Penicillin	Griseofulv
In the following statement which one is correct?	Yeast has	Yeast has	Yeast has
N acetyl glucosamine residues present in _____	Chitin	Hyphae	Mycelium
_____ is the primary storage polysaccharide in fungi.	Mitochon	Golgi app	Cell wall
A hyphae can fragment to form cells that behave as _____	Arthrospo	Blastospo	Conidiosp
The classical classification of algae on recognizes seven divisio	Photosyn	Cell wall	Cell const
Fungi are	chemolith	chemoorg	lithotroph
Which of the following characteristics applies to fungi of the c	the fungi	the fungi l	Rhizopus
The technical name of the common hrewing and baking yeast	Candida a	Escherich	Amanita t
The common mushrooms, puffballs, and truffles belong to the	Ascomyce	Basidiomy	Oomycete
The cause of thrush, yeast infection and other maladies in hu	Cryptoco	Agaricus	Candida a
_____ called rhizoids extend in to the bread and absorb nutr	Hyphae	Stolons	Special hy
Example for pink bread mold is _____	Neurospo	Claviceps	Agaricus
As cellular slime molds food supply is exaust the myxamoeba	cAMP	cATP	Both
Oomycetes have cell walls of _____	Cellulose	Chitin	Polysacch

Opt D	Answer
Basidiomycetes	Deuteromycetes
43oC for 30 min.	65oC for 30 min.
Rose Bengal Agar	Potato dextrose Agar
basidiospores	Ascospores
biological, lightening and ultraviolet light	
Cryptococus	Aspergillus
Saprophytic fungi	Perfect fungi
Plants	Fungi
Superficial mycoses	Systemic mycoses
Fungi imperfecti	Fungi imperfecti
have no asexual reproduction	Contain no peptidoglycan
None of these	Saphrophytes
10o – 35oC	0o – 35oC
Aspergillus	Streptomyces
fungyology	mycology
Mycology	Mycotoxicology
virulence factor	virulence factor
mycorrhizae	mycosis
Archea	eukayotes
obligate aerobe or facultative	obligate aerobe or facultative anaerobe
Sporangiomycete	Basidiomycete
an undulating membrane	ergosterol
Rhizopus	Rhizopus
vascular plants	vascular plants
Spores	Chloroplasts
Glycerol	lipids
sporangium	ascus
sporangium	basidium
Histopl;asma	Candida albicans
Histoplasma	Histoplasma
Histoplasma	Aspergillus
Sporangiomycete	Zygomycete
Sporangiomycete	Ascomycete
muller hinton agar	sabourauds dextrose agar
aflatoxin	aflatoxin
Jock itch	Malaria
muller hinton agar	sabourauds dextrose agar
inhibit microtubule assay	inhibit DNA,RNA synthesis
RTI	pulmanary infection
rubber	rubber

virulence factor	Saprophytes
monkey	silkworm
Animals	Moisture
All the above	Cellular organization and life style
Productivity	Reproduction
Acetic acids	Gallic acids
Streptomycin.	Cyclosporine
Yeast are prokaryotic	Yeast has no flagella but do possess most of the other eukary
Thallus	Chitin
Glycogen	Glycogen
Sporangiospores	Arthrospores
Reproduction	Photosynthetic pigments
physicotrophs	chemoorganotrophs
the sexual spore is called an a	Rhizopus is a member of the class
Saccharomyces cerevisiae	Saccharomyces cerevisiae
Deuteromycetes	Basidiomycetes
Rhizopus stolonifer	Candida albicans
spores	Special hyphae
Amanita phalloides	Neurospora crassa
cGTP	Both
carbohydarte	Chitin

yotic organelles

DEPARTMENT OF MICROBIOLOGY
KARPAGAM ACADEMY OF HIGHER EDUCATION

(Deemed to be University Established Under Section 3 of UGC Act, 1956)

Eachanari Post, COIMBATORE - 641 021, INDIA

I-B.Sc., Microbiology (Batch 2017-2020)

Introduction to Microbiology and Microbial Diversity (Semester-I) (17MBU101)

LECTURE PLAN

UNIT V

Duration	Topic	Reference
01	General characteristics of protozoa	R1:565-569
02	General characteristics of viruses	R1: 352-367
03	General characteristics of *Entameoba histolytica*	R2: 480-482
04	*Trichomonas sp*	R2: 483-484
05	*Giardia sp*	R2: 485-486
06	*Plasmodium sp.*	R2: 487-488
07	Classification of DNA viruses.	R3: 444-453
08	Classification of RNA viruses.	R3: 454-465
09	Classification of viruses-outline	R3: 444-465
10	Last five year old question paper discussion	
11	Revision of all units and possible questions	
	Total hours: 11	

R1: Presscott., Harley and Klein-Microbiology- sixth edition- Mc Graw Hill education. International edition.

R2: Rajan. S. Medical Microbiology, 2007. Second edition. MJP Publishers.

R3: Moshrafruddin Ahmed, S.K. Basumatary, Applied Microbiology, 2008. Second edition. MJP Publishers.

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2017

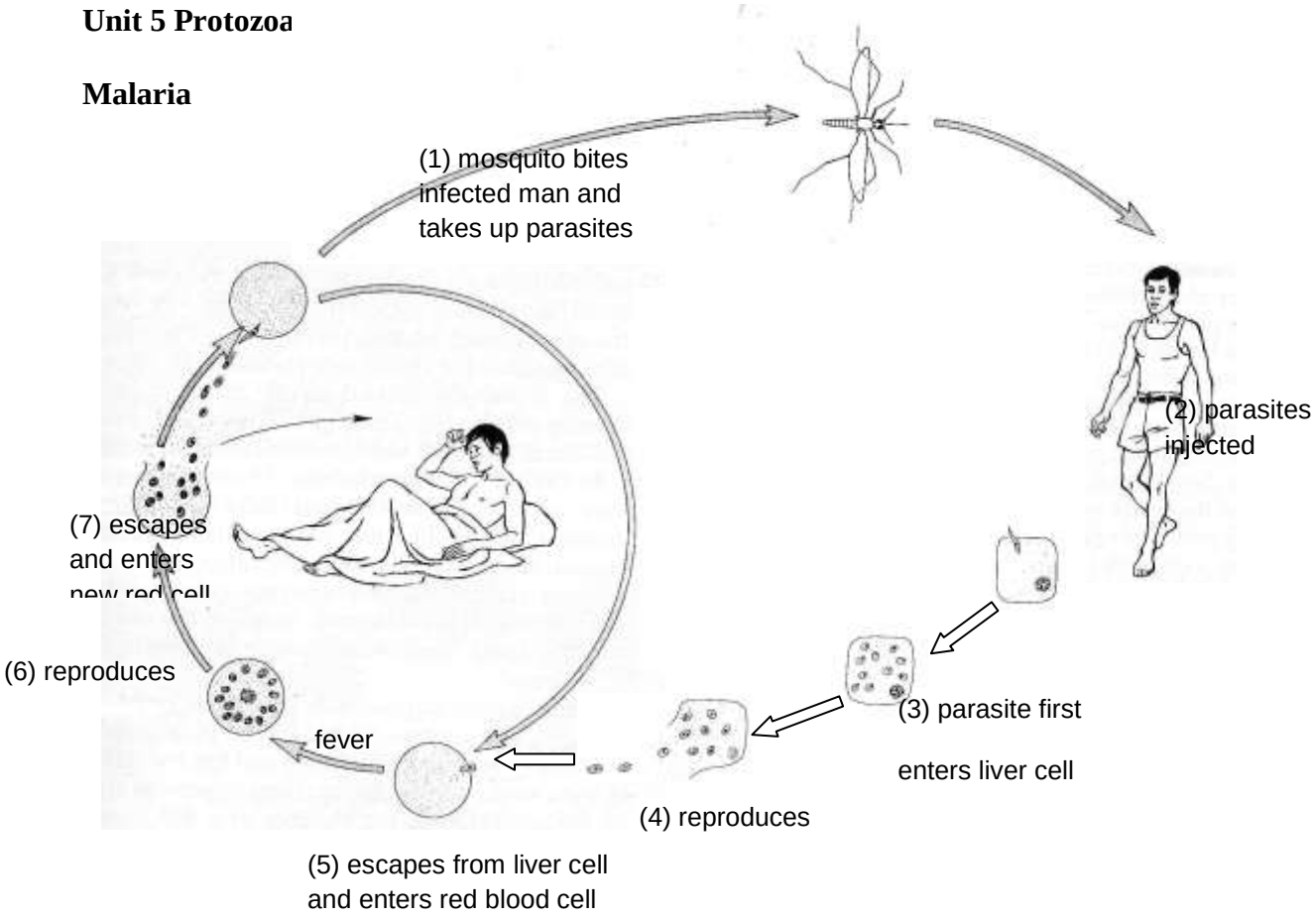
Introduction to microbiology and Microbial diversity

Unit V notes

Prepared by Dr. S. Ramalakshmi, Asst Prof, Dept of Microbiology, KAHE, CBE

Unit 5 Protozoa

Malaria



Transmission and life cycle of *Plasmodium*

Malaria. The malarial parasite, *Plasmodium*, is another protozoan which lives in the blood stream of humans but, unlike the trypanosomes, the parasites enter the red cells and feed on their cytoplasm. The Plasmodium divides repeatedly inside the red cell which eventually bursts, liberating dozens of new parasites into the circulation. Each of these can invade another red cell and undergo the same cycle. When thousands of red cells all burst simultaneously, releasing parasites and their accumulated waste products, the host suffers from a fever. This cycle of feeding, division and release is repeated regularly, so the fever occurs every 48 or 72 hours, according to which of the four species of Plasmodium has become established. The parasites are transmitted from person to person by female mosquitoes of the genus *Anopheles*, which pierce the skin with their sharp, tubular mouthparts and feed on the blood which they suck from the superficial skin capillaries (see Insects, Mosquito). If the blood so taken contains the malarial parasites, these undergo a complicated series of changes within the mosquito, including extensive reproduction, and eventually accumulate in large numbers in the salivary glands. If this mosquito now bites a healthy person, saliva containing hundreds of parasites is injected into his or her blood stream. When the parasites reach the liver they enter the liver cells and reproduce there. The infected liver cells break down and release the parasites once again into the blood

stream where they enter the red cells and begin the cycle of reproduction, release and re-infection. The person will now experience the symptoms of malaria. It is estimated that 300-500 million people each year catch malaria. In about four years or less, depending on the species of the parasite, Plasmodium dies out naturally. However, nearly 3 million people each year, die from the disease.

