BASUDEV GODABARI DEGREE COLLEGE , KESAIBAHAL

Basudev Godabari Degree College
Sambalpur
768228
Kesibahal

BLENDED LEARNING STUDY MATERIAL

UNIT-II

06/07/2021
Principal
Basudev Godabari Degree College
KESAIBAHAL, SAMBALPUR, 768228

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DEPARTMENT OF BOTANY

1^{st} SEMESTER BOTANY Hons.

PAPER- I (MICROBIOLOGY AND PHYCOLOGY)

SELF STUDY

MODULE DETAILS

Class – 1st Semester (2020-21)

Subject- Botany (Hons.)

Paper Name- Microbiology and phycology

Paper – I

Unit – II

I. Bacteria:- Discovery, general characteristic, types archaebacteria, wall-less form (mycoplasm and spheroplasts), cell structure, nutritional types, reproduction-vegetative, asexual and recombination (conjugation, transformation and transduction). Economic importance of bacteria with reference to their role in agriculture and industry. (fermentation and medicine).
II. Cyanobacteria:- Ecology and occurrence, cell structure, heterocyst, repeoduction, economic importance, role in biotechnology, morphology and life cycle of Nostoc. General characteristics of prochlorophyceae, Evolutionary significance of prochloron.

Learning Objectives:

After learning this you should be able to

1. General characters of Bacteria.
2. Structure of a bacterial cell.
3. Economic importance of Bacteria.
4. Genetic recombination of bacteria.
5. Mechanism of transformation of Bacteria.
6. Bacterial Transduction.
7. Conjugation in Bacteria.
8. Different nutritional group of Bacteria.
9. Industrials uses of Bacteria.
10. Bacterial cell wall.

11. Bacterial Genome.
12. Nutritional types of Bacteria.
13. Binary fission in Bacteria.
14. Role of bacteria in Biotechnology.
15. Cell wall of Archaebacteria.
16. Comparison of Archaebacteria with Eubactria.
17. Economic significance of archaebacteria
18. Structure and reproduction of mycoplasm.
19. Ecology and occurrence of cyanobacteria.
20. Life cycle of Nostoc.
21. Role of blue-green algae in biotechnology.

You can use the following video links

https://youtu.be/-dwFfhBiZSI- General character and classification of bacteria.

https://youtu.be/i6h7ev4BQmc- Reproduction in Bacteria vegetative and asexual.

https://youtu.be/yDgV7RSJnel- Conjugation (Genetic recombination in Bacteria)

https://youtu.be/y4x-mphgJco- Transformation with transduction in bacteria.

https://youtu.be/awai3sQLqG4- Transduction in bacteria.

https://youtu.be/KRsjJL-Ynw4- Economic inportant of Bacteria.

https://youtu.be/0-ssfJGCIUK- Role of Bacteria in agriculture .

https://youtu.be/doHUTNTNq-BY/- Thallus reproduction, Life cucle of Nostoc.

https://youtu.be/7FJopom597Y- Prochloron

You can use the following books.

1.Microbilogy and phycology- Bijay Kumar Mishra
Nirupama Dash (Kalyani)

2. Microbilogy and phycology- Singh, Pandy.

Plant Unit –II

No of period to be taken - 06

Date	Time	Period	Topic covered	Signature
11.01.21	10.30 to 11.30am	1	Introduction of Algae, general chatacteristic, ecology and distribution. Rnge of thallus organization, cell structure and components, cell wall,pigment system, Reserve food, flagella.	Al
19.01.21	10.30 to 11.30am	1	Methods of reproduction, classification. Role of Algae in the Environment, Agriculture, biotechnology and Industry.	Al
25.01.21	10.30 to 11.30am	1	Doubt clearing calss	Al
28.01.21	10.30 to 11.30am	1	General character of chlorophyea, Occurrence, Range of thallus organization, cell structure and reproduction.	Al
03.02.21	10.30 to 11.30am	1	Morphology and life cycle of chlamydomonous, volvox, oedogonium and coleochete.	Al
10.02.21	10.30 to 11.30am	1	Doubt clearing class.	Al 10.02.21.

1

MORPHOLOGY AND CLASSIFICATION OF BACTERIA

1.1 INTRODUCTION

Microorganisms are a heterogeneous group of several distinct classes of living beings. Based on the difference in cellular organization and biochemistry, the kingdom protista has been divided into two groups namely prokaryotes and eukaryotes. Bacteria and blue-green algae are prokaryotes, while fungi, other algae, slime moulds and protozoa are eukaryotes. Bacteria are prokaryotic microorganisms that do not contain chlorophyll. They are unicellular and do not show true branching, except in higher bacteria like actinomycetales.

OBJECTIVES

After reading this lesson, you will be able to:

- describe the structure of Prokaryotic and Eukaryotic cell
- explain the size of bacteria
- classify bacteria based on the shape and arrangements
- describe the structure of bacterial cell wall
- describe the phases of Growth curve
- explain the factors affecting the growth of bacteria

1.2 PROKARYOTES

The prokaryotic cells have the following characteristics such as

- No organelles, all the action takes place in the cytosol or cytoplasmic membrane

- Most bacteria possess peptidoglycan, a unique polymer that makes its synthesis a good target for antibiotics
- Protein synthesis takes place in the cytosol with structurally different ribosome's

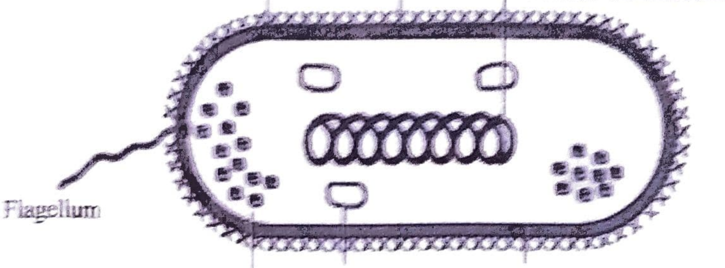


Fig. 1.1: Prokaryote Cell

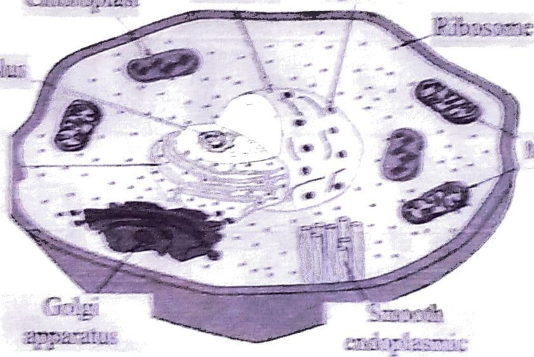


Fig. 1.2: Eukaryote Cell

Difference between Prokaryotic and Eukaryotic Cells

Character	Prokaryotes	Eukaryotes
Nucleus	Absent. No nuclear envelope	Present with nuclear envelope and nucleolus
Membrane-bound organelles	Absent	Present. Includes mitochondria, chloroplasts (plants), lysosomes
Chromosome (DNA)	Single coiled chromosome in cytoplasm 'nucleoid' region in association with 'histone-like' proteins	Multiple linear chromosomes with histone proteins

Cell wall	Eubacteria have a cell wall of peptidoglycan Archaea have cell walls of pseudomurein	No cell wall in animal cellsPlant cell walls = celluloseFungal cell walls = chitin
Mitotic division	Absent	Present
Ribosomes	70S. Free in cytoplasm	80S. Both free in cytoplasm and attached to rough E.R. 70S in mitochondria and chloroplasts
Flagella	when present consist of protein flagellin	consist of 9+2 arrangement of microtubules
Cytoplasmic membrane lipids	Eubacteria= Fatty acids joined to glycerol by ester linkageArchaea= Hydrocarbons joined to glycerol by ether linkage	Fatty acids joined to glycerol by ester linkage
Mitochondria	Absent	Present
Lysosomes	Absent	Present
Golgi apparatus	Absent	Present
Endoplasmic Reticulum	Absent	Present

1.3 BACTERIA

The major characteristics of Bacteria are based on their size, shape and arrangements

1.3.1 Size

The unit of measurement used in bacteriology is the micron (micrometer)

1 micron (µ) or micrometer (µm)	– one thousandth of a millimeter
1 millimicron (mµ) or nanometer (nm)	– one thousandth of a micron or one millionth of a millimeter
1 Angstrom unit (Å)	– one tenth of a nanometer

The limit of resolution with the unaided eye is about 200 microns. Bacteria are smaller which can be visualized only under magnification. Bacteria of medical importance generally measure 0.2 – 1.5 µm in diameter and about 3-5 µm in length.

1.3.2 Microscopy

The morphological study of bacteria requires the use of microscopes. Microscopy has come a long way since Leeuwenhoek first observed bacteria using hand-ground lenses.

The types of microscope are

(i) Light or optical microscope

(ii) Phase contrast microscope

(iii) Dark field/ Dark ground microscope

(iv) Electron microscope

Light or optical microscope

They are of two types namely Simple and Compund Microscope

- Simple Microscope consists of a single lens. A hand lens is an example of a simple Microscope.
- Compound Microscope consists of two or more lenses in series. The image formed by the first lens is further magnified by another lens.

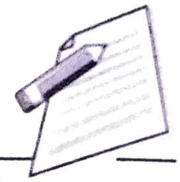
Bacteria may be examined under the compound microscope, either in the living state or after fixation and staining. Examination of wet films or hanging drops indicates the shape, arrangements, motility and approximately size of the cells. But due to lack of contrast details cannot be appreciated.

Phase contrast microscope

This imposes the contrast and makes evident the structure within the cells that differ in thickness or refractive index. The difference in the refractive index between bacteria cells and the surrounding medium makes them clearly visible. Retardation, by a fraction of a wavelength, of the rays of light that pass through the object, compared to the rays passing through the surrounding medium, produces phase difference between the two types of rays.

