

BOTANY

Microbiology & Plant Pathology

for

B.Sc. Sem. I

Chaudhary Charan Singh University, Meerut

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UNIT 1

Indian Ancient, Vedic & Heritage Botany

INDIAN ANCIENT, VEDIC AND HERITAGE BOTANY

India has a rich heritage in botany, with evidence from the Vedas, Samhitas, and archaeological findings from the Indus Valley Civilization. Ancient Indians understood the vital role of plants in life, medicine, agriculture, and culture.

📖 Vedic References to Plants

- **Rigveda** classifies plants as Vriksha (trees), Osadhi (herbs), and Virudh (creepers).
- **Atharvaveda** and **Yajurveda** offer systematic classifications and descriptions of medicinal plants, predating **Theophrastus**, the so-called father of botany.
- Plants like Soma, Peepal, and Sugarcane are frequently mentioned.
- Morphological classification includes traits like texture, shape, color, taste, and leaf type.

📖 Plant Morphology and Anatomy

- **Atharvaveda** categorizes trees based on growth habits.
- Texts describe plant parts (e.g., root, shoot, stem, bark, leaf, flower, fruit) using Sanskrit terms.
- **Parasara's Vrksayurveda** presents an early concept of xylem and phloem and detailed plant cell anatomy.

📖 Plant Physiology & Nutrition

- Ancient texts describe growth stages, movement, sleep, nutrition uptake, and sap ascent.
- **Vrksayurveda** explains photosynthesis-like processes involving water, air, and sunlight.

📖 Plant Pathology

- **Atharvaveda** and other texts detail plant diseases, pest attacks, and natural remedies, showing awareness of plant health and treatment.

📖 Sensitivity and Germination

- Ancient texts acknowledge plant sensitivity, seed structure (vija, vijakosa), and germination processes.
- Concepts of monocot and dicot seeds were recognized.

📖 Reproduction and Heredity

- Reproduction methods include cuttings, grafting, and seeds.
- Gender in plants was noted, e.g., male and female Ketaki.
- Early ideas of heredity resemble Darwin's concept of gemmules.

📖 Taxonomy and Nomenclature

Plants were named based on:

- Usage (e.g., medicinal, edible)
- Morphology (e.g., leaf shape, color)
- Local/environmental associations

- Names like Bodhidruma and Vakrapuspa reflect deep understanding and symbolism.

📖 Plant Classification

Classification by habit, morphology, utility, and family:

- Manu:** 8 types (e.g., Osadhi, Vanaspati, Vriksha, Trna)
- Charaka/Susruta:** Based on flowers, fruits, and longevity
- Parasara:** Advanced taxonomy with monocots/dicots and families like Leguminosae, Rutaceae, Cruciferae, and Compositae

📖 Medicinal Plants

- Texts like **Charaka Samhita** and **Susruta Samhita** include detailed botanical descriptions of hundreds of medicinal plants.

Classification and use of plants in Ayurveda were highly developed.

📖 Ancient Botanists and Ayurvedic Scholars:

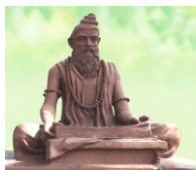
Acharya Charaka

- Known as the **Father of Indian Medicine**.
- Authored the **Charaka Samhita**, a foundational Ayurvedic text detailing diagnosis, treatment, anatomy, and dietetics.



Acharya Sushruta

- Regarded as the **Father of Surgery**.
- Wrote **Sushruta Samhita**, which describes over 300 surgical procedures, instruments, and medical classification systems.



Acharya Vagbhatta

- Authored **Ashtanga Hridaya** and **Ashtanga Sangraha**, systematic compilations of Ayurvedic knowledge focusing on eight branches of medicine.

Acharya Bangsen

- Known for **Bangsen Samhita** detailing Ayurvedic formulations.
- Other notable but partially lost Samhitas include those by **Bhela**, **Harita**, **Agnivesha**, **Jatukaran**, **Parashara** and **Ksheerapani**.

📖 Modern Indian Botanists and Scientists: Jagadish Chandra Bose (1858-1937)

- Demonstrated plant responses to stimuli; invented the crescograph.
- Pioneered studies in plant physiology and early radio science.



Prof. Birbal Sahni (1891-1949)

- Father of Indian Palaeobotany.**
- Studied fossil plants, founded the **Birbal Sahni Institute of Palaeobotany, Lucknow**; Fellow of the Royal Society.



M.O.P. Iyengar (1886-1963)

- Father of Indian Phycology.**
- Studied structure and reproduction of algae, described many new species.



Prof. Shiv Ram Kashyap (1882-1934)

- Father of Indian Bryology.**
- Worked extensively on liverworts and Himalayan flora; several species named after him.



Prof. K.C. Mehta (1892-1950)

- **Pioneer in plant pathology.**
- Studied wheat rust recurrence; proposed disease control through crop rotation.