Some forms of malaria can be treated with drugs such as *quinine*, *choroquine* or *proguanil* but the malarial parasites in many parts of the world have developed resistance to these drugs. Combinations of chloroquine and proguanil are still effective in South America and parts of Africa, but in the Far East, the drugs are largely ineffective. A relatively new drug, *mefloquine* ('Lariam') is effective against most strains of Plasmodium but in about 20 percent of cases it has unpleasant side-effects, sometimes severe in a small number of people. A herbal drug, *artemesinin*, extracted from the 'wormwood' shrub (*Artemesia annua*) is proving valuable, and resistance is not yet a problem. Currently there are attempts to develop a vaccine but so far these have not been successful. If anti-malarial drugs are taken before entering a malarial country, they act as prophylactics, killing off any parasites which get into the blood from an infected mosquito. Unfortunately these drugs suffer from the disadvantage that, in many cases, the parasite has become resistant to them. If mosquitoes could be prevented from biting humans, the disease would die out. An attempt to eradicate malaria was made in the 1950s by spraying insecticides such as DDT on the walls of dwellings. The eradication programme failed largely because mosquitoes became resistant to the insecticides. Other strategies involve draining swamps or turning sluggish rivers into swifter streams. Mosquitoes lay their eggs in static water and the larvae hatch and grow there, so these measures reduce the population of mosquitoes. Water which collects in pots, tin cans, discarded tyres or open tanks is a breeding ground for mosquitoes.

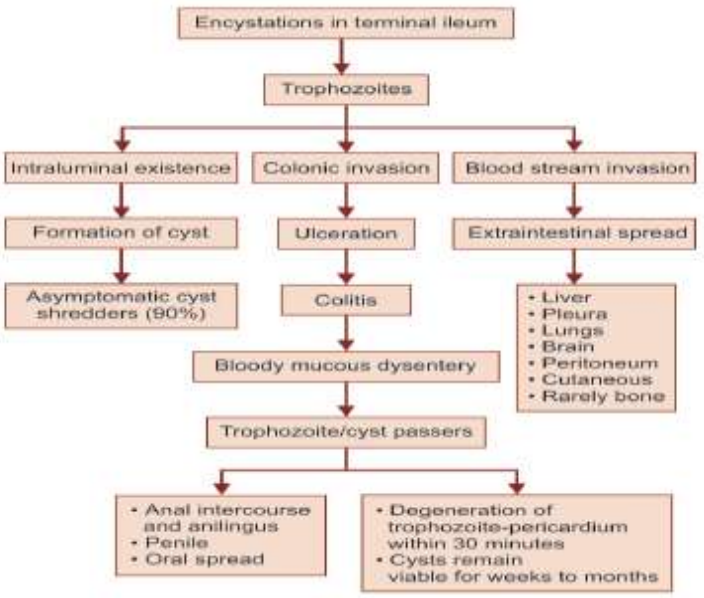
One of the most effective ways of preventing infection with Plasmodium is to sleep under mosquito nets impregnated with an insecticide such as *permethrin*. Studies involving thousands

of children in Ghana, Kenya and The Gambia have found that deaths from malaria can be reduced by two thirds by adopting this practice.

Entamoeba histolytica

Entamoeba histolytica is an anaerobic parasitic protozoan, part of the genus *Entamoeba.* The active (trophozoite) stage exists only in the host and in fresh loose feces; cysts survive outside the host in water, in soils, and on foods, especially under moist conditions on the latter. The cysts are readily killed by heat and by freezing temperatures, and survive for only a few months outside of the host. When cysts are swallowed they cause infections by excysting (releasing the trophozoite stage) in the digestive tract. *E. histolytica*, as its name suggests (histo–lytic = tissue destroying), is pathogenic; infection can be asymptomatic or can lead to amoebic dysentery or amoebic liver abscess.

Symptoms can include fulminating dysentery, bloody diarrhea, weight loss, fatigue, abdominal pain, and amoeboma. The amoeba can actually 'bore' into the intestinal wall, causing lesions and intestinal symptoms, and it may reach the blood stream. From there, it can reach different vital organs of the human body, usually the liver, but sometimes the lungs, brain, spleen, etc. A common outcome of this invasion of tissues is a



liver abscess, which can be fatal if untreated. Ingested red blood cells are sometimes seen in the amoeba cell cytoplasm.

DIAGNOSIS

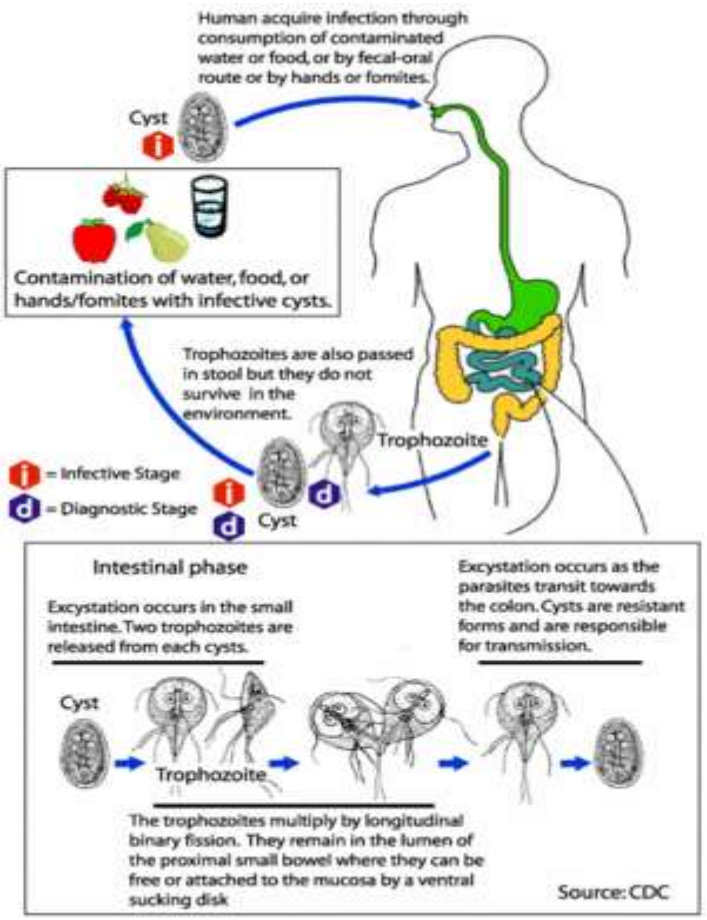
High degree of suspicion in endemic areas is a prerequisite. Fresh liquid stool examination showing hematophagus trophozoites with Charcot-Leyden crystals is characteristic. Stool examination, preferably for three consecutive days is advocated. Presence of only cysts in asymptomatic individuals is not diagnostic, since the cysts of *E. dispar*, which is noninvasive and harmless are indistinguishable from those of invasive *E. histolytica*. Sigmoidoscopic scrapings of ulcers showing hematophagus trophozoites are diagnostic. So also is the finding of amoebae from the walls of hepatic abscess.

TREATMENT

Combination therapy with luminal and tissue amoebicides is highly recommended. Introduction of nitroimidazole derivatives has revolutionized the treatment of amoebiasis. Usage of cardiotoxic emetine and the relatively less toxic dehydroemetine are now of historical interest. Though metronidazole and other derivatives are highly toxic to the vegetative forms and to a lesser extent the cysts, a course of luminal amoebicides is recommended for complete cure.

Giardia lamblia

Giardia lamblia is the most commonly diagnosed intestinal parasite in public health laboratories in the United States, and is diagnosed by finding cysts or trophozoites in the feces of humans or animals (both of *Giardia*'s life cycle stages have a characteristic appearance). The symptoms associated with giardiasis (also called "runner's diarrhea") range from none (in light infections) to severe, chronic diarrhea (in heavy infections), but not dysentery. Symptoms of giardiasis normally begin 1 to 2 weeks (average 7 days) after becoming infected. In otherwise healthy persons, symptoms of giardiasis may last 2 to 6 weeks, though occasionally symptoms last longer.



Giardia lamblia has a characteristic tear-drop shape and measures 10-15 µm in length. It has twin nuclei and an adhesive disk which is a rigid structure reinforced by supelicular microtubules. There are two median bodies of unknown function, but their shape is important for differentiating between species. There are 4 pairs of flagella, one anterior pair, two posterior pairs and a caudal pair. These organisms have no mitochondria, endoplasmic reticulum, golgi, or lysosomes.

Prepared by Dr. S. Ramalakshmi, Asst Prof, Dept of Microbiology, KAHE, CBE

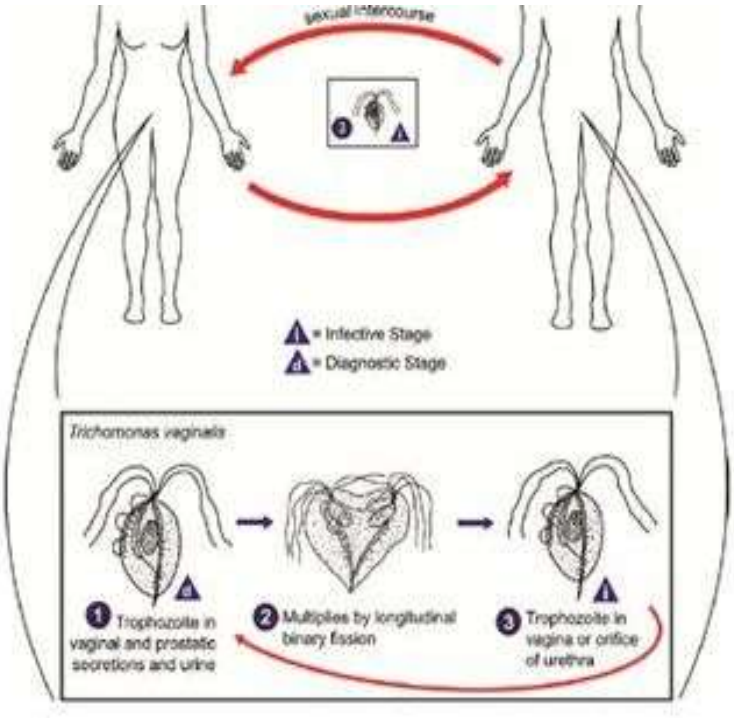
Giardia has a two-stage life cycle consisting of trophozoite and cyst. The life cycle begins with ingested cysts, which release trophozoites (10-20 µm x 5-15 µm) in the duodenum. These trophozoites attach to the surface of the intestinal epithelium using a ventral sucking disk and then reproduce by binary fission. The trigger for encystment is unclear, but the process results in the inactive, environmentally resistant form of Giardia -- a cyst (11-14 µm x 7-10 µm) that is excreted in feces. *Giardia* reproduce by binary fission and must be attached to a surface for this to occur. *Giardia*'s main food source, glucose, is obtained by a process of diffusion or by pinocytosis. Like amoebae, they are aerotolerant anaerobes and require a reducing environment. Food reserves are stored in the form of glycogen. Glucose catabolism via the glycolytic pathway results in production of the end products ethanol, acetate and carbon dioxide. *Giardia* is found worldwide and infects humans as well as domestic and wild animals (e.g., cats, dogs, cattle, deer, and beavers). *Giardia* is found in soil, food, water, or surfaces that have been contaminated with the feces from infected humans or animals.

Treatment: If one is diagnosed with this parasite, the drug of choice for the treatment of giardiasis is Metronidazole (Flagyl), but quinacrin hydrochloride and furazolidone are frequently used as well.