Dark field / Dark ground microscope

Another method of improving the contrast is the dark field microscope in which reflected light is used instead of the transmitted light used in the ordinal microscope. The contrast gives an illusion of increased resolution, so that very slender organisms such as spirochete, not visible under ordinary illumination, can be clearly seen under the dark field microscope.



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Electron Microscope

Beams of electron are used instead of beam of light, used in light microscope. The object which is held in the path of beam scatters the electrons and produces an image which is focused on a fluorescent viewing screen. Gas molecules scatter electron, therefore it is necessary to examine the object in a vacuum.

INTEXT QUESTIONS 1.1

Match the following

	Microscopes		Properties:
1.	Light microscope	(a)	reflected light
2.	Phase contrast microscope	(b)	electron beam
3.	Dark field microscope	(c)	light beam
4.	Electron microscope	(d)	refractive index

1.3.3 Stained Preparations

Live bacteria do not show the structural detail under the light microscope due to lack of contrast. Hence staining techniques are used to produce colour contrast. Routine methods of staining of bacteria involve dying and fixing smears – procedures that kill them. Bacteria have an affinity to basic dyes due to acidic nature of their protoplasm. The commonly used staining techniques are

Simple Stains

Dyes such as methylene blue or basic fuchsin are used for simple staining. They provide colour contrast, but impart the same colour to all bacteria.

Negative Staining

Bacteria are mixed with dyes such as Indian ink or nigrosin that provide a uniformly coloured background against which the unstained bacteria stand out in contrast. Very slender bacteria like spirochetes that cannot be demonstrated by simple staining methods can be viewed by negative staining.

Impregnation Methods

Cells and structures too thin to be seen under ordinary microscope may be rendered visible if they are impregnated with silver on the surface. These are used for demonstration of spirochetes and bacterial flagella.

Notes

Differential Stains

These stains impart different colours to different bacteria or bacterial structures. the two most widely used differential stains are the Gram stain and Acid fast stain. The gram stain was devised by histologist Christian Gram as a method of staining bacteria in tissues.

Gram positive cells are simpler chemical structure with a acidic protoplasm. It has a thick peptidoglycan layer. Teichoic acids are intertwined among the peptidoglycan and the teichoic acids are the major surface antigen determinants

Gram negative cells are more complex, they are rich in lipids. The membrane is bilayered as phospholipids. proteins and lipopolysaccharide. Lipopoly-saccharides (LPS) are also known as endotoxin. Gram negative cells have a peptidoglycan layer which is thin and formed by just one or two molecules. No Teichoic acids are found in the cell wall of Gram negative bacteria. The Outer membrane has Lipopolysaccharide channels with porins which transfer the solutes across. Lipoprotein cross link outer membrane and peptidoglycan layer

Gram reaction may be related to the permeability of the bacterial cell wall and cytoplasmic membrane to the dye-iodine complex, the Gram-negative, but not the Gram-positive cells, permitting the outflow of the complex during decolourisation. Gram staining is an essential procedure used in the identification of bacteria and is frequently the only method required for studying their morphology.

The acid fast stain was discovered by Ehrlich, who found that after staining with aniline dyes, tubercle bacilli resist decolourisation with acids. The method as modified by Ziehl and Neelsen, is in common use now.

INTEXT QUESTIONS 1.2

Match the following:

1. Simple stain	(a) Silver
2. Negative stain	(b) acids
3. Impregnation method	(c) iodine complex
4. Acid fast stain	(d) Methylene blue
5. Gram stain	(e) Indian ink

1.4 SHAPE OF THE BACTERIA

Depending on their shape, bacteria are classified into several varieties

1. Cocci (from kokkos meaning berry) are spherical or oval cells

Notes

2. Bacilli (from baculus meaning rod) are rod shaped cells
3. Vibrios are comma shaped curved rods and derive their name from their characteristics vibratory motility.
4. Spirilla are rigid spiral forms.
5. Spirochetes (from speira meaning coil and chaite meaning hair) are flexuous spiral forms
6. Actinomycetes are branching filamentous bacteria, so called because of a fancied resemblance to the radiating rays of the sun when seen in tissue lesions (from actis meaning ray and mykes meaning fungus)
7. Mycoplasmas are bacteria that are cell wall deficient and hence do not possess a stable morphology. They occur as round or oval bodies and as interlacing filaments.

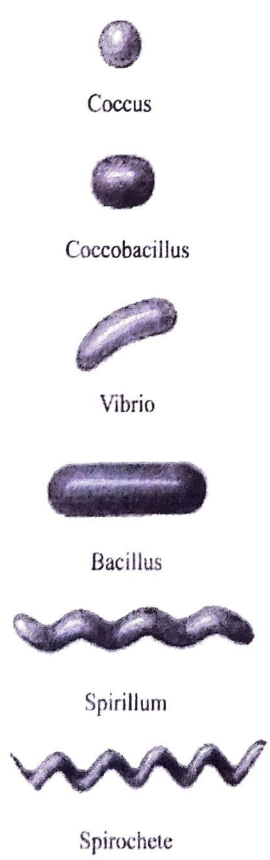

Fig. 1.3: Shapes of bacteria.

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INTEXT QUESTION 1.3

Match the following:

1. Bacilli	(a) coma
2. Cocci	(b) flexous spiral form
3. Vibrio	(c) rigid spiral form
4. Sprillum	(d) rod shaped
5. Spirochetes	(e) spherical shaped

Bacteria sometime show characteristic cellular arrangement or grouping. According to the plane of cellular division, cocci may be arranged in pairs (diplococci), chains (streptococci), groups of four (tetrads) or eight (sarcina), or grape like clusters (staphylococci).

Fig. 1.4: Arrangement of Cocci.

INTEXT QUESTIONS 1.4

Match the following:

1. Diplococci	(a) groups of four
2. Streptococci	(b) groups of eight
3. Tetrads	(c) occurs in pairs
4. Sarcina	(d) grape like clusters
5. Staphylococci	(e) occurs in chains

Notes

1.5 BACTERIAL STRUCTURE

The outer layer or cell envelope consists of two components, a rigid cell wall and beneath it a cytoplasmic or plasma membrane. The cell envelope encloses the protoplasm, comprising the cytoplasm, cytoplasmic inclusions such as ribosomes and mesosomes, granules, vacuoles and the nuclear body.

Cell wall

Beneath the external structures is the cell wall. It is very rigid & gives shape to the cell. Its main function is to prevent the cell from expanding & eventually bursting due to water uptake. Cell Wall constitutes a significant portion of the dry weight of the cell and it is essential for bacterial growth & division. The cell wall cannot be seen by direct light microscopy and does not stain with simple

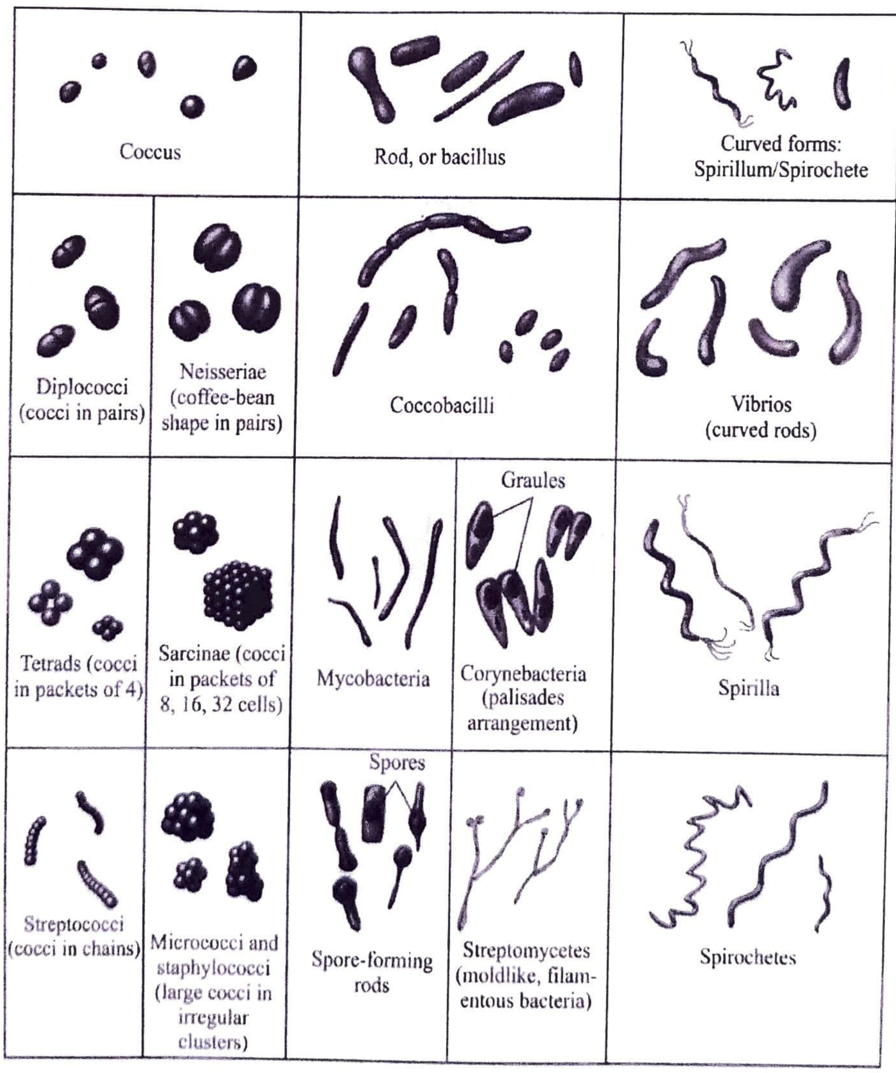

Fig. 1.5

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stains. It may be demonstrated by microdissection, reaction with specific antibodies, mechanical rupture of the cell, differential staining procedures or by electron microscopy.

Chemically the cell wall is composed of peptidoglycan. Mucopeptide (peptidoglycan or murien) formed by N acetyl glucosamine & N acetyl muramic acid alternating in chains, cross linked by peptide chains. Embedded in it are polyalcohol called Teichoic acids. Some are linked to Lipids & called Lipoteichoic acid. Lipotechoic acid link peptidoglycan to cytoplasmic membrane and the peptidoglycan gives rigidity.