Prof. Panchanan Maheshwari (1904-1966)

- **Father of Embryology in India.**
- Authored An Introduction to the Embryology of Angiosperms; founded International Society of Plant Morphologists.



Prof. A.K. Sharma (1924-2017)

- **Father of Indian Cytology.**
- Innovator in chromosome studies and cytogenetics; introduced Orcein staining method.

Dr. M.S. Swaminathan (1925-2023)

- **Father of the Green Revolution in India.**
- Developed high-yielding wheat varieties; global leader in food security and sustainable agriculture.



Prof. Vishambhar Puri (1909-2002)

- **Renowned plant morphologist.**
- Specialized in floral anatomy; authored History of Botany.



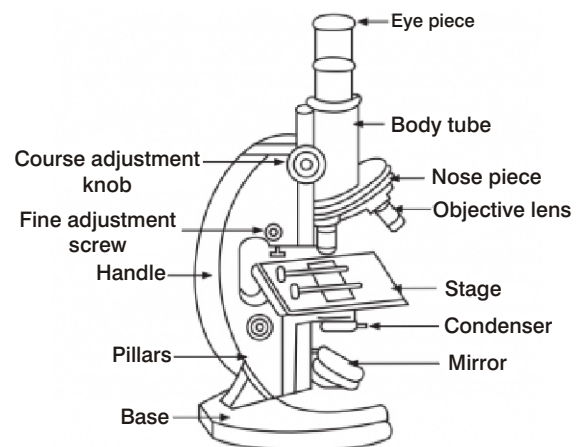
Prof. Ramdeo Misra (1908-1998)

- **Father of Indian Ecology.**
- Established India's first ecology school; founded the journal Tropical Ecology.

MICROBIAL TECHNIQUES & INSTRUMENTATION

Microscopy

Microscopy is the technique of viewing objects too small to be seen by the naked eye. The word "microscope" comes from "micro" (small) and "scope" (to look). It magnifies tiny specimens, allowing for detailed observation. The first microscope was developed by **Zaccharias Janssen** and **Hans Janssen** in 1590. Later, Antonie van Leeuwenhoek, a Dutch scientist, improved simple microscopes and discovered microorganisms in pond water, earning him the title "Father of Microbiology."



Compound Microscope

Principles of Microscopy

A microscope uses lenses, a light source, and mechanical parts. It works on two main principles-magnification and resolution. Magnification increases the apparent size of an object, while resolution refers to the ability to distinguish two nearby points as separate. Light microscopes can magnify objects up to 400X. The total magnification is calculated by multiplying the power of the objective lens and the eyepiece lens. The resolution depends on the wavelength of light and the numerical aperture of the lens. Abbe's formula for resolution is:

$d = \frac{\lambda}{2NA}$, where λ is the wavelength and NA is the numerical aperture.

Light Microscopy

Light or optical microscopes use visible light to magnify specimens. Light bends through lenses to form an image. These microscopes are of two types:

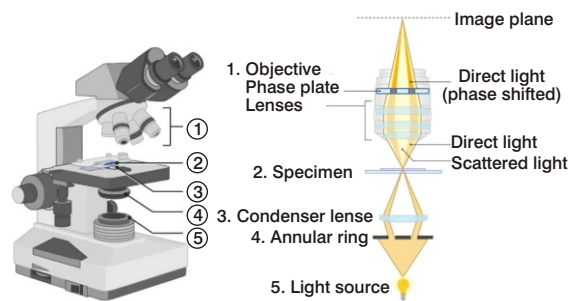
- **Simple microscope** - Uses one lens, magnifies up to 300X, and has low resolution (below 1 μ m).
- **Compound microscope** - Uses two lenses (objective and eyepiece), magnifies up to 2000X, and has higher resolution ($\sim 0.2 \mu$ m).

Types of Light Microscopes

1. **Bright-field microscope:** Gives dark images against a bright background.
2. **Dark-field microscope:** Gives bright images against a dark background, useful for live, unstained specimens.
3. **Fluorescence microscope:** Uses fluorescent dyes or naturally fluorescent materials that emit light when excited by specific wavelengths.
4. **Phase-contrast microscope:** Designed by Frits Zernike, it enhances contrast without staining, helpful in observing live, colorless cells.

Phase Contrast Microscopy

Invented by Frits Zernike, phase contrast microscopy is used to observe living, unstained cells. It works by converting differences in the phase of light passing through the specimen into contrast (visible differences). It helps in studying transparent structures like the nucleus and cytoplasm without the need for staining.



Phase Contrast Microscope

Staining Techniques for Light Microscopy

Staining improves the visibility of structures in light microscopy. Basic dyes like crystal violet or methylene blue bind to cell components. There are two major staining techniques:

- **Simple staining** - Uses one dye to color the specimen.
- **Differential staining** - Uses multiple dyes to distinguish between organisms, e.g., Gram staining (differentiates Gram-positive and Gram-negative bacteria) and Acid-fast staining (used for Mycobacterium species).