Trichomonas vaginalis

Trichomonas vaginalis is an anaerobic, flagellated protozoan parasite and the causative agent of trichomoniasis. It is the most common pathogenic protozoan infection of humans in industrialized countries.Infection rates between men and women are similar with women being symptomatic, while infections in men are usually asymptomatic. Transmission usually occurs via direct, skin-to-skin contact with an infected individual, most often through vaginal intercourse.

Morphology- Unlike other parasitic protozoa (Giardia lamblia, Entamoeba histolytica etc.), *Trichomonas vaginalis* exists in only one morphological stage, a trophozoite, and cannot encyst. The *T. vaginalis* trophozoite is oval as well as flagellated, or "pear" shaped as seen on a wet-mount. It is slightly larger than a white blood cell, measuring 9 × 7 µm. Five flagella arise near the cytostome; four of these immediately extend outside the cell together, while the fifth flagellum wraps backwards along the surface of the organism. The functionality of the fifth flagellum is not known. In addition, a conspicuous barb-like axostyleprojects opposite the four-flagella bundle. The axostyle may be used for attachment to surfaces and may also cause the tissue damage seen in trichomoniasis infections.While *T. vaginalis* does not have a cyst form, organisms can survive for up to 24 hours in urine, semen, or even water samples.



Prepared by Dr. S. Ramalakshmi, Asst Prof, Dept of Microbiology, KAHE, CBE

Protein function- *T. vaginalis* lacks mitochondria and therefore necessary enzymes and cytochromes to conduct oxidative phosphorylation. *T. vaginalis* obtains nutrients by transport through the cell membrane and by phagocytosis. The organism is able to maintain energy requirements by the use of a small amount of enzymes to provide energy via glycolysis of glucose to glycerol andsuccinate in the cytoplasm, followed by further conversion of pyruvate and malate to hydrogen and acetate in an organelle called the hydrogenosome.
Virulence factors- One of the hallmark features of *Trichomonas vaginalis* is the adherence factors that allow cervicovaginal epithelium colonization in women. The adherence that this organism illustrates is specific to vaginal epithelial cells (VECs) being pH, time and temperature dependent. A variety of virulence factors mediate this process some of which are the microtubules, microfilaments, adhesins (4), and cysteine proteinases. The adhesins are four trichomonad enzymes called AP65, AP51, AP33, and AP23 that mediate the interaction of the parasite to the receptor molecules on VECs. Cysteine proteinases may be another virulence factor because not only do these 30 kDa proteins bind to host cell surfaces but also may degrade extracellular matrix proteins like hemoglobin, fibronectin or collagen IV.
Mechanism of infection- *Trichomonas vaginalis*, a parasitic protozoan, is the etiologic agent of trichomoniasis, and is a sexually transmitted infection. More than 160 million people worldwide are annually infected by this protozoan.
Symptoms- Pap smear, showing infestation by*Trichomonas vaginalis*. Papanicolaou stain, 400x Trichomoniasis, a sexually transmitted infection of the urogenital tract, is a common cause of vaginitis in women, while men with this infection can display symptoms ofurethritis. 'Frothy', greenish vaginal discharge with a 'musty' malodorous smell is characteristic.
Signs- Only 2% of women with the infection will have a "strawberry" cervix (*colpitis macularis*, an erythematous cervix with pinpoint areas of exudation) or vagina on examination. This is due to capillary dilation as a result of the inflammatory response.
Complications-Some of the complications of *T. vaginalis* in women include: preterm delivery, low birth weight, and increased mortality as well as predisposing to HIV infection, AIDS, and cervical cancer. *T. vaginalis* has also been reported in the urinary tract,fallopian tubes, and pelvis and can cause pneumonia, bronchitis, and oral lesions. Condoms are effective at reducing, but not wholly preventing, transmission.
T. vaginalis infection in males has been found to cause asymptomatic urethritis and prostatitis. It has been proposed that it may increase the risk of prostate cancer; however, evidence is insufficient to support this association as of 2014.
Diagnosis- Classically, with a cervical smear, infected women have a transparent "halo" around their superficial cell nucleus. It is unreliably detected by studying a genital discharge or with a cervical smear because of their low sensitivity. *T. vaginalis* was traditionally diagnosed via a wet mount, in which "corkscrew" motility was observed. Currently, the most common method of diagnosis is via overnight culture, with a sensitivity range of 75–95%. The presence of*T. vaginalis* can also be diagnosed by PCR, using primers specific for GENBANK/L23861.
Treatment- Infection is treated and cured with metronidazole or tinidazole.

Virus classification

Virus classification is the process of naming viruses and placing them into a taxonomic system. Similar to the classification systems used for cellular organisms, virus classification is the subject of ongoing debate and proposals. This is mainly due to the pseudo-living nature of viruses, which is to say they are non-living

particles with some chemical characteristics similar to those of life. As such, they do not fit neatly into the established biological classification system in place for cellular organisms.

Viruses are mainly classified by phenotypic characteristics, such as morphology, nucleic acid type, mode of replication, host organisms, and the type of disease they cause. Currently, two main schemes are used for the classification of viruses: the International Committee on Taxonomy of Viruses (ICTV) system and Baltimore classification system, which places viruses into one of seven groups. Accompanying this broad method of classification are specific naming conventions and further classification guidelines set out by the ICTV.

Virus species definition Species form the basis for any biological classification system. The ICTV had adopted the principle that a virus species is a polythetic class of viruses that constitutes a replicating lineage and occupies a particular ecological niche. In July 2013, the ICTV definition of species changed to state: "A species is a monophyletic group of viruses whose properties can be distinguished from those of other species by multiple criteria.

ICTV classification

The International Committee on Taxonomy of Viruses began to devise and implement rules for the naming and classification of viruses early in the 1970s, an effort that continues to the present. The ICTV is the only body charged by the International Union of Microbiological Societies with the task of developing, refining, and maintaining a universal virus taxonomy. The system shares many features with the classification system of cellular organisms, such as taxon structure. However, this system of nomenclature differs from other taxonomic codes on several points. A minor point is that names of orders and families are italicized, unlike in the International Code of Nomenclature for algae, fungi, and plants and International Code of Zoological Nomenclature. Viral classification starts at the level of order and continues as follows, with the taxon suffixes given in italics:

Order (-*virales*)

Family (-*viridae*)

Subfamily (-*virinae*)

Genus (-*virus*)

Species Species names generally take the form of *[Disease] virus*.

The establishment of an order is based on the inference that the virus families it contains have most likely evolved from a common ancestor. The majority of virus families remain unplaced. As of 2012, seven orders, 96 families, 22 subfamilies, 420 genera, and 2,618 species of viruses have been defined by the ICTV. The orders are the *Caudovirales, Herpesvirales, Ligamenvirales, Mononegavirales, Nidovirales, Picornavirales,* and *Tymovirales*. These orders span viruses with varying host ranges. The *Ligamenvirales*, infecting archaea, are the most recent addition to the classification system.

Prepared by Dr. S. Ramalakshmi, Asst Prof, Dept of Microbiology, KAHE, CBE

Structure-based virus classification

It has been suggested that similarity in virion assembly and structure observed for certain viral groups infecting hosts from different domains of life (e.g., bacterial tectiviruses and eukaryotic adenoviruses or prokaryotic Caudovirales and eukaryotic herpesviruses) reflects an evolutionary relationship between these viruses. Therefore, structural relationship between viruses has been suggested to be used as a basis for defining higher-level taxa - structure-based viral lineages - that could complement the existing ICTV classification scheme.

Baltimore classification

The Baltimore Classification of viruses is based on the method of viral mRNA synthesis. Baltimore classification (first defined in 1971) is a classification system that places viruses into one of seven groups depending on a combination of their nucleic acid(DNA or RNA), strandedness (single-stranded or double-stranded), Sense, and method of replication. Named after David Baltimore, a Nobel Prize-winning biologist, these groups are designated by Roman numerals. Other classifications are determined by the disease caused by the virus or its morphology, neither of which are satisfactory due to different viruses either causing the same disease or looking very similar. In addition, viral structures are often difficult to determine under the microscope. Classifying viruses according to their genome means that those in a given category will all behave in a similar fashion, offering some indication of how to proceed with further research. Viruses can be placed in one of the seven following groups:

I: **dsDNA viruses** (e.g. Adenoviruses, Herpesviruses, Poxviruses)

II: **ssDNA viruses** (+ strand or "sense") DNA (e.g. Parvoviruses)

III: **dsRNA viruses** (e.g. Reoviruses)

IV: **(+)ssRNA viruses** (+ strand or sense) RNA (e.g. Picornaviruses, Togaviruses)

V: **(−)ssRNA viruses** (− strand or antisense) RNA (e.g. Orthomyxoviruses, Rhabdoviruses)

VI: **ssRNA-RT viruses** (+ strand or sense) RNA with DNA intermediate in life-cycle (e.g. Retroviruses)

VII: **dsDNA-RT viruses** (e.g. Hepadnaviruses)

DNA viruses

Virus family	Examples (common names)	Virion naked/enveloped	Capsid symmetry	Nucleic acid type	Group
1. Adenoviridae	Adenovirus, infectious canine hepatitis virus	Naked	Icosahedral	ds	I

2. Papovaviridae	Papillomavirus, polyomaviridae, simian vacuolating virus	Naked	Icosahedral	ds circular	I
3. Parvoviridae	Parvovirus B19, canine parvovirus	Naked	Icosahedral	ss	II
4. Herpesviridae	Herpes simplex virus, varicella-zoster virus, cytomegalovirus, Epstein–Barr virus	Enveloped	Icosahedral	ds	I
5. Poxviridae	Smallpox virus, cow pox virus, sheep pox virus, orf virus, monkey pox virus, vaccinia virus	Complex coats	Complex	ds	I
6.Hepadnaviridae	Hepatitis B virus	Enveloped	Icosahedral	circular, partially ds	VII
7. Anelloviridae	Torque teno virus	Naked	Icosahedral	ss circular	II

RNA viruses

Virus Family	Examples (common names)	Capsid naked/enveloped	Capsid Symmetry	Nucleic acid type	Group
1. Reoviridae	Reovirus, rotavirus	Naked	Icosahedral	ds	III
2. Picornaviridae	Enterovirus, rhinovirus, hepatovirus, cardiovirus, aphthovirus, poliovirus, parechovirus,erbovirus, kobuvirus, teschovirus, coxsackie	Naked	Icosahedral	ss	IV
3. Caliciviridae	Norwalk virus	Naked	Icosahedral	ss	IV
4. Togaviridae	Rubella virus, alphavirus	Enveloped	Icosahedral	ss	IV
5. Arenaviridae	Lymphocytic choriomeningitis virus	Enveloped	Complex	ss(-)	V
6. Flaviviridae	Dengue virus, hepatitis C virus, yellow fever virus	Enveloped	Icosahedral	ss	IV

7.Orthomyxoviridae	Influenzavirus A, influenzavirus B, influenzavirus C, isavirus, thogotovirus	Enveloped	Helical	ss(-)	V
8.Paramyxoviridae	Measles virus, mumps virus, respiratory syncytial virus, Rinderpest virus, canine distemper virus	Enveloped	Helical	ss(-)	V
9. Bunyaviridae	California encephalitis virus, hantavirus	Enveloped	Helical	ss(-)	V
10.Rhabdoviridae	Rabies virus	Enveloped	Helical	ss(-)	V
11. Filoviridae	Ebola virus, Marburg virus	Enveloped	Helical	ss(-)	V
12.Coronaviridae	Corona virus	Enveloped	Helical	ss	IV
13. Astroviridae	Astrovirus	Naked	Icosahedral	ss	IV
14. Bornaviridae	Borna disease virus	Enveloped	Helical	ss(-)	V
15. Arteriviridae	Arterivirus, equine arteritis virus	Enveloped	Icosahedral	ss	IV
16. Hepeviridae	Hepatitis E virus	Naked	Icosahedral	ss	IV

Reverse transcribing viruses

Group VI: viruses possess single-stranded RNA viruses that replicate through a DNA intermediate. The retroviruses are included in this group, of which HIVis a member.