The functions of Teichoic acid are

- gives negative charge
- major antigenic determinant
- transport ions
- anchoring
- external permeability barrier

Characteristics	Gram Positive	Gram Negative
Thickness	Thicker	Thinner
Variety of amino acids	Few	Several
Lipids	Absent	Present
Teichoic acid	Present	absent

Outer Membrane

Outer membrane is found only in Gram-negative bacteria, it functions as an initial barrier to the environment and is composed of lipopolysaccharide (LPS) and phospholipids

Lipopolysaccharide (LPS)

The LPS present on the cell walls of Gram-negative bacteria account for their endotoxic activity and antigen specificity.

A bacterium is referred as a protoplast when it is without cell wall. Cell wall may be lost due to the action of lysozyme enzyme, which destroys peptidoglycan. This cell is easily lysed and it is metabolically active but unable to reproduce.

A bacterium with a damaged cell wall is referred as spheroplasts. It is caused by the action of toxic chemical or an antibiotic, they show a variety of forms and they are able to change into their normal form when the toxic agent is removed, i.e. when grown on a culture media

Cytoplasmic membrane

Cytoplasmic membrane is present immediately beneath the cell wall, found in both Gram positive & negative bacteria and it is a thin layer lining the inner surface of cell wall and separating it from cytoplasm. It acts as a semipermeable membrane controlling the flow of metabolites to and from the protoplasm.

Cytoplasm

The cytoplasm is a Colloidal system containing a variety of organic and inorganic solutes containing 80% Water and 20% Salts, Proteins. They are rich in ribosomes, DNA & fluid. DNA is circular and haploid. They are highly coiled with intermixed polyamines & support proteins. Plasmids are extra circular DNA.

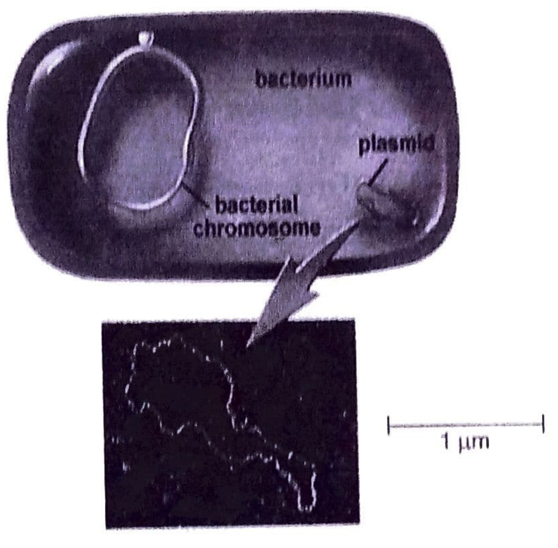


Fig. 1.6

Ribosomes

They are the centers of protein synthesis. They are slightly smaller than the ribosomes of eukaryotic cells

Mesosomes

They are vesicular, convoluted tubules formed by invagination of plasma membrane into the cytoplasm. They are principal sites of respiratory enzymes and help with cell reproduction

Cytoplasmic Inclusions

The Inclusion bodies are aggregates of polymers produced when there is excess of nutrients in the environment and they are the storage reserve for granules,

Notes

phosphates and other substances. Volutin granules are polymetaphosphates which are reserves of energy and phosphate for cell metabolism and they are also known as metachromatic granules.

Nucleus

The Nucleus is not distinct and has no nuclear membrane or nucleolus and the genetic material consist of DNA. The cytoplasmic carriers of genetic information are termed plasmids or episomes.

Capsule

Capsule is the outer most layer of the bacteria (extra cellular). It is a condensed well defined layer closely surrounding the cell. They are usually polysaccharide and if polysaccharide envelops the whole bacterium it is capsule and their production depends on growth conditions. They are secreted by the cell into the external environment and are highly impermeable. When it forms a loose mesh work of fibrils extending outward from the cell they are described as glycocalyx and when masses of polymer that formed appear to be totally detached from the cell and if the cells are seen entrapped in it are described as slime layer.

The Capsule protects against complement and is antiphagocytic. The Slime layer & glycocalyx helps in adherence of bacteria either to themselves forming colonial masses or to surfaces in their environment and they resists phagocytosis and desiccation of bacteria.

Flagella

Flagella are long hair like helical filaments extending from cytoplasmic membrane to exterior of the cell. Flagellin is highly antigenic and functions in cell motility. The location of the flagella depends on bacterial species as polar situated at one or both ends which swims in back and forth fashion and lateral at along the sides.

The parts of flagella are the filament, hook and the basal body. Filament is external to cell wall and is connected to the hook at cell surface, the hook & basal body are embedded in the cell envelope. Hook & filament is composed of protein subunits called as flagellin. Flagellin is synthesized within the cell and passes through the hollow centre of flagella. The arrangement of flagella may be described as

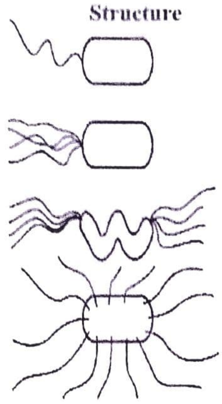
(i) Monotrichous – single flagella on one side

(ii) Lophotrichous – tuft of flagella on one side

(iii) Amphitrichous – single or tuft on both sides

(iv) Peritrichous – surrounded by lateral flagella

Notes



Structure	Flagella Type	Example
	Monotrichous	Vibrio cholerae
	Lophotrichous	Bartonella bacilliformis
	Amphitrichous	Spirillum serpens
	Peritrichous	Escherichia coli

Fig. 1.7: Flagella.

Various types of mobility is observed because of the presence of the flagella as Serpentine motility is seen with Salmonella, Darting motility with Vibrio and Tumbling motility with Listeria monocytogenes

Pili / Fimbriae

Hair-like proteinaceous structures that extend from the cell membrane to external environment are pili which are otherwise known as fimbriae. They are thinner, shorter and more numerous than flagella and they do not function in motility. The fimbriae is composed of a subunit called pilin.

There are two types pili namely Non-sex pili (Common pili) eg. fimbriae or type IV and the sex pili. The fimbriae are antigenic and mediate their adhesion which inhibits phagocytosis. The sex pili help in conjugation.

INTEXT QUESTIONS 1.5

Match the following:

1. Monotrichous	(a) single or tuft on both sides
2. Lophotrichous	(b) surrounded by lateral flagella
3. Amphitrichous	(c) single flagella on one side
4. Peritrichous	(d) tuft of flagella on one side

Spore

Some bacteria have the ability to form highly resistant resting stage called spores, which helps them to overcome adverse environmental conditions that are unfavorable for vegetative growth of cell. They are not a reproductive form and phosphates and other substances. Volutin granules are polymetaphosphates which are reserves of energy and phosphate for cell metabolism and they are also known as metachromatic granules.

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(iv) Peritrichous – surrounded by lateral flagella

Notes

Characteristics of Bacteria Cell Structures

Structure	Functions(s)	Predominant chemical composition
Flagella	Swimming movement	Protein
Pili		
Sex pilus	Stabilizes mating bacteria during DNA transfer by conjugation	Protein
Common pili or fimbriae	Attachment to surfaces; protection against phagotrophic engulfment	Protein
Capsules (includes "slime layers" and glycocalyx)	Attachment to surfaces; protection against phagocytic engulfment, occasionally killing or digestion; protection against desiccation	Usually polysaccharide; occasionally polypeptide
Cell wall		
Gram-positive bacteria	confers rigidity and shape on cells	Peptidoglycan (murein) complexed with teichoic acids
Gram-negative bacteria	confers rigidity and shape; outer membrane is permeability barrier; associated LPS and proteins have various functions	Peptidoglycan (murein) surrounded by phospholipid protein-lipopolysaccharide "outer membrane"
Plasma membrane	Permeability barrier; transport of solutes; energy generation; location of numerous enzyme systems	Phospholipid and protein
Ribosomes	Sites of translation (protein synthesis)	RNA and protein
Inclusions	Often reserves of nutrients; additional specialized functions	Highly variable; carbohydrate, lipid, protein or inorganic
Chromosome	Genetic material of cell	DNA
Plasmid	Extrachromosomal genetic material	DNA

not a storage granule. These spores are resistant to bactericidal agents and adverse physical conditions. Each spore can give rise to only one endospore which play a role in heat resistance. Spores consists of three layers namely core, cortex and spore coat

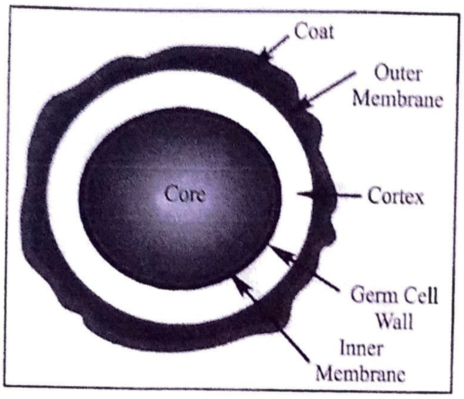

Fig. 1.8: Spore

1.6 GROWTH AND MULTIPLICATION OF BACTERIA

Bacteria divide by binary fission and cell divides to form two daughter cells. Nuclear division precedes cell division and therefore, in a growing population, many cells having two nuclear bodies can be seen. Bacterial growth may be considered as two levels, increase in the size of individual cells and increase in number of cells. Growth in numbers can be studied by bacterial counts that of total and viable counts. The total count gives the number of cells either living or not and the viable count measures the number of living cells that are capable of multiplication.

1.6.1 Bacterial Growth Curve

When bacteria is grown in a suitable liquid medium and incubated its growth follows a definite process. If bacterial counts are carried out at intervals after innoculation and plotted in relation to time, a growth curve is obtained. The curve shows the following phase

(i) Lag phase

Immediately following innoculation there is no appreciable increase in number, though there may be an increase in the size of the cells. This initial period is the time required for adaptation to the new environment and this lag phase varies with species, nature of culture medium and temperature.