Staining helps identify cell parts and types of microbes under the microscope.

Staining Techniques

Staining helps in increasing contrast for better visibility. Some tissues absorb specific dyes and are called chromatic. Stains can be:

- Acidophilic (attracted to acidic dyes like eosin),

- Basophilic (attracted to basic dyes like methylene blue), or
- Amphophilic (stains with both types).

Types of Staining:

- **Simple staining:** Uses one dye (e.g., methylene blue) to stain cells.
- **Negative staining:** Uses acidic dyes like nigrosin, staining the background instead of the cells.

- **Differential staining:** Differentiates between cell types:

Gram staining: Classifies bacteria as Gram-positive (purple) or Gram-negative (red).

Acid-fast staining: Identifies Mycobacterium species (acid-fast cells appear red; others blue).

Comparison between Light microscope and Electron microscope

Features	Light Microscope	Electron Microscope
Invented by	It is believed that Dutch spectacles makers Zacharius Jansen and his father Hans were the first to invent the compound microscope in the 16th century.	In 1931 physicist Ernst Ruska and German engineer Max Knoll.
Illuminating source	Illuminating source is the Light. Uses light (approx wavelength 400-700 nm) to illuminate the objects under view.	Illuminating source is the beam of electrons. Uses a beam of electrons (approx equivalent wavelength 1 nm) to make objects larger for a detailed view.
Principle	The image is formed by the absorption of light waves.	The image is formed by scattering or transmission of electrons.
Lenses used	Lenses are made of glass.	Lenses are made of electromagnets.
Vacuum	Not used under a vacuum	Operates under a high vacuum
Specimen type	Fixed or unfixed, stained or unstained, living or non-living.	Fixed, stained, and non-living.
Specimen observed	Both live and dead specimens can be observed.	Only dead specimens are possible to be observed.
Specimen preparation	Less tedious and simple.	It generally involves harsher processes, e.g. using corrosive chemicals. More skill required – both to prepare specimens and to interpret EM images (due to artifacts).
Preparation time	Specimen preparation takes usually few minutes to hours.	Specimen preparation takes usually takes few days.
	Condenser, Objective and eye piece lenses are made up of glasses.	All lenses are electromagnetic.
	It has low resolving power (0.25µm to 0.3µm).	It has high resolving power (0.001µm), about 250 times higher than light microscope.
	It has a magnification of of 500X to 1500X.	It has a magnification of 100,000X to 300,000X.

Features	Light Microscope	Electron Microscope
Thickness of specimen	The object is 5µm or thicker.	The object is 0.1µm or thinner.
	Image is Colored.	Image is Black and White.
	Vacuum is not required.	Vacuum is essential for its operation.
	There is no need of high voltage electricity.	High voltage electric current is required (50,000 Volts and above).
	Filament is not used.	Tungsten filament is used to produce electrons.
	Radiation risk is absent.	There is risk of radiation leakage.
	Specimen is stained by colored dyes.	Specimen is coated with heavy metals in order to reflect electrons.
	Image is seen by eyes through ocular lens.	Image is received in Zinc Sulphate Fluorescent Screen or Photographic Plate.
	It is used for the study of detailed gross internal structure.	It is used in the study of external surface, ultra structure of cell and very small organisms.

Electron Microscopy

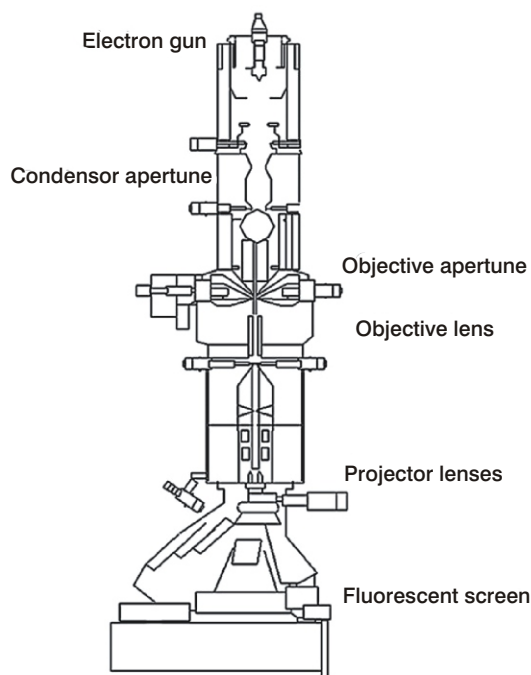
Electron microscopy (EM) provides very high-resolution images using an electron beam instead of light. It requires vacuum and uses electromagnetic lenses. EM helps in studying ultrastructure of cells and organelles. There are two main types:

Transmission Electron Microscopy (TEM)

In TEM, electrons pass through a very thin specimen. The image is formed on a fluorescent screen or digital camera. It offers high magnification and resolution (up to 50 million times). The sample must be fixed, dehydrated, embedded in resin, sectioned very thin (using ultramicrotome), and stained with heavy metals like uranium or lead. TEM provides detailed 2D images of internal structures.