Group VII: viruses possess double-stranded DNA genomes and replicate using reverse transcriptase. The hepatitis B virus can be found in this group.

KARPAGAM ACADEMY OF HIGHER EDUCATION
DEPARTMENT OF MICROBIOLOGY
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY (17MBU101)

UNIT V Q	Opt A	Opt B	Opt C	Opt D	Answer
Viruses re	bacteria	plants	animals	living cells	living cells
Which of	No growtl	Not sensit	No energ	Insensitive to interferon	Insensitive to interf
Main caus	Fox virus	Mumps vi	Measles v	None of these	None of these
HIV is be	Retro Viri	Rhabdo V	Toga Viri	Paramyxo Viridae	Retro Viridae
Special fe	Reverse t	RNA direc	Both a &	Boils	Both a & b
Viruses ca	Lab media	Broth	Living cel	None of these	Living cells
Virus is a	obligate i	clinical	host	medical	obligate intracellula
RNA virus	Capsid	Nucleus	Cytoplasn	Envelope	Cytoplasm
The viral	genome a	capsid an	envelope	capsomere and genome	genome and capsid
Plasmodiu	quartan fe	tertian ma	oval tertia	malignant tertian malaria	tertian malaria
The term	Goldfuss	Losch	leeuwenh	Schavdin	Goldfuss
Cell mem	cellwall	plasma m	vacuole	plasmalemma	plasmalemma
Microscop	blood	fresh vagi	csf	urine	fresh vaginal discha
Who gave	Lable	Losch	Schavdin	Louis	Schavdin
Total anti	4	2	3	5	3
The nucle	envelope	covering	membron	capsid	envelope
Which of	Hepatitis	Hepatitis	Varicella-	Herpes simplex virus type 2	Varicella-Zoster viru
The tail of	10	1000	100	10000	100
___ phage	Temperat	Lysogenic	Tryptic	Virulent	Virulent
Plasmodiu	quartan fe	tertian ma	oval tertia	malignant tertian malaria	malignant tertian m
Giardia h	20S	30S	50S	70S	70S
Plasmodiu	quartan fe	tertian ma	oval tertia	malignant tertian malaria	oval tertian malaria
A tempor	Flagellum	Pseudopo	Pili	Cilia	Pseudopodium
The virus	Bacterial	Bacterial	Bacteriop	Various	Bacteriophages
The size c	0.02–0.2 ì	0.5–10 ìm	0.015–0.2	0.1–100 ìm	0.015–0.2 ìm
Virion me	Infectious	Non-infec	Incomple	Defective virus particles	Infectious virus part
Trichomo	sarcodina	flagellata	sporozoa	acompixa	flagellata
Assembly	Nucleus	Cytoplasn	Capsid	Envelope	Nucleus
Plasmodiu	quartan fe	tertian ma	oval tertia	malignant tertian malaria	quartan fever
Which is	Macconke	Philips m	Simple m	Differential media	Philips medium
Identify tl	*Entamoeb*	*Entamoeb*	*Entamoeb*	*Entamoeba nana*	*Entamoeba gingivali*
Envelope	Lysogeny	Lysis	Budding	Endocytosis	Budding
Naked vir	Cell Lysis	Budding	Endocyto	Phaging	Cell Lysis
Picorna V	DNA	RNA	Obligate	Plant	RNA
Polioviru	Rhinoviru	Aphthovii	Cardiovir	Enteroviruses	Enteroviruses
In phage l	Lytic	Symbiosis	Lysogeny	Temperate	Lytic
___ phage	Neuramir	Polymera	Muramid	cellulose	Muramidase
Entamoeb	sarcodina	flagellata	sporozoa	acompixa	sarcodina
The time	*Eclipse pe*	*Window p*	*Dormant*	*Latent period*	*Latent period*
Protozoa	pasteur	robert ho	fritch	leeuwenhoek	leeuwenhoek

In protoz	pedicle	pentent	pellicle	persistent		pellicle
Trichomo	protozoa	animalia	fungi	plantae		protozoa
The bacte	*Lysogen*	*Colin*	*Plasmin*	*Dolphin*		*Lysogen*
The small	Parvo viru	Rhabdo vi	Pox virus	varicella virus		Rhabdo virus
Plasmodiu	sarcodina	flagellata	sporozoa	acompixa		sporozoa
Shape of l	Brick shaj	Bullet sha	Helical sh	Tadpole shape		Tadpole shape
In ____ ph	Temperat	Lysogenic	Cryptic	Virulent		Temperate
The integ	Coliphage	Prophage	Lytic phaş	Prephage		Prophage
Giardia in	Fat	Carbohyd	Protein	amino acid		Fat
Viral genc	Prophage	Tempera	Bacteriop	Metaphage		Prophage
The Larg	Parvo viru	Pox virus	Rhabdo v	None of these		Pox virus
Trichomo	kinetopla	rhizopod	sarcodina	sporozoa		kinetoplasta
The extra	Capsid	Nucleocaş	Virion	None of these		Virion

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[17MBU101]

KARPAGAM ACADEMY OF HIGHER EDUCATION

KARPAGAM UNIVERSITY

(Established Under Section 3 of UGC Act, 1956)

Eachanari Post, Coimbatore, Tamil Nadu, India – 641 021

B. Sc., DEGREE FIRST INTERNAL EXAMINATION AUGUST 2017

Microbiology

INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

TIME: 2 Hours **Max Marks: 50 Marks**

Date:

PART –A **20 x 1= 20 marks**

1. Father of microbiology is

A. Louis Pasteur B. Lister C. Leeuwenhock D. Robert Koch

2. The antiseptic method was first demonstrated by

A. Lwanowski B. Joseph Lister C. Edward Jenner D. Beijerinck

3. Small pox vaccine was first discovered by

A. Robert Koch B. Louis Pasteur C. Joseph Lister D. Edward Jenner

4. Phagocytic phenomenon was discovered by

A. Louis Pasteur B. Alexander Fleming C. Elie Metchnikoff D. Lister

5. The main feature of prokaryotic organism is

A. Absence of locomotion B. Absence of nuclear envelope

C. Absence of nuclear material D. Absence of protein synthesis

6. During conjunction the genetic material will be transferred through

A. Cell wall B. Medium C. Pili D. Capsule

7. *E.coli* was first isolated by

A. Louis Pasteur B. Lister C. Escherich D. SHIGA

8. *Mycobacterium tuberculosis* was first discovered by

A. Robert Koch B. Edward Jenner C. Louis Pasteur D. Escherich

9. Father of Medical Microbiology is

A. Robert Koch B. Edward Jenner C. Louis Pasteur D. Alexander Fleming

10. Term vaccine was coined by

A. Robert Koch B. Louis Pasteur C. Needham D. Edward Jenner

11. Who defined numerical taxonomy

A. Carl Linnaeus B. Sneath & Sokal C. Robert Koch D. Louis Pasteur

12. Five Kingdom concept was devised by_____

A. Carl Linnaeus B. Carl woose C. Whittaker D. Charles

13. The manual for classifying bacteria was first published in the year

A. 1920 B. 1923 C. 1940 D. 1929

14. The very first comprehensive system of bacterial classification was proposed by

A. Pasteur B. Buchanan C. Haeckel D. Koch

15. The manual for classifying bacteria was first published by

A. Carl Linnaeus B. David Friefelder C. David Bergey D. Benjamin

16. Carl woese described

A. three domain concept B. no domain concept

C. single domain concept D. multiple domain concept

17. Nomenclature stands for _____

A. Naming B. Dividing C. Segregation D. Allocation

18. On five kingdom classification, the organisms are based on

A. Pigmentation B. Environment C. Nutrient Type D. Temperature

19. Diatoms, brownalgae, cryptomonads & oomycetes are placed in _____ kingdom

A. Protista B. Fungi C. Monera D. Chromista

20. Example for morphological features

A. Cell shape B. Cytoplasm C. Mitochondria D. Ribosomes

PART B (3 x 2 = 6 Marks)

21. What is vaccine? Tell about types of vaccines?

22. What is phagocytosis?

23. What is phenetic method of classification?

PART C (3 x 8 = 24 MARKS)

24. Explain Whittaker five kingdom classification OR

Explain Carl Woese three kingdom classification

25. Write about the contributions of Robert Koch OR

Who disproved spontaneous generation? Explain with diagram.

26. Outline the golden age of microbiology.OR

Write about contributions of Louis Pasteur.

KARPAGAM ACADEMY OF HIGHER EDUCATION

(Under Section 3 of UGC Act 1956)

COIMBATORE-641 021

B. Sc DEGREEEXAMINATION, 2016

INTERNAL TEST-I

MICROBIOLOGY

INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

PART-A

1. C). Leeuwenhoek
2. B). Joseph Lister
3. D). Edward Jenner
4. C). Elie Metchnikoff
5. B). Absence of nuclear envelope
6. C). Pili
7. C). Esherich
8. A). Robert Koch
9. A). Robert Koch
10. B). Louis Pasteur
11. A). Carl Linnaeus
12. C). Whittaker
13. B). 1923
14. C). Hackel
15. C). David Bergey
16. A). Three domain concept
17. A). Naming
18. C). Nutrient Type
19. D). Chromista
20. A). Cell shape

PART-B

21.Vaccines-Vacca:cow-active acquired immunity-prepared from pathogens-types-live and attenuated

22. Phagocytosis- process- engulfing pathogens- immunity- macrophages

23. Phenetic method- based on phenotype- morphology- analogously similar are grouped

PART-C

24. a). Five Kingdom Classifications:

Five kingdom classifications- Whittaker- 1969- classified- based on nutrition, cell wall integrity, complexity of cells, Unicellular or Multicellular- Kingdom-Monera, Protista, Fungi, Plantae, Animalia. **Kingdom Monera**: Prokaryotes-Peptidoglycan cell wall- Binary fission- Energy source-organic chemicals, inorganic chemicals, or photosynthesis-Bacteria-Archaea-living in extreme environments-unusual metabolism-No peptidoglycan cell wall-Examples halophiles, thermophiles, acidophiles

Kingdom Protista: Primarily unicellular organism- eukaryotes-complex mode of reproduction- cell wall carbohydrates, lipids-autotrophic-algae-photosynthesis-heterotrophic-Protozoa-pathogenic-Example: *Chalymdomonas.* **Kingdom Fungi:** Unicellular yeasts-eukaryotes-saprophytic- cell wall chitin-Multicellular molds- Mushroom-Hyphae-dead and decaying matter-non photosynthetic-*Pencillium.*

Kingdom Plantae: Eukaryotes- Multicellular-cell wall cellulose, pectin, lignin-very rigid-Autotrophic-Photosynthesis-starch as storage material-Green plants and trees-Needs Nitrogen-some are carnivorous-*Nepenthes.* **Kingdom Animalia:** Eukaryote-Multicellular- no cell wall- phospholipid- plasma membrane-

heterotrophic and holozoic mode of nutrition-Sponges, worms, insects, chordates.