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(ii) Log or exponential phase

Following the lag phase, the cell starts dividing and their numbers increase exponentially with time

(iii) Stationary phase

After a period of exponential growth, cell division stops due to depletion of nutrient and accumulation of toxic products. The viable count remains stationary as an equilibrium exists between the dying cells and the newly formed cells.

(iv) Phase of decline

This is the phase when the population decreased due to cell death.

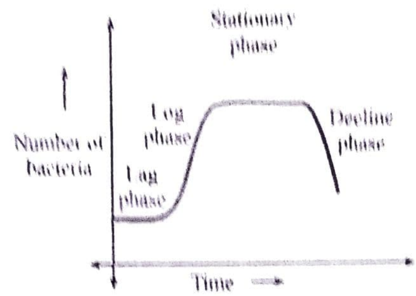


Fig. 1.8: The growth curve of bacteria showing different phases

The various stages of bacterial growth curve are associated with morphological and physiological alterations of the cells. The maximum cell size is obtained towards the end of the lag phase. In the log phase, cells are smaller and stained uniformily. In the stationary phase, cells are frequently gram variable and show irregular staining due to the presence of intracellular storage granules. Sporulation occurs at this stage. Also, many bacteria produce secondary metabolic products such as exotoxins and antibiotics. Involution forms are common in the phase of decline.

1.7 FACTORS THAT AFFECT THE GROWTH OF BACTERIA

Many factors affect the generation time of the organism like temperature, oxygen, carbon dioxide, light, pH, moisture, salt concentration.

Nutrition

The principal constituents of the cells are water, proteins, polysaccharides, lipids, nucleic acid and mucopeptides. For growth and multiplication of bacteria, the minimum nutritional requirement is water, a source of carbon, nitrogen and some inorganic salts.

Bacteria can be classified nutritionally, based on their energy requirement and on their ability to synthesise essential metabolites. Bacteria which derive their energy from sunlight are called phototrophs, those who obtain energy from chemical reactions are called chemotrophs. Bacteria which can synthesise all their organic compounds are called autotrophs and those that are unable to synthesise their own metabolites are heterotrophs.

Some bacteria require certain organic compounds in minute quantities. These are know as growth factors or bacterial vitamins. Growth factors are called essential when growth does not occur in their absence, or they are necessary for it.

Oxygen

Depending on the influence of oxygen on growth and viability, bacteria are divided into aerobes and anaerobes.

Aerobic bacteria require oxygen for growth. They may be obligate aerobes like cholera, vibrio, which will grow only in the presence of oxygen or facultative anaerobes which are ordinarily aerobic but can grow in the absence of oxygen.

Most bacterial of medical importance are facultative anaerobes. Anaerobic bacteria, such as clostridia, grow in the absence of oxygen and the obligate anaerobes may even die on exposure to oxygen. Microaerophilic bacteria are those that grow best in the presence of low oxygen tension.

Carbon Dioxide

All bacteria require small amounts of carbon dioxide for growth. This requirement is usually met by the carbon dioxide present in the atmosphere. Some bacteria like Brucella abortus require much higher levels of carbon dioxide.

Temperature

Bacteria vary in their requirement of temperature for growth. The temperature at which growth occurs best is known as the optimum temperature. Bacteria which grow best at temperatures of 25-40°C are called mesophilic. Psychrophilic bacteria are those that grow best at temperatures below 20°C. Another group of non pathogenic bacteria, thermophiles, grow best at high temperatures, 55-80°C.

The lowest temperature that kills a bacterium under standard conditions in a given time is known as thermal death point.

Moisture and Drying

Water is an essential ingredient of bacterial protoplasm and hence drying is lethal to cells. The effect of drying varies in different species.

Light

Bacteria except phototrophic species grow well in the dark. They are sensitive to ultraviolet light and other radiations. Cultures die if exposed to light.

Notes

H-ion concentration

Bacteria are sensitive to variations in pH. Each species has a pH range, above or below which it cannot survive and an optimum pH at which it grows best. Majority of pathogenic bacteria grow best at neutral or slightly alkaline pH (7.2 – 7.6)

Osmotic Effect

Bacteria are more tolerant to osmotic variation than most other cells due to the mechanical strength of their cell wall. Sudden exposure to hypertonic solutions may cause osmotic withdrawal of water and shrinkage of protoplasm called plasmolysis.

WHAT YOU HAVE LEARNT

- Bacteria are prokaryotic microorganism that do not contain chlorophyll
- They are unicellular and do not exhibit true branching.
- The morphological study of bacteria requires the use of microscope like optical or light microscope, phase control microscope, dark/field microscope, electron microscope
- Staining techniques like simple stain, negative stain, impregnation stain, differential stains are used to exhibit structure of bacteria
- Bacteria are classified based on the shape as cocci, bacilli, vibrio, Spirilla. And based on arrangements they are classified as diplococci, streptococci, tetrads, sarcina, staphylococci
- Bacterial cell has cell wall, inner protoplasm and other components
- Bacterial growth phase has a lag phase, log phase, stationary phase and a decline phase

TERMINAL QUESTIONS

1. Describe the structure of cell wall
2. Classify bacteria based on shaped and arrangement with examples
3. Explain the factors affecting the growth of the bacteria
4. Describe growth curve

Notes

ANSWERS TO INTEXT QUESTIONS

1.1

1. (c) 2. (d) 3. (a) 4. (b)

1.2

1. (d) 2. (e) 3. (a) 4. (b) 5. (c)

1.3

1. (d) 2. (e) 3. (a) 4. (c) 5. (b)

1.4

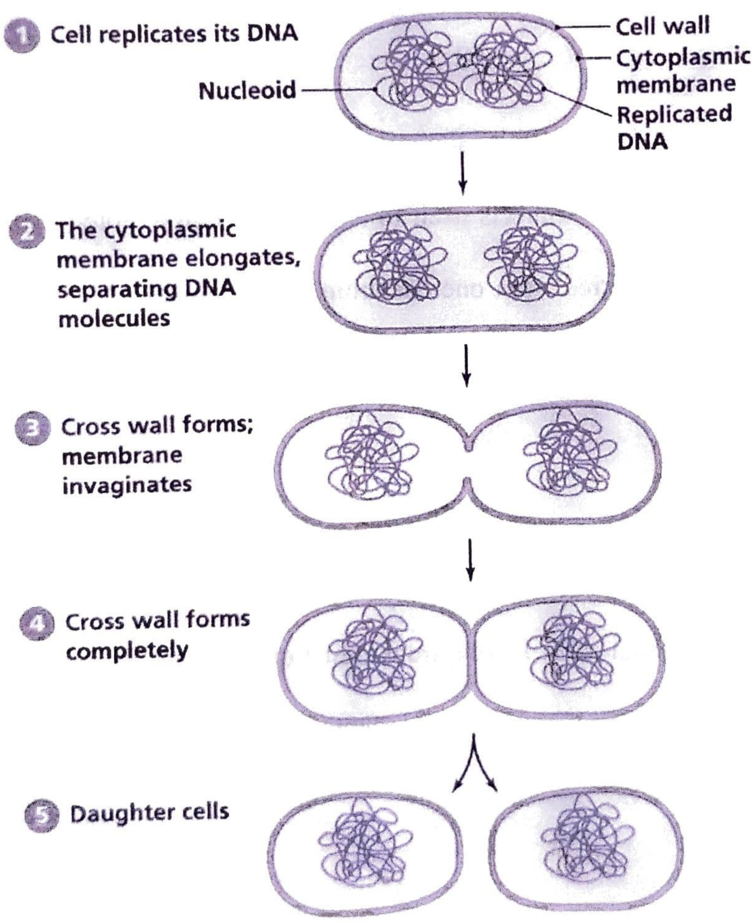
1. (c) 2. (e) 3. (a) 4. (b) 5. (d)

1.5

1. (c) 2. (d) 3. (a) 4. (b)

REPRODUCTION IN BACTERIA

Bacteria are prokaryotic organisms that reproduce asexually. Most prokaryotes reproduce by binary fission. Binary fission involves the division of a single cell, which results in the formation of two cells that are genetically identical. In binary fission, the cell elongates, replicates its chromosome, and separates the newly formed DNA molecules so there is one chromosome in each half of the cell. Finally, a septum (or cross wall) is formed at midcell, dividing the parent cell into two progeny cells, each having its own chromosome and a complement of other cellular constituents.



Binary fission.

BACTERIAL RECOMBINATION

Binary fission is an effective way for bacteria to reproduce, however it is not without problems. Since the cells produced through this type of reproduction are identical, they are all susceptible to the same types of threats, such as environmental changes and antibiotics. These hazards could destroy an entire colony. In order to avoid such perils, bacteria can become more genetically varied through recombination. Recombination involves the transfer of genes between cells. Bacterial recombination is accomplished through conjugation, transformation, or transduction.

Conjugation

Some bacteria are capable of transferring pieces of their genes to other bacteria that they contact. During conjugation, one bacterium connects itself to another through a protein tube structure called a **pilus.** Genes are transferred from one bacterium to the other through this tube.

Transformation

Some bacteria are capable of taking up DNA from their environment. These DNA remnants most commonly come from dead bacterial cells. During transformation, the bacterium binds the DNA and transports it across the bacterial cell membrane. The new DNA is then incorporated into the bacterial cell's DNA.

Transduction

Transduction is a type of recombination that involves the exchange of bacterial DNA through bacteriophages. Bacteriophages are viruses that infect bacteria. There are two types of transduction: generalized and specialized transduction.

Once a bacteriophage attaches to a bacterium, it inserts its genome into the bacterium. The viral genome, enzymes, and viral components are then replicated and assembled within the host bacterium. Once formed, the new bacteriophages lyse or split open the bacterium, releasing the replicated viruses. During the assembling process however, some of the host's bacterial DNA may become encased in the viral capsid instead of the viral genome. When this bacteriophage infects another bacterium, it injects the DNA fragment from the previously infected bacterium. This DNA fragment then becomes inserted into the DNA of the new bacterium. This type of transduction is called **generalized transduction**.