Scanning Electron Microscopy (SEM)

SEM scans the surface of specimens with an electron beam. The emitted secondary electrons create a 3D image of the surface.



Transmission Electron Microscope

SEM is ideal for studying surface textures. It requires less sample preparation than TEM but provides lower resolution (up to 2 million times). Samples are coated with metals (gold/palladium) for better imaging.

Differences between SEMs and TEMs.

	SEM	TEM
Electron stream	Fine, focused beam	Broad beam
Image taken	Topographical/ surface	Internal structure
Resolution	Lower resolution	Higher resolution
Magnification	Up to 2,000,000 times	Up to 50,000,000 times
Image dimension	3-D	2-D
Sample thickness	Thin and thick samples okay	Ultrathin samples only
Penetrates sample	No	Yes
Sample restriction	Less restrictive	More restrictive
Sample preparation	Less preparation required	More preparation required
Cost	Less expensive	More expensive
Speed	Faster	Slower

Operation	Easy to use	More complicated; requires training
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Sample Preparation for Electron Microscopy

Electron microscopy requires special preparation since it operates in a vacuum and uses electron beams. The steps include:

1. **Fixation** - Stabilizing cells using chemicals like glutaraldehyde and osmium tetroxide.
2. **Dehydration** - Removing water using alcohol or acetone.
3. **Embedding** - Infiltrating specimen in resin like Araldite.
4. **Sectioning** - Cutting ultra-thin slices using a tool called ultramicrotome.
5. **Staining** - Using heavy metals (lead, uranium) to increase contrast.

For TEM:

- Fixation with aldehydes and osmium tetroxide.
- Dehydration using alcohol or acetone.
- Embedding in epoxy resin.
- Sectioning with ultramicrotome.
- Staining with heavy metals.

For SEM:

- Fixation with glutaraldehyde.
- Dehydration through ethanol series.
- Drying (Critical Point Drying).
- Coating with metal.
- Mounting on a metal stub for imaging.

COMMON MICROBIOLOGY EQUIPMENTS



Autoclave

An autoclave is a crucial equipment used in microbiology laboratories for sterilization. It is a pressurized chamber that uses moist heat (steam) to kill all forms of microbial life,

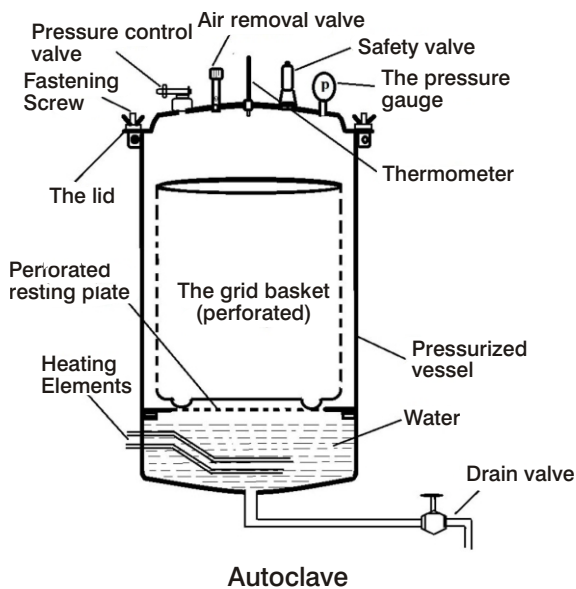
including spores. The working principle of the autoclave is based on the fact that steam under pressure increases the boiling point of water, allowing it to reach 121°C at 15 psi pressure, which is sufficient to destroy microorganisms. All the items to be sterilized

must come in direct contact with the steam for effective sterilization. It is widely used for sterilizing culture media, glassware, surgical instruments, and contaminated materials.

Principle: Uses moist heat sterilization (steam under pressure at 121°C, 15 psi for 15-20 mins) to kill microbes, including spores.

Working:

- Steam penetrates materials, denaturing proteins and nucleic acids.
- Used for sterilizing culture media, glassware, and surgical tools.
- **Types:** Gravity displacement, pre-vacuum.