24. b). Three domain concept:

Three domain concept: Carl Woese-1990-Eubacteria, Archaea, Eukarya-based on cell type, nutrition, cell wall, Membrane lipids, complexity of cells. Identified-16s rRNA analysis- **Domain Eubacteria/Bacteria:** Prokaryotes-Peptidoglycan cell wall- rarely have organelles- often motile using flagella or cilia-can be found in any environment-can be found in many different shapes and structures- shows various forms of nutrition-no nuclear membrane- have plasmids-beneficial-some are harmful-70s Ribosome-Example *E.coli*

Domain Archae: Prokaryotes-Living in extreme environments-unusual metabolism-No peptidoglycan cell wall-Examples halophiles, thermophiles, acidophiles-special features for the survival in extreme environments-Methanogens-obtain energy using CO_2 to oxidise H_2 producing Methane-lives in swamps-Halophiles-lives in saline environment-*Halococcus*-Thermophiles-lives in hot environment-Acidophiles/Alkaliphiles-thrive in Acidic/Basic respectively.

Domain Eukarya: Eukaryotes-some are photosynthetic-autotrophs-algae and plants-some are heterotrophic-animals, humans-some are saprophytic-fungi- cell wall may be present-made up of carbohydrates-cellulose, pectin, lignin-plasma membrane-phospholipids-well defined nucleus and cell organelles-unicellular and multicellular organisms –reproduction by sexual

methods and some asexual methods also found-80s Ribosome-Example: Amoeba

Comparisons among the three domains

CHARACTERISTICS	DOMAIN		
	Bacteria	**Archaea**	**Eukarya**
Nuclear envelope	Absent	Absent	Present
Membrane-enclosed organelles	Absent	Absent	Present
Peptidoglycan in cell wall	Present	Absent	Absent
Reproduction	Asexual	Asexual	Sexual/Asexual
Introns (noncoding parts of genes)	Rare	Present in some genes	Present
Response to the antibiotics streptomycin and chloramphenicol	Growth inhibited	Growth not inhibited	Growth not inhibited
Histones associated with DNA	Absent	Present	Present
Circular chromosome	Present	Present	Absent
Ability to grow at temperatures >1000C	No	Some Species	No

25. a). Contributions of Robert Koch:

ROBERT KOCH (1843-1912)- German country Doctor -Professor of hygiene and Director of institute of infective diseases at Berlin. He perfected many bacteriological techniques -"Father of Practical Bacteriology". He discovered rod shaped organisms in the blood of animals, that died of anthrax- in pure culture on a depression slide by inoculation of infected blood into the aqueous humour of a bullock's eye- multiplication of bacteria and spore formation- spores into mice and reproduced the disease- He passed anthrax bacilli-from one mouse to another through twenty generations, and found that they bred true. He worked out its life-history.

He introduced staining techniques. He prepared dried bacterial films (Smears)-on glass slides -stained with aniline dyes for producing a better contrast under microscope. He discovered tubercle bacillus (*Mycobacterium tuberculosis*) .He discovered *Vibrio cholera*- causative

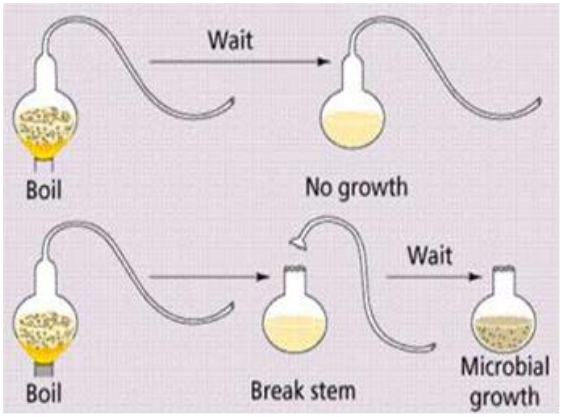
agent of cholera disease. He developed pure culture techniques -solid media- agar-agar -dried sea weeds (*Gelidium Sp*.).
He discovered "Old Tuberculin"- when tubercle bacilli or its protein extract was injected into a Guinea-pig already infected with the bacillus, an exaggerated reaction took place and the reaction remain localized.
KOCH'S POSTULATES :Koch -causative role between a particular microorganism and a particular disease. They are popularly known as Koch's postulates (Henle-Koch's Posulates). They are :1. A specific organism should be found constantly in association with the disease.2. The organism should be isolated and grown in a pure culture in the laboratory.
3. The pure culture when inoculated into a healthy susceptible animal should produce symptoms/
lesions of the same disease.
4. From the inoculated animal, the microorganism should be isolated in pure culture.
5. An additional criterion introduced is that specific anitbodies to the causative organism should
be demonstrable in patient's serum.

Contributions of Robert Koch (1870's)-"one disease-one organism" pure culture technique-agar (red algae Gelidium/Gracilaria, w. Pacific Ocean); petri dish/agar plate -Koch's postulates-Discovered causative agents of anthrax -1876(Bacillus anthracis), tuberculosis-1882 (Mycobacterium tuberculosis), conjunctivitis-1883, cholera-1884 (Vibrio cholera)-In 1905, he won the nobel prize in physiology/medicine.

25. b). Spontaneous generation:

Until the mid-1880s- many people believed in spontaneous generation-the idea that living organisms could arise from nonliving matter. It was disproved-Louis Pastuer- Swann necked experiment. Louis Pastuer- Professor of Chemistry at the University of Lille, France. -"Father of Microbiology", He proved the theory of "Biogenesis". He - microorganisms are in the air everywhere -offered proof of biogenesis - in 1861. To allow air to enter the flasks and at the same time prevent air-borne bacteria from gaining entry- Pasteur bent the necks of his flasks after he added broth- boiled the broth, killing any microorganisms that were present.

If the theory of biogenesis was valid there should be no growth in the sterilized broth. As a matter of fact, some of the original flasks are still on display at the Pasteur Institute today. Pasteur's discoveries led to the development of aseptic techniques used in laboratory and medical procedures to prevent contamination by microorganisms that are in the air.



26. a).Golden age of Microbiology:

1665-Hooke-First observation of cells
1673-A.V.Leewenhoek-First observation of live organisms-Animalcules
1735-linnaeus-Nomenclature for organism
1835-Bassi-Silkworm fungus
1840-Semmelewis-childbirth fever

1853-Debary-Fungal Plant disease

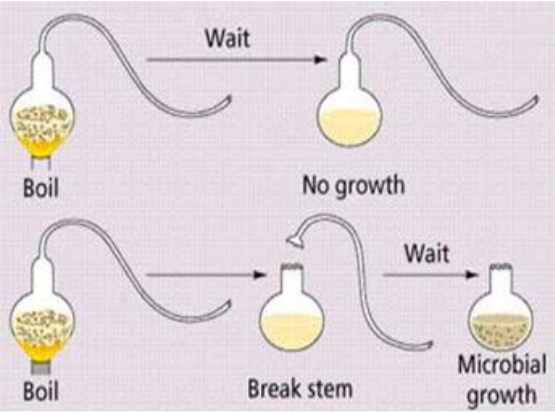
1857-Pasteur-Fermentation
1861-Pasteur-Disproved spontaneous generation
1864-Pasteur-Pasteurization
1867-Lister-Aseptic surgery
1876-Koch-Germ theory of disease
1879-Neisser-*Neisseria gonorrhea*
1881-Koch-Pure culture
Finley-Yellow fever
1882-Koch-*Mycobacterium tuberculosis*
Hess-Agar media
1883-Koch-*Vibrio cholera*
Metchnikoff-Phagocytosis
Hans Christian Gram-Gram's Staining
Escherich-*Escherichia coli*
1887-Petri-Petri dish
1889-Kitasto-*Clostridium tetani*
1890-Von behring-Diptheriaantitoxin
Ehrlich-Theory of Immunity
1892-Winogradsky-Sulfur cycle
1898-Shiga-*Shigella dysenteriae*
1908-Ehrlich-Syphilis
1910-Chagas-*Trypanosoma cruzi*
1911-Rous-Tumor causing virus

1928-Flemming, Chain, Florey-Pencillin
Griffith-Transformation in bacteria
1934-Lancefield-Strptococcal antigens
1935-Stanley, Northrup, Sumner-Crystallized virus

1941-Beadle and Tatum-Relationship between genes and enzymes
1944-Avery, MacLeod, McCarty-Genetic material is DNA
1946-Leaderberg and Tatum-Bacterial Conjugation
1953-Watson and Crick-DNA structure
1957-Jacob and Monad-Protein synthesis
1964-Epstein, Achong, Barr-Epstein Barr Virus
1973-Berg, Boyer, Cohen-Genetic Engineering
1975-Dulbecco, Temin, Baltimore-Reverse Transcriptase
1983-McClintock-Transposons
1997-Pruisner-Prions

26. b). Contributions of Louis Pasteur:

Louis Pasteur-Professor of Chemistry at the University of Lille, France- "Father of Microbiology"-proved the theory of "Biogenesis" disproved Abiogenesis- experimentally by using swan-necked flasks. He - microorganisms are in the air everywhere and offered proof of biogenesis -in 1861. To allow air to enter the flasks and at the same time prevent air-borne bacteria from gaining entry, Pasteur bent the necks of his flasks after he added broth- boiled the broth, killing any microorganisms that were present. If the theory of biogenesis was valid there should be no growth in the sterilized broth- Pasteur's discoveries - aseptic techniques - to prevent contamination by microorganisms.



Pasteur- souring of wine and beer - alcohol spoilage is due to the growth of undesirable organisms- produce alcohol by a chemical process called “Fermentation”. He - wine did not spoil- if it is heated to 50-60°C - Pasteurization- dairy units, to kill pathogenic microorganisms in milk.