In **specialized transduction**, fragments of the host bacterium's DNA become incorporated into the viral genomes of the new bacteriophages. The DNA fragments can then be transferred to any new bacteria that these bacteriophages infect.

LIFE HISTORY OF OEDOGONIUM

Classification

Class – Chlorophyceae
Order – Oedogoniales
Family –Oedogoniaceae
Genus – *Oedogonium*

Distribution

There are more than 285 species found everywhere, but only in fresh water. In India, more than 114 species are found. The more common Indian species are *O. elegans*, *O. undulatum*, *O. areolatum* etc.

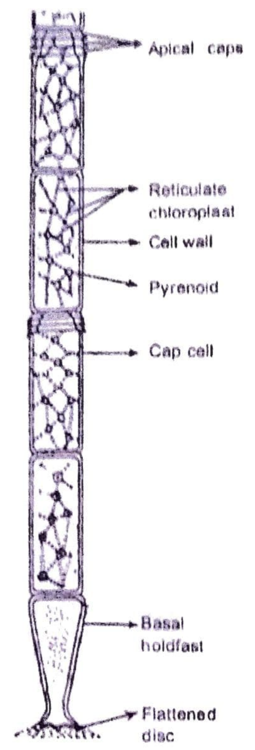
Habit and habitat

It is a freshwater alga found in fresh water bodies like ponds, tanks, ditches, quiet areas of rivers. Some species are epiphytic on aquatic plants. while, one species, *O. terrestris* is found on moist soil.

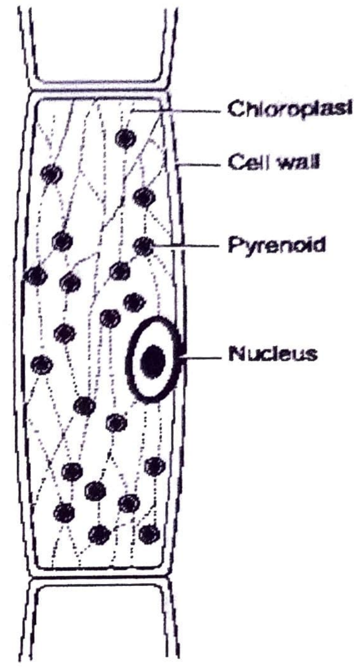
The plant body is thalloid, green, filamentous, unbranched with basal cell as holdfast which attaches the plant with substratum.

Thallus structure

The thallus is filamentous, multicellular and unbranched. All the cells of the filament are cylindrical except the basal and apical cell. The basal cell is colourless and forms holdfast. The proximal end of the hold fast extends to produce finger like projections which help the filament to attach on the substratum. The apical cell is rounded or elongated in



a) A part of filament



b) A cell enlarged

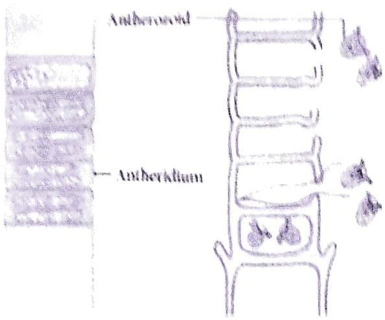
Shape. The vegetative cell is cylindrical and possesses a thick cell wall. The inner layer is cellulosic and the outer layer is made up of pectin. A thin layer of chitin is present above the pectin layer. The protoplasm contains reticulate, parietal chloroplast and it extends from one end of the cell to the other. It is made up of microtubules. A single nucleus and many pyrenoids are present. There is one large central vacuole. The pigmentation is typical chlorophycean type having chlorophyll a, b, β-carotene and xanthophyll.

The terminal cell is rounded. Some cells below the terminal cell possess apical caps which are ring like markings on their upper part called apical caps. Such cells are known as cap cells. The presence of cap cell is characteristic feature of *Oedogonium*.

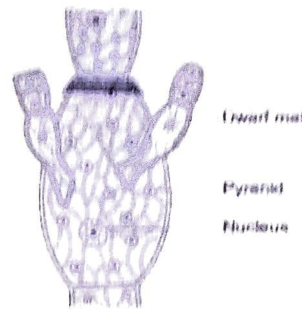
Reproduction

Oedogonium reproduces by vegetative, asexual and sexual methods.

Vegetative reproduction



Antherozoid formation and liberation



Dwarf male on oogonial wall

zoospore. The androspores look similar to zoospore except for the smaller size.

After swimming about for some time, the androspore settles on oogonial wall e.g., *O. ciliatum* or on the supporting cell e.g., O. *concatenatum*. The androspore germinates into a dwarf male. The nannandria are 2-4 celled long. It has a basal attaching cell, the stipe and all others cells are antheridial cells.

Here, antheridia and their further developments are same as in macrandrous form. The antherozoids are released by disorganization of antheridial cell or through the opening.

Oogonia:

In Oedogonium the oogonia are highly differentiated. The structure and development of oogonium is identical in macrandrous and nannandrous species. Like antheridia, any freely divided or actively growing cap cell functions as the oogonial mother cell. The oogonial mother cell divides by transverse division into two unequal cells. The upper larger cell contains more cytoplasm, food and enlarges into spherical or flask shaped oogonium and the lower smaller cell function as supporting cell or suffultory cell. When supporting cells divide again, many oogonia are formed in chain.

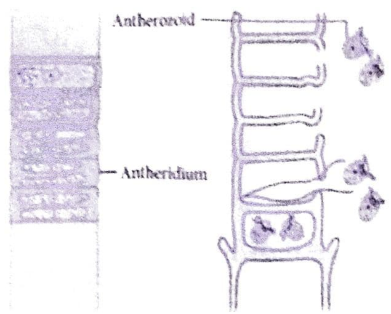
The protoplast in oogonium transforms into a single egg or oosphere. The oosphere is non-motile, green due to chlorophyll and has a central nucleus. As the ovum matures, the nucleus moves to periphery, the oosphere retracts slightly from the oogonial wall and develops a hyaline or receptive spot just outside the nucleus. The receptive spot receives antherozoids for fertilization.

Fertilization:

The antherozoids swim through the opening of oogonial wall and enter the egg through hyaline receptive spot. Only one male antherozoid is able to fuse with ovum. After fusion the diploid zygote secretes a thick wall around itself and forms oospore. The colour of the oospore changes from green to reddish brown. The oospore is liberated by the disintegration of oogonial wall.

Oospore and its germination

The oospore is spherical and reddish brown in colour. It is three layered and contains a diploid nucleus and dense cytoplasm. Oospore is a resting spore and it may become dormant for a year or more. The diploid oospore divides meiotically to form four haploid daughter protoplasts. Each daughter protoplast metamorphosises into a zoospore, known as meiozoospore. The meiozoospores are liberated in a vesicle. Soon the vesicle breaks and meiozoospores come in water. Each spore germinates and forms a new plant.



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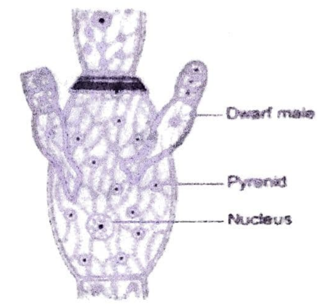

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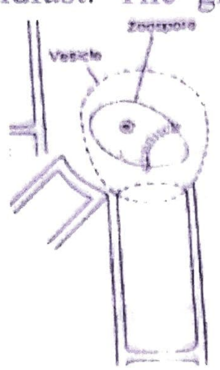
It takes place by fragmentation and akinete formation.

Asexual reproduction

During favourable conditions, some of the vegetative cells function as zoosporangia and a single zoospore is produced per zoosporangium. A ring of short flagella is found at the base of colourless, beak like anterior end of the zoospore. The zoospore is released from the zoosporangium and swims in water. If it reaches a suitable substratum, it divides into two cells. The lower cell forms holdfast. The green upper cell divides and produces the filament.



Liberation of zoospore

A single zoospore

Sexual reproduction

The sexual reproduction in *Oedogonium* is of advanced oogamous type. Sexual reproduction is more frequent in still waters than in running water. The male gametes are produced in antheridia and the female gametes are produced in oogonia. Depending upon the nature of antheridia producing plants, *Oedogonium* species are of two types:

(i) Macrandrous:

Here, antheridia are produced on normal size plant. Macrandrous species may be monoecious or dioecious. Monoecious macrandrous species are *O. fragile, O. hirnii, O. kurzii and O. nodulosum*. In dioecious macrandrous species antheridia and oogonia are produced on separate male and female plants of normal size.

(ii) Nannandrous:

The oogonia are normal. The antheridia are produced on special type of dwarf plants, known as Dwarf male. Dwarf males are formed by androspores which are produced in androsporangia. If androsporangia and oogonia are formed on same plant, they are called gynandrosporous e.g., *O. concatinatum*. If androsporangia and oogonia are formed on different plants, then called idioandrosporous e.g., *O. confertum*.

Antheridia:

(i) In macrandrous forms:

Normally a cap cell forms one antheridial mother cell which divides to forms a row of 2-40 antheridia. The antheridia are broad, flat, short and cylindrical. The contents of an antheridial cells divide longitudinally into two antherozoids. The antherozoids are liberated in the same fashion as zoospores.

The liberated antherozoids are pale green or yellow green, oval or pear shaped. The antherozoids are motile about 30 sub-apical flagella present at the base of beak or hyaline spot. The antherozoids swim freely in water before they reach oogonia. The antherozoids are similar to zoospores in structure but these are smaller than zoospores.

(ii) In nannandrous forms:

The antheridia are formed on dwarf males or nannandria. The dwarf male filament is produced by the germination of a special type of spore known as androspore. The androspore is produced singly within an androsporangium.