Autoclave

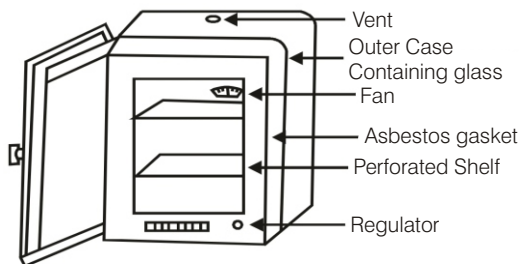
Hot Air Oven

The hot air oven is another sterilization device, but unlike the autoclave, it uses dry heat instead of steam. It operates on the principle of dry heat sterilization, where hot air is circulated within the oven to kill microorganisms through oxidative processes. The typical temperature used is 160-180°C for 2 hours. There are two types: forced air ovens, where fans distribute the heat evenly, and

static air ovens, where heat rises naturally. It is used for sterilizing materials that may be damaged by moisture, such as glassware, metal instruments, and powders.

Principle:

Dry heat sterilization at 160-180°C for 2 hours.



Hot Air Oven

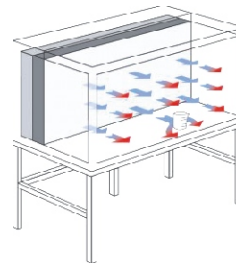
Working:

- Heat conduction kills microbes by oxidation.
- Ideal for glassware, metal instruments, and moisture-sensitive items.

Limitation: Not suitable for liquids or heat-labile materials.

Laminar Air Flow (LAF)

Laminar air flow is used to maintain a sterile environment during microbiological procedures. It works on the principle of providing a constant, unidirectional flow of sterile air over the workspace.



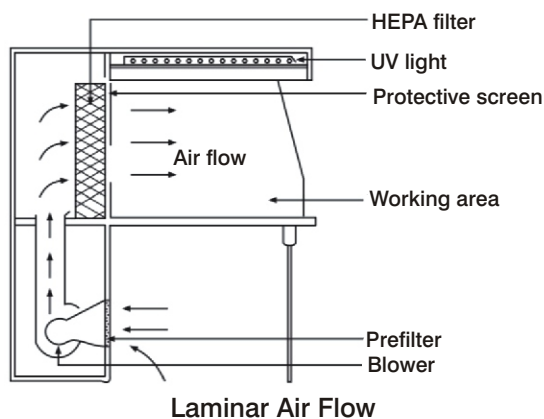
This air passes through HEPA filters that trap airborne contaminants. Laminar hoods are made of stainless steel and designed to minimize corners and joints to avoid microbial

buildup. The system must be turned on 15-20 minutes before use, and the surface cleaned with ethanol. It is commonly used for plant tissue culture, genetic transformation, and aseptic handling of materials.

Principle: Provides HEPA-filtered, sterile air (0.3 µm particles filtered) in a unidirectional flow.

Working:

- Vertical/Horizontal airflow prevents contamination during microbial cultures.
- Used in tissue culture, vaccine preparation, and sterile assays.



Centrifuge

A centrifuge is a device that uses centrifugal force to separate components of a liquid based on their density. When a sample is spun at high speed, denser particles move outward to the bottom of the tube while lighter ones remain at the top. This principle is called sedimentation. Laboratory centrifuges are commonly used to separate blood components, cell organelles, nucleic acids, and proteins. Angled tubes in tabletop centrifuges reduce the distance particles need to travel, making separation more efficient.

Principle: Separates particles using centrifugal force ($RCF = 1.118 \times 10^{-5} \times r \times RPM^2$).



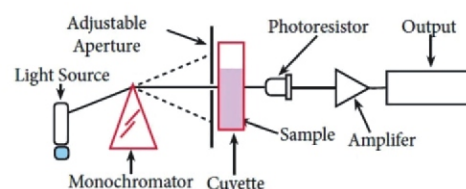
Centrifuge

Types & Uses:

- **Low-speed:** Cell harvesting (500-5,000 RPM).
- **High-speed:** Organelle isolation (10,000-30,000 RPM).
- **Ultracentrifuge:** Virus/DNA separation (>50,000 RPM).

Colorimetry

Colorimetry is an analytical technique based on the Beer-Lambert Law, which states that the absorbance of light by a colored solution is proportional to the concentration of the solute and the path length. A colorimeter consists of a light source, monochromator, cuvette holder, and detector. It measures the intensity of transmitted light and converts it into absorbance values. This method is used in clinical biochemistry to measure substances like glucose, proteins, or enzymes, and also in environmental testing and food quality control.



Colorimetry

Principle: Measures light absorbance by samples at specific wavelengths.