Pasteur - “attenuation” - “chicken cholera” in fowls. He -cultures - stored in the laboratory - kill the animals as fresh cultures did. This attenuation is now used in protective vaccination against diseases. Pasteur - anthrax disease in cattle and sheep is caused by a bacterium-anthrax organisms in sterile yeast water- cultures can produce disease when inoculated in to healthy animals- developed a live attenuated anthrax vaccine- 40-42°C. Pasteur -vaccine against rabies (Hydrophobia)- which made a greatest impact in medicine.

At those time-many scientists- air converted the sugars in beverages into alcohols.Pasteur - Those microbes called yeasts - sugars to alcohols in the absence of air - fermentation-In the presence of air- bacteria - alcohol - into vinegar (acetic acid)-Pasteurization - reduce spoilage and kill potentially harmful bacteria in milk , alcoholic drinks.
Contributions of Louis Pasteur-spontaneous generation (swan-neck flasks) 1859-distribution of microbes in air-fermentation-pasteurization-vaccines (chicken cholera/rabies-laid foundation for germ theory of disease.

Reg. No._____

[17MBU101]

KARPAGAM ACADEMY OF HIGHER EDUCATION

KARPAGAM UNIVERSITY

(Established Under Section 3 of UGC Act, 1956)

Eachanari Post, Coimbatore, Tamil Nadu, India – 641 021

B. Sc., DEGREE SECOND INTERNAL EXAMINATION AUGUST 2017

Microbiology

INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

TIME: 2 Hours **Max Marks: 50 Marks**

Date:

PART –A **20 x 1= 20 marks**

1. Algology means.
   a. Study of algae b. Study of fungi
   c. Study of bacteria d. Study of virus
2. All algae are _____.
   a. Chlorophyllous halophy b. Chlorophyllous thallophyte
   c. Chlorophyllous thermophyte d. Chlorophyllous homophyte
3. The eukaryotic algal cell is surrounded by rigid structure is called as _____
   a. Nucleus b. Mitochondria
   c. Cellwall d. Tissue
4. Algae associate with fungi is called _____
   a. Benthic b. Lotenic
   c. Neustonic d. Lichens
5. When the first edition of Bergey's manual was updated?
   a. 1923 b. 1952
   c. 1974 d. 1929
6. Protists are _____.
   a. Prokaryotes with unicellular b. Eukaryotes with multicellular
   c. Prokaryotes with multicellular d. Eukaryotes with unicellular
7. The word algae was originally used to define _____
   a. Green plants b. Aquatic plants
   c. Fungi d. Bacteria
8. Algae is a
   a. Prokaryotes b. Lower plants
   c. Eukaryotes d. Plantae
9. Zooplankton is made up of _____.
   a. Animals & nonphotosynthetic protists b. Algae & small plants
   c. Plant & animal d. Water & soil
10. Chlorophyta is also called as _____
    a. Red algae b. Brown algae
    c. Blue green algae d. Green algae
11. Flagellated motile spores are called _____
    a. Aplanospore b. Oogonia
    c. Arthrospore d. Zoospore
12. The vegetative body of algae is called _____

a. Nucleus b. Thallus
c. Mitochondria d. Vacuole

13. Red Algae contain _____
a. Phycoerythrin b. Elythesin
c. Elythrocytin d. Cynin

14. Starch is an energy storage material characteristic of
a. Chlorophyta b. Chrysophyta
c. Phaeophyta d. Rhodophyta

15. Chloroplast contain _____
a. Chlorophylls a &, b b. Chlorophyll a
c. Chlorophyll b d. chorophyll z

16. Chlamydomonas is_____
a. Red algae b. Blue algae
c. blue green algae d. Brown algae

17. Algae reproduce asexually by producing_____
a. Zoospores b. Ascospores
c. Basidiospores d. Myxospores

18. The chloroplast have membrane bound sac called _____ that carryout the light reaction of photosynthesis
a. Thylakoids b. Cell wall
c. Pyrenoids d. Flagella

19. Agar, which is the solidifying agent in many bacterial culture media, is part of the cell wall of
a. Chlorophyta b. Chrysophyta
c. Pyrrophyta d. Rhodophyta

20. Bergey's manual has been updated in the year 1984 and it was renamed as_____
a. Bergey's manual of systemic bacteriology
b. Bergey's manual of classifiying bacteriology
c. Bergey's manual of pigmented bacteriology
d. Bergey's manual of genomic bacteriology

PART –B **3 x 2= 6 marks**

21. What is caraggeenen, alginate and agar?
22. Name the pigments present in red algae, brown algae and green algae?
23. Give the examples for archae bacteria with its types?

PART –C **3 x 8= 24 marks**

24. a. Discuss the characteristic differences between Prokaryotes and eukaryotes.

(Or)

b. Give the outline of Bergey’s manual of systemic bacteriology.

25. a. With a neat sketch explain the algal Ultrastructure.

(Or)

b. Give the general characteristics of algae in detail.

26. a. Comment on application of algae in agriculture.

(Or)

b. Describe the characteristics and life cycle of *Chlamydomonas reinharteii*?

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COIMBATORE-641 021
B. Sc DEGREE EXAMINATION, 2016
INTERNAL TEST-II
MICROBIOLOGY
INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

PART-A

1. A). Study of Algae
2. B). Cholorophyllousthallophyte
3. C). Cell wall
4. D). Lichens
5. C). 1974
6. D). Eukaryotes with unicellular
7. B). Aquatic Plants
8. C). Eukayote
9. A). Animals &nonphotosyntheticprotsits
10. D). Green algae
11. D). Zoospore
12. B). Thallus
13. A). Phycoerythrin
14. A). Chlorophyta
15. A). Chloroplast a & b
16. B). Blue algae
17. A). Zoospores
18. A). Thylakoids
19. D). Rhodophyta
20. A). Bergey's manual of systemic bacteriology

PART-B

21. Carrageenan-stabilizer, emulsifier-extracted from walls of red algae-Example:*Chondrus, Gigartina*.Alginic acid-salts obtained from brown algae-Example: *Macrocystis, Agarum, and Laminaria.* Agar-solidifing agent-obtained from red algae-Example: *Gelidium and Gracilaria.*

22. Pigments-red algae-Phycoerythrin-brown algae-Fucoxanthin-Green algae-Chrolophyll.

23. Archae-Methanogens-obtain energy using CO2 to oxidise H2 producing Methane-lives in swamps-Example*Methanococcus*-Halophiles-lives in saline environment-*Halococcus*-Thermophiles-lives in hot environment-Acidophiles/Alkaliphiles-thrive in Acidic/Basic respectively-*Sulfolobus*

PART-C

24. a). Difference between Prokaryotes and Eukaryotes:

PROKARYOTES	EUKARYOTES
ORGANISMAL GROUPS Archaeobacteria, Eubacteria	Protists (protozoa & algae), Fungi, Plants, Animals
CELL ORGANIZATION Simple, all cell functions take place within a single intracellular space bounded by a unit membrane. Cells (0.2-)0.5-2(-80) µm wide.	Intracellular space is compartmentalized into membrane-bounded organelles performing specialized functions. Cells (0.5-)10-50(-200,000) µm wide.
DEVELOPMENT Mostly unicellular and microscopic forms. Differentiation limited.	Uni- and multicellular, micro- and macroscopic forms. Differentiation can be extensive.
CELL WALL Contains peptidoglycan only in Eubacteria. Glycoproteins only in Archaeobacteria. Cell wall absent in mycoplasmas.	Contains chitin or cellulose. Glycoproteins common. Cell wall absent in protozoa and animals.
DNA A single molecule of DNA is in a closed-loop chromosome (nucleoid), attached to plasma membrane. Additional DNA in circular plasmids.	DNA distributed in several linear chromosomes, complexed with proteins (histones), within a membrane-bounded nucleus which also contains RNA.
SEXUAL SYSTEMS Absent or unidirectional (from donor to recipient). Genetic transfer and recombination by transformation, transduction, or conjugation	Regular, involving equal participation of both partners. Diploid and haploid forms alternate betweem fertilization and meiosis
RIBOSOMES All ribosomes with a sedimentation constant of 70S (Swedberg units, with subunits of 50S & 30S)	Ribosomes in cytoplasm with sedimentation constant of 80S (subunits 60S & 40S), those in mitochondria and plastids of 70S or variable
CELL DIVISION Cell division by fission, following DNA duplication and separation along plasma membrane.	Cell division by various forms of mitosis, involving microtubules and mitotic spindle in chromosome separation.
MOTILITY Simple, rotating bacterial flagella composed of flagellin protein. No cytoskeleton, intracellular motility or phagocytosis. Gliding motility common. Gas vesicles present in some forms.	Complex, flexing 9+2 flagella and cilia, composed of tubulin and other proteins. Cytoskeleton, amoeboid movement and phagocytosis based on actin-like proteins. Gliding motility common. Gas vesicles absent.
Endospores containing dipicolinic acid, heat-resistant. Actinospores, conidia, myxospores, akinetes.	Endospores absent. Various reproductive and resting spores following mitosis, meiosis, or fertilization (zygospores).
METABOLISM Extremely diverse. Obligately and facultatively anaerobic, microaerophilic, and aerobic forms.	Almost all are aerobic; exceptions are few and mostly secondary.
GLYCOLYSIS AND RESPIRATION Several glucose metabolism pathways. Respiration enzymes bound to plasma membrane or mesosomes. Not packaged separately.	Embden-Meyerhof glucose metabolism, followed by Krebs (CTA)-cycle, and cytochrom-based electron transport. Respiration enzymes packaged within mitochondria
PHOTOSYNTHESIS Anoxygenic and oxygenic photosyntheses, with one or two photosystems. Various electron donors including H_2O. Enzymes bound to plasma membrane, chromatophores, thylakoids or vesicles, not packaged separately.	Only oxygenic photosynthesis involving two photosystems. H_2O is used as electron donor. Enzymes for photosynthesis in thylakoids, packaged within membrane-bounded plastids.
LIPIDS AND SECONDARY PRODUCTS Vaccinic and oleic acids, and hopanes common. Archeobacterial lipids ether-linked. Steroids rare. Various antibiotics common.	Linoleic acid common, Steroids and alcaloids common.

24. b). Outline of Bergey's Manual:

Bergey's manual-David Bergey-compendium-standard and molecular information-available prokaryotes-based on Morphological features, Differential staining, Biochemical testing, Serology, DNA probes, PCR. First Edition-4 volumes-Gram positive bacteria, Gram negative bacteria, Bacteria with unusual properties, Filamentous bacteria-does not have phylogenetic information-Second edition -5 volumes-Archae,Cyanobacteria-Proteobacteria-Low G+C gram positives-High G+C gram postives-Planctomycetes, Spirochetes, Bacteriodes, Fusobacteria.

Vol 2. Proteobacteria

- This volume has gram negative bacteria. They were further divided into 5 subgroups as α, β, γ, δ and ε.
- They contain medically, industrially and agriculturally important bacteria.