The androsporangia are flat, discoid cells slightly larger than antheridia. Each androsporangium produces a single androspore just as in the case of zoospore. Liberation of androspore is similar to that of

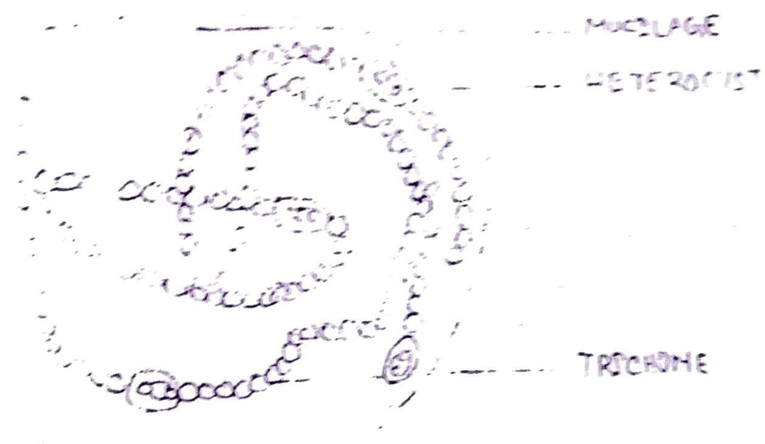
NOSTOC (Blue-green algae)

Systematic position
Division - Cyanophyta
Class - Cyanophyceae
Order - Nostocacales
Family - Nostocaceae
Genus - Nostoc

Occurrence

The Nostoc is filamentous form of both aquatic and terrestrial habitats. It doesnot occur in single filaments. It grows as jelly masses of mucilagenous colony of closely packed trichomes. It grows as ball like colony floating or microscopic. It frequently grows as ball like attached to the submerged plant in fresh water ponds. The terrestrial species Nostoc commune grows on damp soil and forms leathery sheath.

Structure of the colony



The chains or bed like cells or trichomes of varying length are intricately tangled in a gelatinous matrix to form a colony. Each trichome is enclosed by its own mucilagenous sheath called a filament.

The numerous filament in the colony are held together by mucilagenous envelop. The mucilage lump is bounded externally by a firm tough. Pellicle like bounding membrane to form a definite colony.

Each colony look like a bluish green or yellowish mass of jelly. The young colonies are small and microscopic. The matured colonies are large. So many

Structure of trichomes

[Filament with a single trichome]

I- The trichomes are much contorted, moniliform and intertwined. (cell are in closer)

II- They wined about in every direction in the gelatinous matrix.

III- Each trichome is composed of many rounded or oval cells.

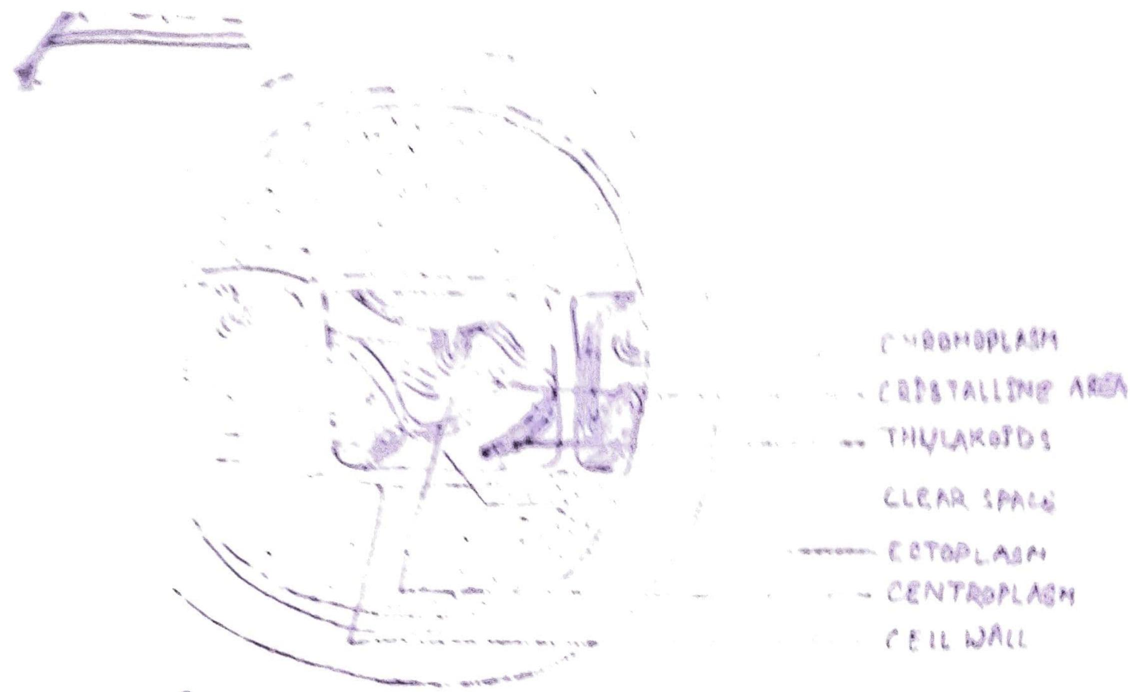
IV- The cells are joined loosely from end to end into a trichome.

V- A colourless empty, spherical or barrel shaped cells are present interval along with trichomes called heterocyst.

VI- The heterocyst are intercalary and have thicker wall than vegetative cell.

VII- Each trichome with it's individual cell is called filament.

VIII- Under certain conditions the trichome is enlarged, stored with food material & thickened to become resting bodies called akinetes.



[CELL STRUCTURE OF NOSTOC]

I- The cell consist of cell wall surrounding the protoplast. (plant cell- cell wall)

II- The protoplast is differentiated into outer pigmented cytoplasmic region called chromoplasm and inner colour-less centroplasms.

III- There is well organised plastids.

IV- The pigments are c-phycocyanin, r-phycoerythrin, chlorophyll-a etc.

V- The pigments are found in the form of <u>lamellae</u> in the chromoplasm.

VI- The chromoplasm contains the food materials are cyanophycean starch and proteinaceous cyanophycean granules.

VII- The centroplasm consists of a number of chromatin materials in the form of granules.

VIII- No well organised nucleus is present.

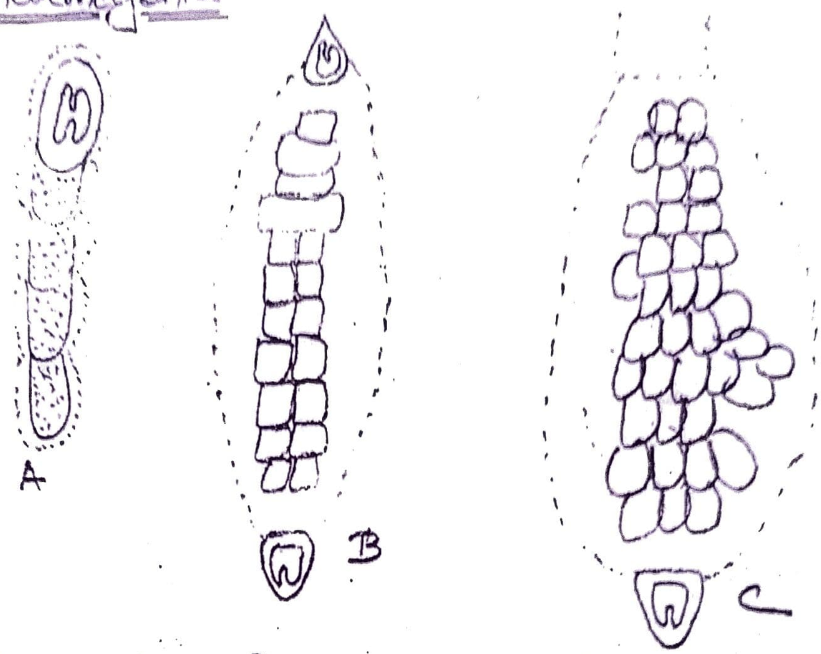
<u>Reproduction</u>

Nostoc reproduces only by vegetative method. There is no sexual and asexual reproduction. The vegetative reproduction takes place by-

1- By fragmentation
2- By hormogonia
3- By akinetes
4- By endospore
5- By heterocyst

The Nostoc colony may break into small pieces due to mechanical, physiological and other factors. Each of the fragment grows up to the size of parent colony.

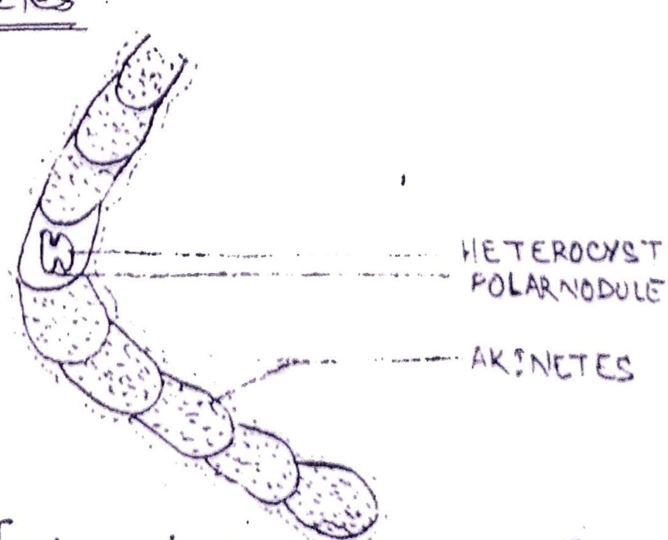
(2) By harmogonia



[Germination of Harmogonia and Formation of new colony]

The trichome breaks into small segment due to degeneration of intercallary vegetative cells (dead cells). The multicellular fragments formed are called harmogonia. They come out of the gelatinous sheath, and multiply rapidly form new colonies. Sometimes the harmogonia can't come out of the parent colony and divide inside the gelatinous sheath. This results in the formation of large number of trichomes inside the parent colony.