Working:

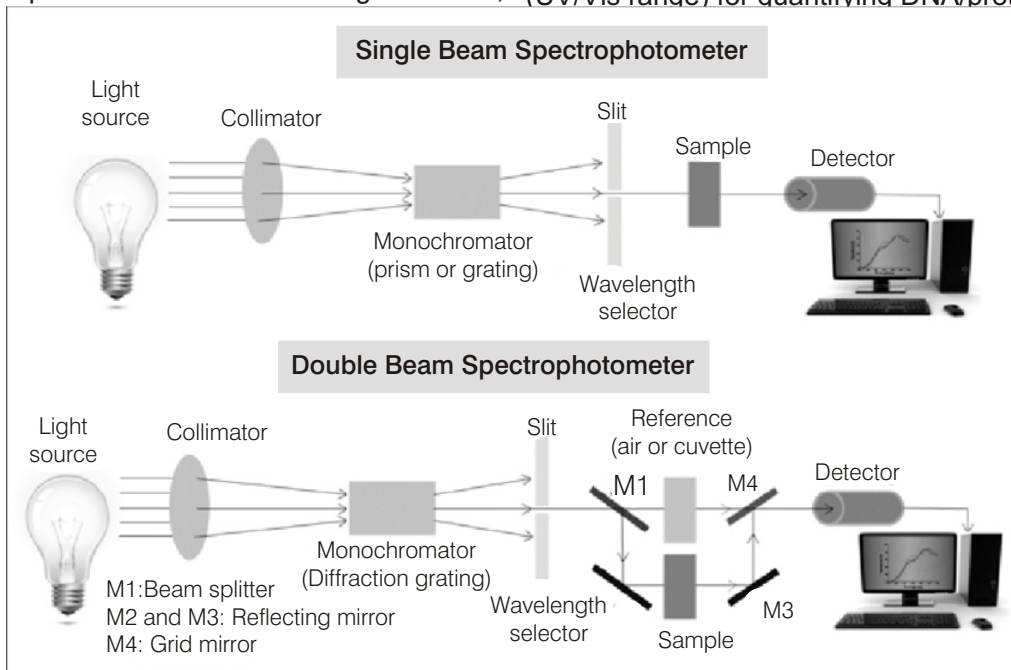
- **Colorimeter:** Uses filters (e.g., 540 nm for bacterial growth).
- **Applications:** Microbial growth curves, enzyme assays.

☞ Spectrophotometry

Spectrophotometry extends the principles of colorimetry by analyzing light absorption across a range of wavelengths. It can be used in UV, visible, and infrared regions. A spectrophotometer includes a light source,

monochromator to isolate specific wavelengths, a sample holder, and a photodetector. It is used to determine the concentration and properties of compounds, such as DNA, RNA, proteins, and even pollutants. There are single-beam and double-beam spectrophotometers, and specialized types like fluorescence or atomic absorption spectrophotometers for advanced applications.

Spectrophotometer: Monochromatic light (UV/Vis range) for quantifying DNA/proteins



Spectrophotometry

IMMOBILIZATION METHODS IN MICROBIOLOGY & BIOTECHNOLOGY



Immobilization refers to the confinement or attachment of cells/enzymes to a solid support or matrix, allowing their repeated use while maintaining catalytic activity.

Applications

- **Food Industry:** Immobilized lactase for lactose-free milk.
- **Biofuels:** Yeast cells immobilized for ethanol production.
- **Wastewater Treatment:** Bacteria entrapped in beads degrade pollutants.
- **Medicine:** Enzymes like asparaginase (cancer therapy) immobilized for stability.

Common Methods

Method	Principle	Example	Advantages	Disadvantages
Adsorption	Cells/enzymes bind to surfaces via weak forces (ionic/hydrophobic).	Yeast on alginate beads.	Simple, low cost.	Leakage of enzymes.
Encapsulation	Trapped within a porous matrix (e.g., gel, fibers).	Lactase in calcium alginate beads.	High stability, protects cells.	Diffusion limitations.
Covalent Bonding	Enzymes chemically linked to carriers (e.g., cellulose, chitosan).	Glucose isomerase on silica.	No leakage, reusable.	Complex, may reduce activity.
Cross-linking	Enzymes/cells linked together using glutaraldehyde.	Lipase cross-linked with glutaraldehyde.	No support needed.	May denature enzymes.
Entrapment	Cells enclosed in polymer networks (e.g., polyacrylamide).	Pseudomonas in polyacrylamide gel.	Protects from harsh conditions.	Substrate diffusion issues.

Key Concepts for Exams**Advantages of Immobilization:**

- Reusability, stability, continuous processing.

Disadvantages:

- Reduced enzyme activity, high cost for covalent methods.

Examples:

- **Alginate beads:** Most common for microbial cell immobilization.
- **Glutaraldehyde:** Used for cross-linking enzymes.

FERMENTATION AND FERMENTERS

**🔍 Fermentation**

Fermentation is a metabolic process carried out by microorganisms where organic substances like glucose are broken down anaerobically (without oxygen) to produce energy, along with alcohol, organic acids, or gases. It is a form of catabolism where the end products depend on the type of microorganism and substrate used. The most common fermentation pathways are alcoholic fermentation (used by yeast to produce ethanol) and lactic acid fermentation (used by some bacteria). Fermentation is vital for the production of bread, beer, wine, yogurt, antibiotics, enzymes, amino acids, and more.