S.No.	Important Bacteria	Characters	Example
α Proteobacteria			
1.	Purple bacteria	Anoxygenic Photosynthetic – sulphur bacteria	*Rhodospirillum, Rhodobacter,*

2.	Associative Nitrogen fixing bacteria	These bacteria present in the rhizosphere of graminaceous plants and symbiotically fix atmospheric nitrogen.	*Azospirillum*
3.	Symbiotic Nitrogen fixing bacteria	Form nodules in legume roots and fix atmospheric nitrogen.	*Rhizobium, Bradyrhizobium,*
		Some form galls in the roots	*Agrobacterium*
4.	Free living Nitrogen fixing bacteria	Present in the soil as heterotrophs – use verity of carbon sources in soil and fix atmospheric nitrogen	*Azotobacter, Beijerinkia*
5.	Pseudomonas group	Some are Plant Growth Promoting Rhizobacteria	*Pseudomonas*
		Some are pathogens	*Xanthomonas*
		Some produce alcohol	*Zymomonas*
6.	Rickettsia	Endoparasites	*Rickettsia*
7.	Sulphur oxidizing bacteria	Uses S as electron donor – Chemolithotrophs – Strict aerobes	*Thiobacillus*
8.	Acetic acid producing bacteria	Fermentative bacteria	*Acetobacter, Gluconobacter*
9.	Budding bacteria	Reproduction by budding like yeast	*Caulobacter*
10.	Hydrogen bacteria	Hydrogen producing bacteria	*Alkaligenes*
β Proteobacteria			
1.	Nitrifying bacteria	Chemolithotroph – strict aerobe – soil bacteria – important form N cycle	*Ammonia to nitrite – Nitrosomonas Nitrite to nitrate – Nitrobacter*
2.	Neisseria & relatives		Neisseria
3.	Spirillum	Aerobes & facultative aerobes	*Spirillum sp.*
4.	Sheathed bacteria		*Sphaerotilus*
γ Proteobacteria			
1.	Purple sulphur bacteria	Anoxygenic photosynthetic – sulphur bacteria	*Thiobacillus, Thiospirillum*
2.	Methylotrophs	Uses methane and methanol as carbon source	*Methylomonas, Methylobacter, methylococcus*
3.	Coliforms	Present in the intestinal track of mammals	*Escherichia, Salmonella*

δ Proteobacteria			
1.	Sulphur reducing bacteria	Anaerobes – use S as terminal electron acceptor	*Desulfovibrio, Desulfomonas*
2.	Glding bacteria	Gliding movement	*Myxobacteria*
3.	Vibrio group	Most are pathogenic	*Vibrio, Erwinia*

Vol 3. Low G+C gram positives

S.No	Group	Characters	Example
1.	Clostridia group	Strict anaerobes – mostly fermentative nutrition – few thermotolerant – endospore producers	*Clostridium, Thermoanaerobacteriu, Thermoanaerobium*
2.	Mycoplasma group	Absence of cell wall	*Mycoplasma, Mesoplasma, Spiroplasma*
3.	Bacilli and Lactobacilli group	Lactic acid producing bacteria – endospore producers – aerobes – aerotolerant – fermentative	*Leuconostoc, Lactococcus, Streptococcus*

2.	Neisseria & relatives		Neisseria
3.	Spirillum	Aerobes & facultative aerobes	*Spirillum sp.*
4.	Sheathed bacteria		*Sphaerotilus*
γ Proteobacteria			
1.	Purple sulphur bacteria	Anoxygenic photosynthetic – sulphur bacteria	*Thiobacillus, Thiospirillum*
2.	Methylotrophs	Uses methane and methanol as carbon source	*Methylomonas, Methylobacter, methylococcus*
3.	Coliforms	Present in the intestinal track of mammals	*Escherichia, Salmonella*
δ Proteobacteria			
1.	Sulphur reducing bacteria	Anaerobes – use S as terminal electron acceptor	*Desulfovibrio, Desulfomonas*
2.	Glding bacteria	Gliding movement	*Myxobacteria*
3.	Vibrio group	Most are pathogenic	*Vibrio, Erwinia*

Vol 4. High G+C gram positives

S.No	Group	Characters	Example
1.	Actinomycetes	Filamentous – sporangiospores – conidiospores – soil habitat – antibiotics producers	*Actinomyces, Nocardia, Sreptomyces*
		Symbiotic with *Casuarina* – form root nodules – N2 fixation	*Frankia*
2.	Mycobacterium	Presence of mycolic acid in the cell wall – acid fast staining – human pathogens	*Mycobacterium lepri*
3.	Corynebacterium	Human pathogens	*Corynebacterium diptheriaea*

Vol 5. Planomycetes, Spirochetes, Bacteroides and Fusobacteria

S. No	Group	Characters	Example
1.	Chlamydia group	Obligate parasites to man, animal and birds	*Chlamydia*
2.	Bacteroides	Obligate anaerobes	*Bacteroides*
3.	Spirochete	Gram negative – flexile – endoflagella presence	*Spirocheta, Leptospira*

25. a). Ultrastructure of Eukaryotic Algal Cell:

The cell is bounded by a thin, cellulose cell wall-Cellulose layer is finely striated with parallel cellulose fibrils- there is a pectose layer external to it which dissolves in water - mucilaginous pectin layer. According to Roberts et. al. (1972), Hills (1973) the cell wall in C. Reinhardt consists of seven layers.

Plasma Lemma of Eukaryotic Algal Cell- below the cell wall - two opaque layers which remain separated by less opaque zone

Protoplast of Eukaryotic Algal Cell- bounded by plasma lemma- differentiated -cytoplasm, nucleus, chloroplast with one or more pyrenoids, mitochondria, Golgi bodies, two contractile vacuoles, a red eye spot and two flagella.

Chloroplast of Eukaryotic Algal Cell- species of *Chlamydomonas*- cytoplasm contains of a single, massive cup shaped chloroplast - oral or pear shaped body of the cell-It bears number of photosynthetic lamellae (disc or thylakoids).

The lamellae -lipo-proteinaceous in nature - (stroma)-About 3-7 thylakoids bodies fuse to form grana like bodies. Matrix - ribosomes, plastoglobuli, microtubules and many crystals like bodies.

Flagella of Eukaryotic Algal Cell-The anterior part of thallus bears two flagella- whiplash or acronematic type, equal in size. Each flagellum - a basal granule or blepharoplast and comes out through a fine canal in cell wall- shows a typical 9+ 2 arrangement. Fibrils remain surrounded by a peripheral fibril. - 2 central ones are singlet fibrils and 9 peripheral ones are doublet fibrils .

Stigma or Eyespot of Eukaryotic Algal Cell-The anterior side of the chloroplast - tiny spot of orange or reddish colour-stigma or eyespot- is photoreceptive organ - direction of the movement of flagella-The eye spot is made of curved pigmented plate- 2-3 parallel rows of droplets or granules containing carotenoids - The other structures such as mitochondria, Golgi bodies, endoplasmic reticulum and nucleus are also bounded by double-layered unit membrane.

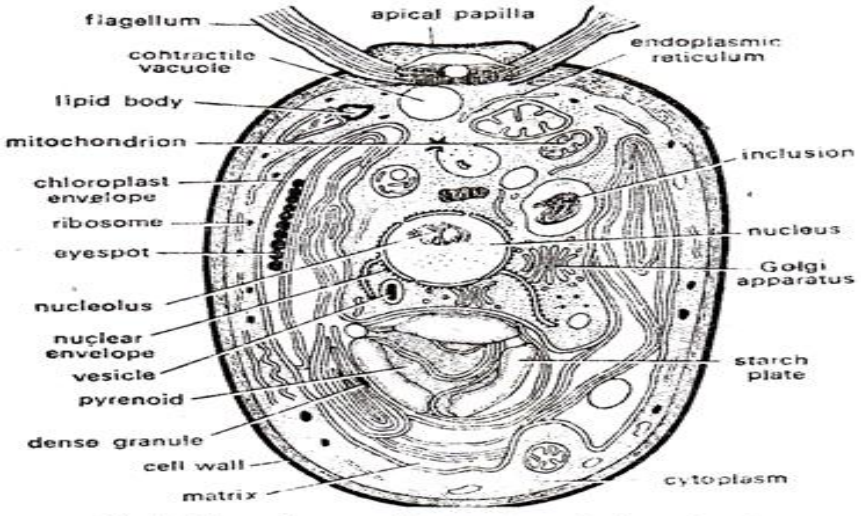


Fig. 1. *Chlamydomonas.* Ultrastructure of eukaryotic cell.

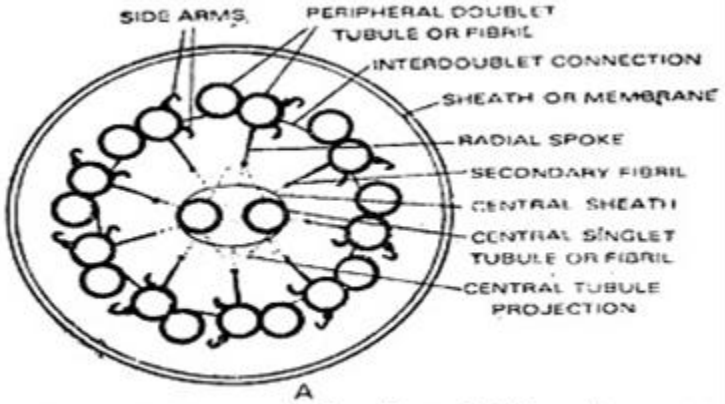


Fig. 2. Ultrastructure of flagellum of *Chlamydomonas.*

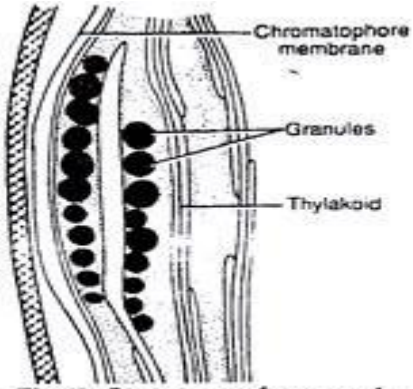


Fig. 3. Structure of eyespot.

25. b). General Characteristics of Algae:

Algae - of chlorophyll containing thalloid plants -unicellular or multicellular sex organs and the sex organs - An undifferentiated plant body is known as‘thallus’- there is no differentiation of plant body into true roots, stem and leaves.