(3) By akinetes



[Filament showing akinetes]

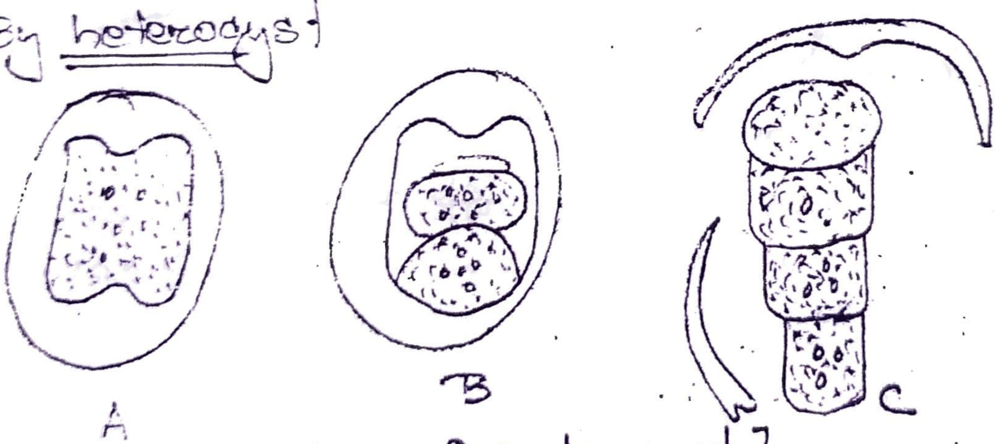
... condition some cells of the trichome are modified into resting spores called akinetes. These cells are covered with a 3 layered coat outside the normal cell wall.

The cells are filled with storage food material. The akinetes can resists cold, drought conditions. During favourable conditions, the outer thick wall breaks down the protoplasm becomes active and a new trichome is formed.

(4) By endospore

According to Brand (1901) and Spratt (1911) found that sometimes the heterocyst becomes densely cytoplasmic. The protoplast divided 2-4 numbers of cells developed inside the cell wall and form the endospore. The endospore on libration give rise to new trichomes.

(5) By heterocyst



[Germination of heterocyst]

In some species, heterocyst act as resting spores. The protoplasm of the heterocyst becomes functional and germinates to form a new trichomes. At the time of germination the protoplast divides by a transverse division to form 2 cells. Both the cell dividesagain to form 4 cells filament. The thick wall of the heterocyst ruptures and the young filament comes out and developed into a new trichome.

VOLVOX UNIT-VI

CHLOROPHYTA & CHAROPHYTA

Division - chlorophyta
class - chlorophyceae
Family
order - volvocales
Family - volvocaceae
Genus - volvox

20

OCCURRENCE

Volvox is a green, flagellate colonial algae comprising 20 species. It occurs both in temporary or permanent fresh water of ponds; pools and ditches. It is found in spring and summer but is very common in the rainy season.

STR. OF COENOBIUM

The volvox colony is of constant size and shape for any given species. A colony consists of definite no of cell. arranged whole is called a coenobium.

The coenobia look like minute green balls the size of a small pinhead from 0.5-2.0mm. in diameter. The coenobium is a sphere of extracellular mucilage with a bounding in the gelatinous matrix and arranged in the peripheral layer.

The volvox coenobium is a hollow sphere and no cellular organisation no of the volvox is an association of no of clamydomonad cells. Each cell has mucilaginous envelope. Each cell is connected

12

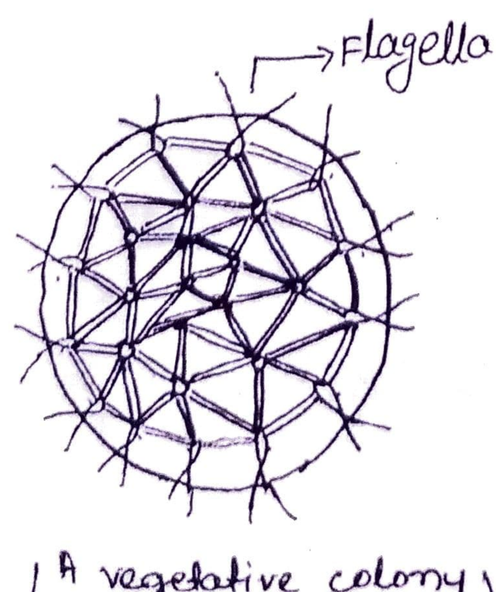
by a series of cytoplasmic strands and form aline continous spherical nucleus. The coenobium has a central cavity filled with waterymucilarge. All the cells of young calony are green and vegetative in function. The coenobia of volvox are motile.

CELL STRUCTURE

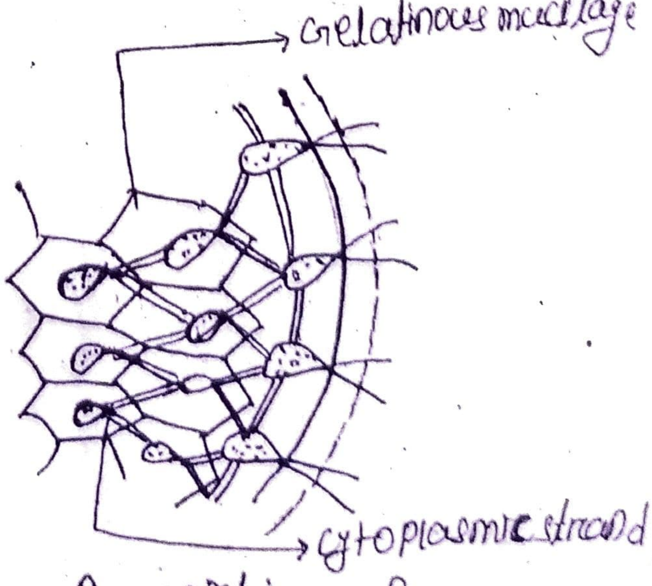
The no of cells in a colony varies from 500-50,000 Each cell has two flagella at it's anterior end the flagella develops from the body.

Two contractile vacuoles are present near the base of the flagella. A cup shaped green chloroplast with are pyrenoid are present. A single nucleus is present in the cytoplasm the reddish-brown eyespot is present in the anterior region of the chloroplast.

volvox is an assemblies of similar and independent cell. Each cell functioned an individuals carring out its own nutrition, respiration, and excretion.



(A vegetative colony of volrox)



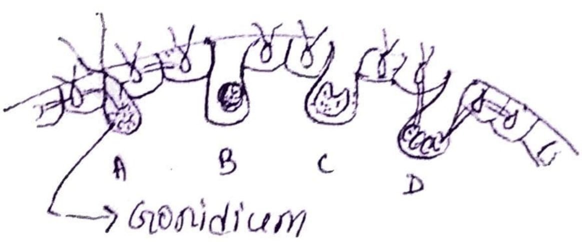
(A portion of vegitative colony)

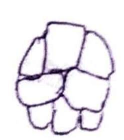
REPRODUCTION

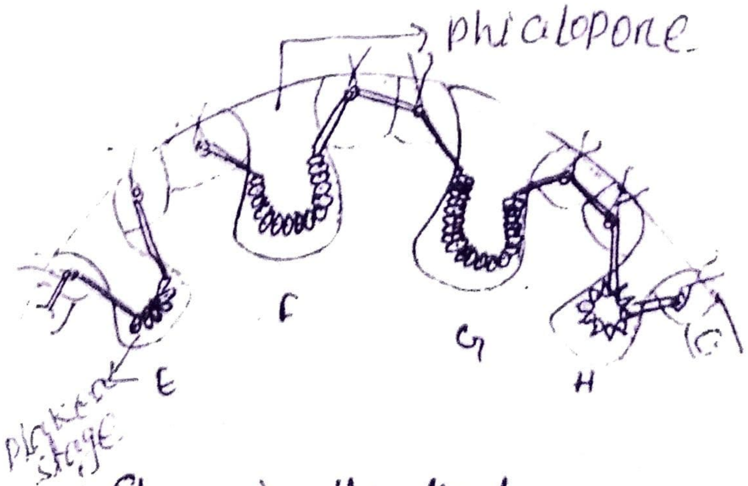
The reproduction in volvox is brought about by ① Asexual reproduction
② sexual reproduction

when the season in favourable for growth, a coenobium has all its reproductive cell reproduces asexually.

A few no of peripheral cell ~~repro~~ undergo asexual reproduction. They with draw the flagella, enlarges in size and 10 or more time then the vegetative cell from rounded structure. The enlarge size is known as Gonidia or parthinogonidia. The cell is large in size, well defined nuclei and more amount of cytoplasm.







(Stages in the development of daughter colony) by a series of cytoplasmic strands and form aline continous spherical nucleus. The coenobium has a central cavity filled with waterymucilarge. All the cells of young calony are green and vegetative in function. The coenobia of volvox are mutile.

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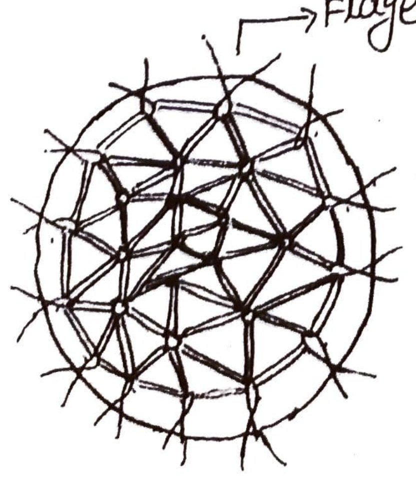
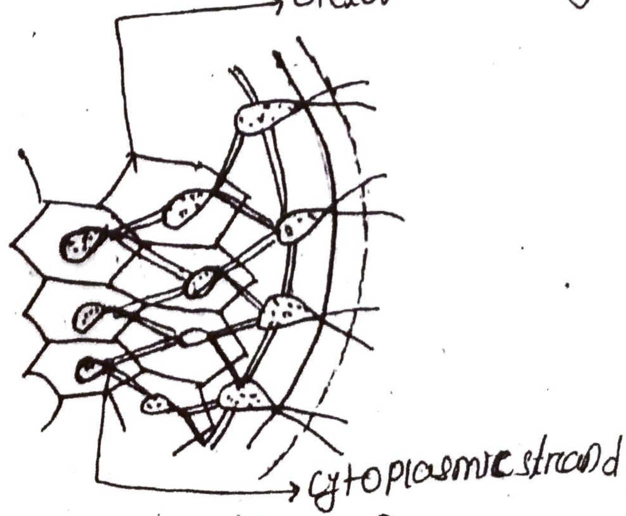


(A vegetative colony of volvox)



(A portion of vegitative colony)

DEVELOPEMENT OF DAUGHTER COLONY

PLAKEA STAGE

After the contraction of the protoplast, the gonidium divide longitudinally from anterior to posterior end the 2nd division is also longitudinal but right angle to the first division. so four no of cells are produced. The 3rd division is also longitudinal to form 8 cells which are curved plate like structure. This stage is known as plakea stage.