Types of Fermentation based on Products

Type	Microbe Used	End Product	Application
Alcoholic	<i>Saccharomyces cerevisiae</i>	Ethanol, CO ₂	Beer, wine, biofuel production.
Lactic Acid	<i>Lactobacillus</i>	Lactic acid	Yogurt, cheese, pickles.
Acetic Acid	<i>Acetobacter</i>	Acetic acid (vinegar)	Vinegar, food preservatives
Citric Acid	<i>Aspergillus niger</i>	Citric acid	Food additives, soft drinks.

Types of Fermentation

There are different types of fermentation based on how the process is carried out:

- **Batch Fermentation:** All nutrients are added at the start, and the fermentation continues until nutrients are exhausted.
- **Fed-Batch Fermentation:** Substrates are added in intervals to prolong the growth and production phase.
- **Continuous Fermentation:** Fresh medium is continuously added, and the product is continuously removed. This allows for a steady-state production.

Each method has its advantages depending on the product yield, type of microorganism, and production cost.

Fermenters (Bioreactors)

A fermenter, also known as a bioreactor, is an equipment used to cultivate microorganisms under controlled conditions to carry out fermentation on a large scale. A fermenter maintains optimal conditions such as temperature, pH, oxygen supply (aeration), agitation (stirring), and nutrient availability to maximize microbial growth and product formation. It is designed to prevent contamination and ensure sterile conditions throughout the process.

Types of Fermenters

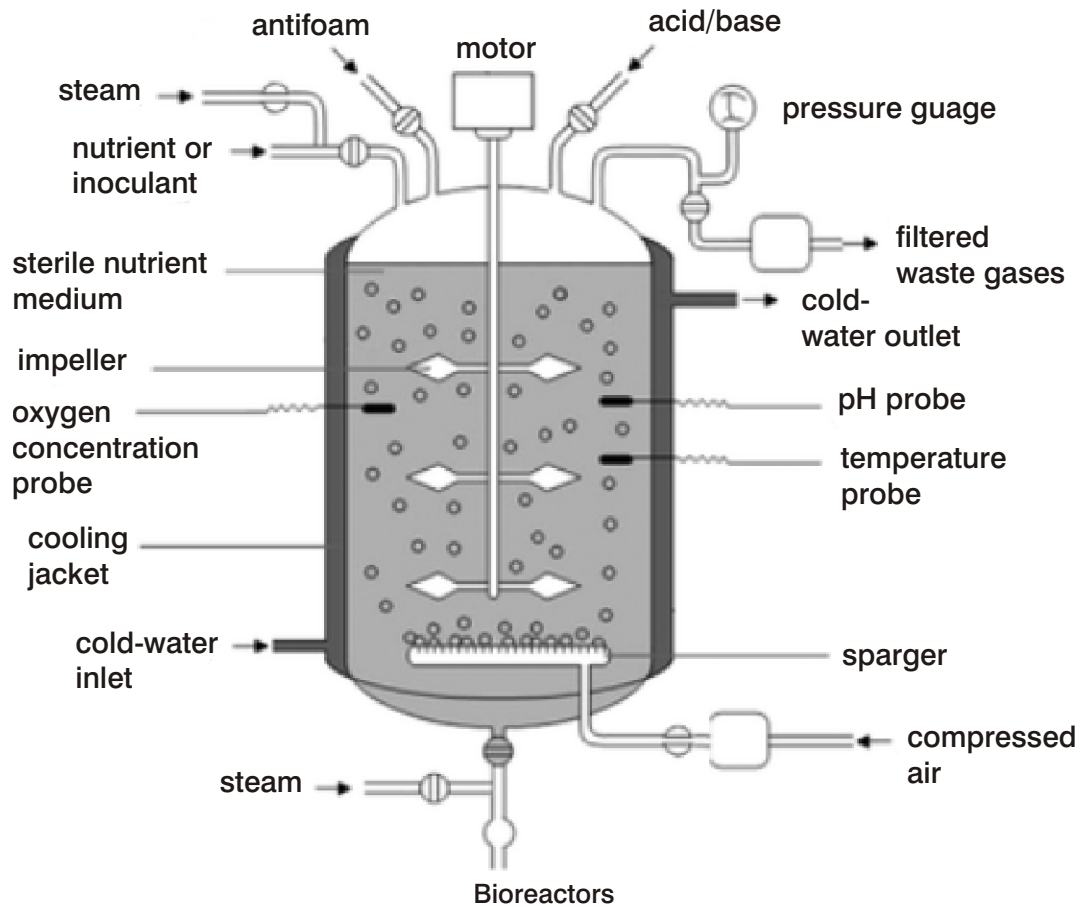
- **Simple fermenter (e.g., shaking flask):** Used in small-scale labs.
- **Stirred-tank fermenter:** Most commonly used in industries; it uses a motor-driven impeller for mixing.
- **Airlift fermenter:** Uses air or gas for circulation instead of mechanical stirring.
- **Packed bed and fluidized bed fermenters:** Used for immobilized enzymes or cells.