Thalloid plant body-In Eichler’s system of classification- algae are placed in the Division Thallophyta along with Fungi and Lichens.Algae are autotrophs -Majority of algae - aquatic habitat (fresh water or marine)- some algae are terrestrial also-Algae are present in all parts of the world - Arctic and Antarctic regions (universal occurrence)-Sex organs are unicellular or multicellular- lack jacket cells around them (naked sex organs)-If jacket cells are present, they have different origin-Embryos is not formed after zygote formation-Show distinct alternation of generation- Cellular organization may be prokaryotic (blue green algae) or eukaryotic (all other algae)

Occurrence of algae- Found in a variety of habitats (Fresh water, marine, on rocks, with in plants or animals) Aquatic forms are most common On the basis of habitat, algae are classified into three groups- Aquatic forms- Terrestrial forms- Algae of unusual habitats- Aquatic algae- Two types- Fresh water and marine forms-Fresh water forms- Occurs in ponds, lakes, river etc. (*Spirogyra*)-Marine water forms- Occurs in saline condition -seas and oceans (Most of the Red and Brown algae such as *Polysiphonia* and *Sargassum*)- Terrestrial Algae- Found in/on soil, rocks, moist wall, tree trunks etc- Example: *Vaucheria and Fritschiella*-Algae of unusual habitat-Halophytic algae- algae present in highly saline water (Example: *Dunaliella*)-Epiphytic algae- algae grown on the surface of other plants/algae (Example *Oedogonium*)-Epizoic algae-

algae grown on animals such as snails and fishes (Example: *Cladophora* grows on the shells of snails)-Endozoic algae- algae growing inside the animals (Example: *Zoochlorella* grow inside Hydra)-Symbiotic algae- Symbiotic (mutual) association with fungi in lichen- in Bryophytes (*Anthoceros)*- in Pteridophytes (*Azolla*)- gymnosperms (corolloid roots of *Cycas)* and in angiosperms-Parasitic algae- grow as parasite on plants or animals (Example: *Cephaleuros*- parasitic green algae grow on the leaves of many plants causing red rust diseases)-Thermophytic algae- grow in hot springs. (Example: *Heterohormogonium*)-Fluviatile algae- algae found in rapidly running water such as water falls- (Example: *Ulothrix*- mountains water falls- Thallus diversity in algae- Wide range or thallus variation in algae Thallus - unicellular to multicellular and microscopic to macroscopic Plant -few micron to several meters- Example: *Chlamydomonas*- single celled algae - On the basis of thallus organization algae are following five types- Unicellular forms (Example:*Chlamydomonas, Chlorella*)- Colonial forms (*Volvox, Pandorina*)-Filamentous forms-Un-branched filamentous (*Spirogyra*, *Oedogonium*)- Branched filamentous (*Cladophora*, *Pithophora*)- Siphonaceous forms (*Vaucheria)*-Parenchymatous forms (*Sargassum, Laminaria*)

Pigmentation in algae- Algae also shows great diversity in pigmentation- Different groups of algae -different pigment composition- Distribution pattern of pigments -taxonomic significance in algae- The classification of algae by Fritsch - based of the pigmentation in algae- Pigments in algae belongs to three major categories-Chlorophylls- Carotenoids-Phycobilins. All major algal groups have at least one characteristic pigment-Cyanophyceae(blue green algae): Phycocyanin-Chlorophyceae (green algae): Chlorophyll b-Pheophyceae (brown algae): Fucoxanthin-Rhodophyceae (red algae): Phycoerythrin-Chlorophyll a is universally present in all algal grous

Plastids in algae- Except in Cyanophyceae (blue green algae, BGA) pigments in algae are found in membrane bound organelles called plastids- In BGA- plastids are absent-chromoplasm-Pyrenoids-are proteinacious bodies-chromatophores- Considered as the organelle of synthesis and storage of starch- In some Chlorophyceae-pyrenoidsare surrounded by starch grains-Pyrenoids arise de-novo or by the division of preexisting pyrenoids-absent in blue green algae-Reproduction in algaeAlgae reproduce by three methods- Vegetative reproduction- Asexual reproduction- Sexual reproduction.

26). A). Application of algae in agriculture:

Algae- complete protein with essential amino acids -that are involved in major metabolic processes - energy and enzyme production- high amounts of simple and complex carbohydrates -In particular, the sulfated complex carbohydrates - to enhance the immune system's regulatory response- extensive fatty acid profile- including Omega 3 and Omega 6-essential fatty acids also play a key role in the production of energy- of synergistic vitamins- minerals- trace elements in naturally-occurring design.

Many species-algae-red algae-used as food-*Porphyra*-Japan-nori-processed in dried sheets-washed in fresh water-remove debris-spreaded to frames-toasted over flame-sushi-Red algae-*Chondrus, Acanthopetlis, Nemalion*-eaten as vegetable-sweetened jellies-significant food in China-seaweed collection-mentioned since 600 B.C-Brown algae-*Laminaria japonica*-edible food-Asian and Polynesian people-Laver-Irish Moss-Dulse-British, Northern and Western countries.

Smaller forms of algae-*Chollerla*-food in humans and domestic animals-grown under suitable conditions-rich source of

protein-essential amino acids-source of carbohydrates and lipids-can be used as human food or animal feed.

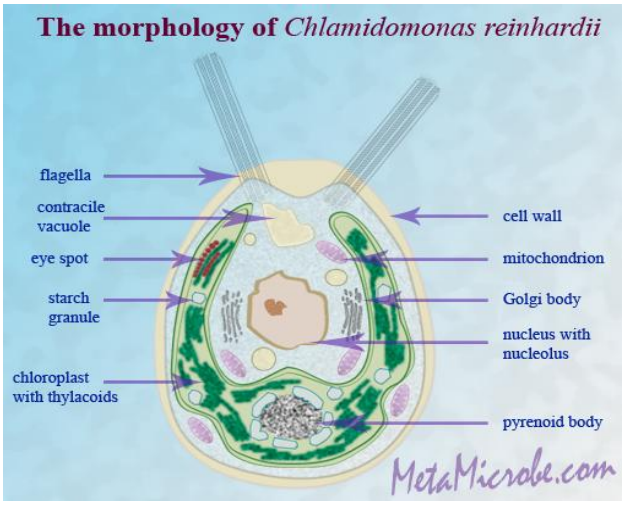
26. b).Characteristics and life cycle of *Chalmydomonasreinharteii:*

Chlamydomonas - haploid and has a controlled sexual cycle -the possibility of tetrad analysis- photosynthetic apparatus -related to that of vascular plants- eukaryote- photosynthesis genes -nuclear and chloroplast genomes- the cell of *Chlamydomonas* has a cell wall- ability to grow heterotrophically- the isolation of viable mutants - unable to perform photosynthesis- flagellum- phototaxis-minimizing photodamage- can adopt an anaerobic metabolism-producing hydrogen ga-such as formate and ethanol- eukaryote in which the nuclear, chloroplast and mitochondrial genomes – transformed- most closely models plant cells- powerful and versatile system - variety of molecular and cellular processes.

Life cycle: Generation time takes approximately 5 hours-Haploid cells - asexually by fission- the protoplast dividing to form 4-8 zoospores similar to the parent-GAMETOGENESIS-MeSH -Under - nitrogen starvation- vegetative cells develop into gametes of two mating types: mt+ and mt-. ADHESION -Gametes of opposite mating types -attracted to each other and form aggregates-GAMETE ACTIVATION-Release of cell walls- formation of mating structures- Fusion of mt+ fertilization tubule with mt- mating structure-MeSH Complete cell fusion-zygote is not flagellated -dormant form of the species in the soil-MeSH –Zygote-meiosis to form 4 haploid zoospores.

Mating type - Mating - between individuals of opposite mating types - interaction of cell surface components- The equivalent in lower organisms of the sexes in higher organisms- differ only physiologically

and not in physical form- MT+ -Activation of cells of mating type mt+ results in production of a long membrane-enclosed fetilization tubule-covered with a glycoprotein- polymerized actin filaments- MT-Cells of mating type mt- move membrane proteins- specific region of the plasma membrane and produce a short-lived tubule with no microfilaments.



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[17MBU101]

KARPAGAM ACADEMY OF HIGHER EDUCATION

KARPAGAM UNIVERSITY

(Established Under Section 3 of UGC Act, 1956)

Eachanari Post, Coimbatore, Tamil Nadu, India – 641 021

B. Sc., DEGREE THIRD INTERNAL EXAMINATION SEPTEMBER 2017

Microbiology

INTRODUCTION TO MICROBIOLOGY AND MICROBIAL DIVERSITY

TIME: 2 Hours **Max Marks: 50 Marks**

Date:

PART –A **20 x 1= 20 marks**

1. Fungi are
   a. Chemolithotrophs b. Chemoorganotrophs
   c. Lithotrophs d. Physicotrophs
2. Ascospores are produced and enclosed in a sac like structure called _____
   a. Basidium b. Zygus
   c. Ascus d. Sporangium
3. Most fungi are soil _____
   a. Parasites b. Obligate Parasites
   c. Saprophytes d. Virulence factor
4. *Entamoeba* belongs to _____ class
   a. Sarcodina b. Flagellata
   c. Sporozoa d. Acompixa.
5. Protozoans are to be regarded as _____
   a. Unicellular b. Multicellular animal
   c. Cellular animal d. Acellular animal.
6. Virus can be observed under_____ Microscope.
   a. Simple b. Compound
   c. Electron d. Darkfield
7. The viral glycoprotein projection are called _____
   a. Filaments b. Spikes
   c. Flagella d. Pili.
8. Enveloped viruses are released from the host cell by the process of ____
   a. Lysogeny b. Lysis
   c. Budding d. Endocytosis
9. In phage life cycle when the host is ruptured it is known as _____ cycle.
   a. Lytic b. Symbiosis
   c. Lysogeny d. Temperate
10. *Plasmodium* belongs to _____ class.
    a. Sarcodina b. Flagellata
    c. Sporozoa d. Acompixa
11. Protozoans were first observed by _____
    a. Pasteur b. Robert hoek
    c. Fritch d. Leeuwenhoek
12. Virus means _____.
    a. Poison b. Protein
    c. Fragrance d. Cancer
13. Fungi differ from the other eukaryotic microbes in having --------
    a. flagella b. ergosterol

c. chloroplasts d. an undulating membrane

14. Fungi posses a cell membrane that contains _____
    a. lipids b. Protein
    c. Fat d. Glycerol
15. The integrated phage is known as _____ .
    a. Coliphage b. Prophage
    c. Lytic phage d. Prephage
16. Basidiospores are borne in a specialised stalk called_____
    a. basidium b. zygus
    c. ascus d. sporangium
17. In protozoa, in addition to cell membrane, a compound envelope of a modified structure is called _____
    a. pedicle b. pentent
    c. pellicle d. persistent
18. Microscopic examination of _____ will reveal the presence of *Trichomonas* from infected individual.
    a. blood b. fresh vaginal discharge
    c. CSF d. urine
19. Viruses require _____ for growth.
    a. bacteria b. plants
    c. animals d. living cells
20. The nucleocapsid is covered by an outer membrane like structure called --------
    a. envelope b. covering
    c. membronocapsid d. capsid

PART –B **3 x 2= 6 marks**

21. Define mycotoxins, dikaryont?
22. What are trophozoites, sporozoites, merozoites, cysts?
23. What is reverse transcriptase?

PART –C **3 x 8= 24 marks**

24. a. With a neat sketch explain the fungal structure, its habitat and distribution.

(Or)

b. Outline the economic importance of fungi..

25. a. Comment on *Entamoeba histolytica*.

(Or)

b. Explain the life cycle of Malarial Parasite.

26. a. Brief on the classification of fungi.

(Or)

b. How are DNA viruses classified?