It is a flask shaped structure with an opening known as phiopore. It is directed towords the exterior of the mother coenobium. By further cell devision, the cell no increases to the required no of a particular species in this stage. the anterior end of each cell is directed towards the centre of the plakea.

INVERSION

The anterior flagellar end are situated towards the centre in the young daughter colony. The anterior end finally remains towords the exterior by the process of inversion. After inversion the cell return to their normal form. Each cell develop flagella and the cell are inter connected by cytoplasmic strands. The daughter colony may remain inside the mother colony or it may liborated through the opening.

The sexual reproduction is favourable at the end of the growing season. It is of oogamoou type. most of the species are monoecious & fewar dioecious. The reproductive organ is known as gamentangium. The male gametangium is antheridium and female gametangium is oogonium.

COLONY SHOWING IN THE DEVELOPMENT OF SPERM

The biflagellate cells perform to develope. The antheridium. They withdraw the flagella enlarges in size. The protoplast of the antheridium undergoes successive devision and produce 128 small conical. motile spermatozoids. They are grouped as bowl. shaped plate They from a hollow sphere like structure and undergoes inversion. After inversion the individual cell developed the flagella elongated or conical structure. The flagella are inserted apically at the long, pointed anterior end.

DEVELOPEMENT OF DAUGHTER COLONY

(i) PLAKEA STAGE

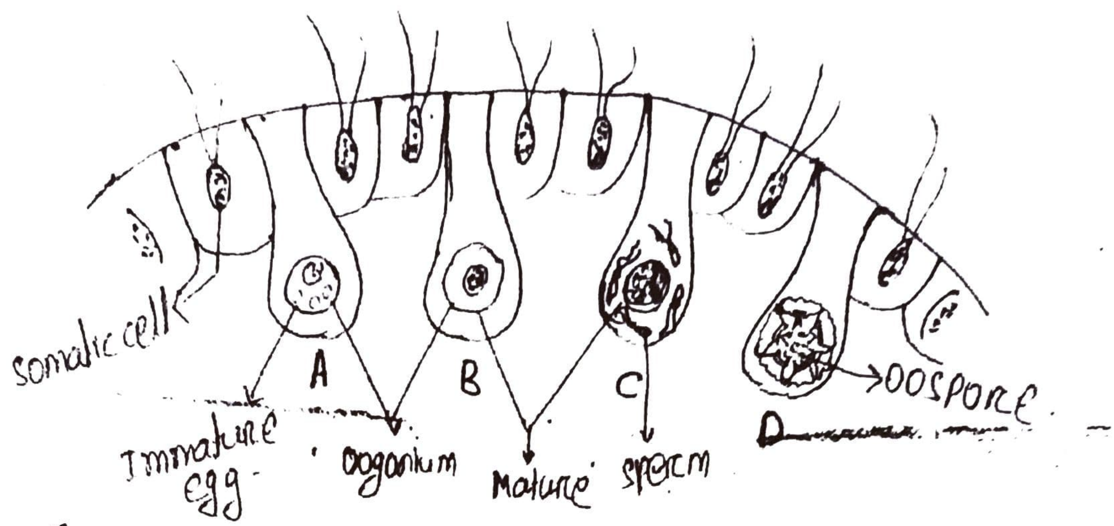
After the contraction of the protoplast, the gonidium devide longitudinally from anterior to posterior end the 2nd devision is also longitudinal but right angle to the first devision, so four no of cells are produced. The 3rd devision is also longitudinal to form 8 cells which are curved plate like structure. This stage is known as plakea stage.

It is a flask shaped structure with an opening known as phiopore. It is directed towords the exterior of the mother coenobium. By further cell devision, the cell no increases to the required no of a particular species in this stage, the anterior end of each cell is directed towards the centre of the plakea.

INVERSION

The anterior flagellar end are situated towards the centre in the young daughter colony. The anterior end finally remains towords the exterior by the process of inversion. After inversion the cell return to their normal form. Each cell develop flagella and the cell are inter connected by cytoplasmic strands. The daughter colony may remain inside the mother colony or it may liborated through the opening.

The sexual reproduction is favourable at the end of the growing season. It is of oogamo-



[STAGES IN THE DEVELOPMENT OF OOGONIUM]

A number of peripheral cell from the oogonium. They withdraw the flagella and enlarges in size. and looks like a gonidium. There is no division of protoplast. The entire protoplast of the oogonium metamorphosed into single non-flagellate green spherical egg or oosphere. It has a large central vacuole and a parietal chloroplast with many pyrenoids. The oosphere developa beak like which marks the point of entrance of the sperm.

FERTILIZATION

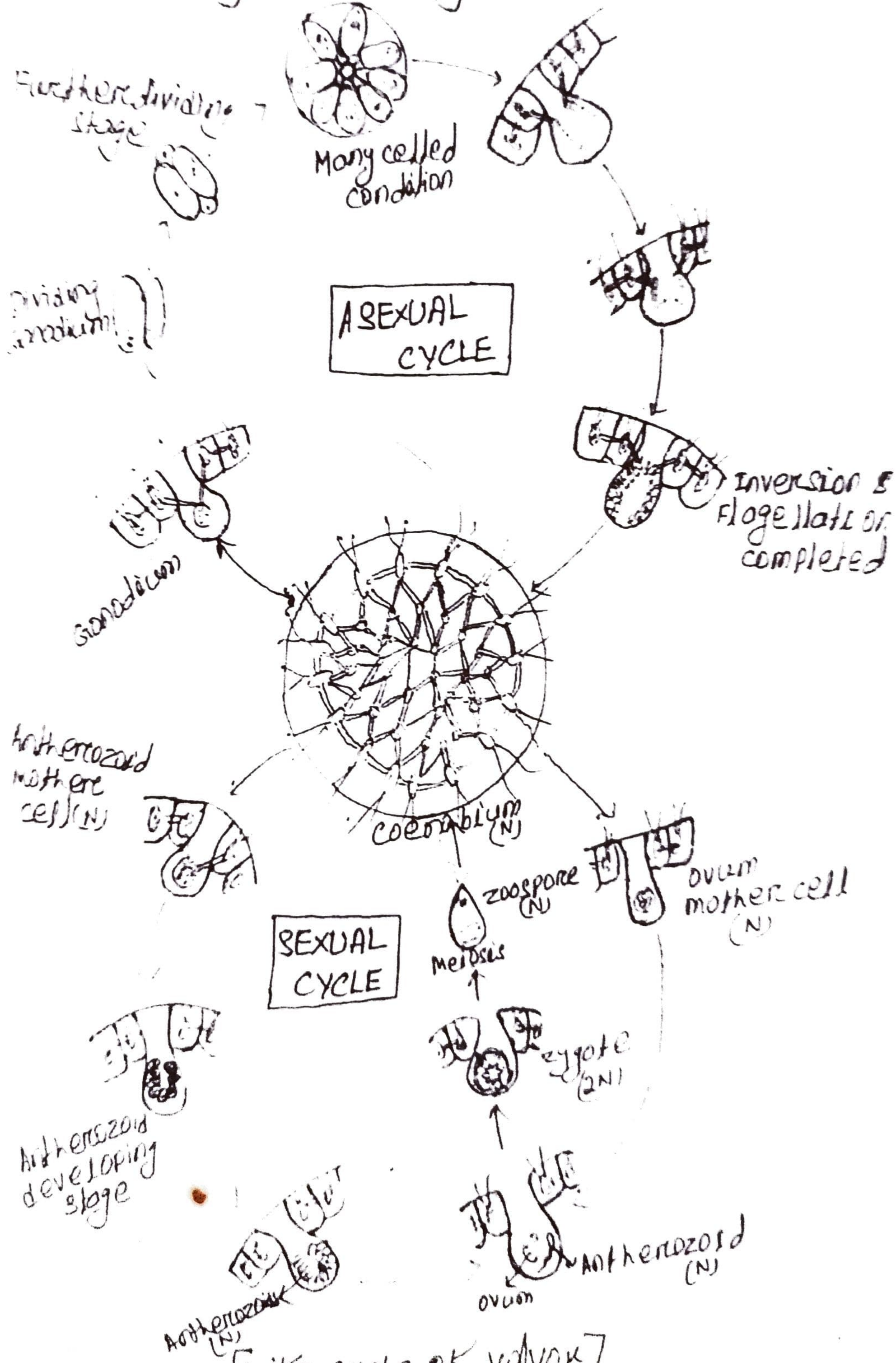
when the colony of antherozoid comes in contact with the oogonium, the antherozoids are separated. The motile antherozoids enter the oogonial cavity. one of the antherozoid enters into the oogonium and unit with the oosphere completely. As a result of fertilization the diploid oospore in formed inside the cavity.

GERMINATION OF OOSPORE

The oospore germinate with the return of favourable conditions for growth. The

* diploid nucleus of the oospore divide meiotically to form 4 haploid nuclei.

The protoplast divide longitudinal into 4 cell. The 4 cell structure by further cell division. plakea stage and inversion grows into a daughter colony.



[Life cycle of volvox]