Each fermenter design is selected based on the type of fermentation (aerobic or anaerobic) and the nature of the product.

Applications of Fermentation and Fermenters

Fermentation is widely used in food and beverage production (bread, yogurt, alcohol), pharmaceutical industries (antibiotics like penicillin), and biotechnology (enzyme production,

vaccine manufacturing). Fermenters allow large-scale production of microbial products with high efficiency, sterility, and quality control.



QUESTIONS



Section A: Very Short Answer Type Questions

1. Match the following

(CCSU 2021, MSU 2021, 2022)

1. Acharya Charak	A. Father of Botany
2. Acharya Susruta	B. Morphology
3. Acharya Vagbhatta	C. Bangsen Samhita
4. Acharya Bangsen	D. Susruta Samhita
5. Prof. V. Puri	E. Charak Samhita
6. Theophrastus	F. Ashtanga Hridaya

1 2 3 4 5 6
(a) E D F C B A
(c) C D E F A B

1 2 3 4 5 6
(b) A B C D E F
(d) F E D C B A

Ans. (a)

2. Match the following

1. Vrksayurveda	A. M.S. Swaminathan
2. Ashtang Sangraha	B. Birbal Sahni
3. Crescograph	C. Parasara
4. Father of Green Revolution	D. K.C. Mehta
5. A paleobotanist	E. Vagbhatta
6. Studies on wheat rusts in India	F. J. C. Bose

1 2 3 4 5 6
(a) A B C D E F
(c) C E F A B D

1 2 3 4 5 6
(b) F E D C B A
(d) A B D C E F

Ans. (c)

3. What is Vrikshayurveda?

(CCSU 2021)

Ans. Vrikshayurveda is an ancient Sanskrit text (attributed to Parashara, ~400 CE) that systematically documents plant science. It covers plant classification, soil science, propagation techniques, pest control, and medicinal uses of plants, serving as India's earliest scientific treatise on arboriculture and agriculture.

4. Name two medicinal plants described in Atharva Veda.

(CCSU 2022)

Ans. Brahmi (*Bacopa monnieri*): Used for enhancing memory and treating neurological disorders.

Haritaki (*Terminalia chebula*): A rejuvenating herb used in digestive formulations.

5. Who wrote "Charaka Samhita"? Mention its importance in ancient botany. (CCSU 2019)

Ans. Authored by Acharya Charaka (3rd century BCE). Its botanical importance lies in:

- Classification of 350+ medicinal plants into Vanaspati (trees), Virudh (creepers), and Oshadhi (herbs).
- Detailed documentation of plant-based medicines and their therapeutic uses.

6. What is the significance of "Soma" in Rig Veda? (CCSU 2020)

Ans. Soma was a sacred plant (identity debated - possibly Ephedra or Amanita muscaria) used in Vedic rituals. It was:

- Personified as a deity in Rig Veda (Book 9 dedicated to Soma).
- Believed to grant immortality and divine connection to priests.
- Used to prepare a ritual drink with stimulant properties.

7. Define "Panchavati" and list its five sacred trees. (CCSU 2021)

Ans. Definition: A sacred grove of five trees in Hindu tradition, symbolizing ecological harmony.

Trees:

- | | |
|--|---|
| 1. Peepal (<i>Ficus religiosa</i>) | 2. Banyan (<i>Ficus benghalensis</i>) |
| 3. Bel (<i>Aegle marmelos</i>) | 4. Ashoka (<i>Saraca asoca</i>) |
| 5. Amla (<i>Phyllanthus emblica</i>) | |

8. How did sacred groves help in biodiversity conservation? (CCSU 2023)

Ans. Sacred groves conserved biodiversity by:

- Protecting endemic species through religious taboos (e.g., Khasi groves in Meghalaya).
- Preserving old-growth forests untouched by human interference.
- Maintaining microclimates and groundwater recharge zones.

9. Name the instrument invented by J.C. Bose to study plant growth. (CCSU 2018)

Ans. Crescograph: A high-precision device that could measure plant growth at resolutions of 1/100,000 inch per second, proving plants respond to stimuli.

10. What was Birbal Sahni's contribution to Indian palaeobotany? (CCSU 2022)

Ans. Pioneered study of fossil plants:

- Discovered Gondwana-era plant fossils.
- Established the Birbal Sahni Institute of Palaeosciences (Lucknow).
- Reconstructed extinct species like *Homoxylon rajmahalense*.

11. Give two examples of crops improved by M.S. Swaminathan. (CCSU 2021)

Ans.

- **Sharbati Sonora wheat:** High-yielding dwarf variety.
- **IR8 rice:** Semi-dwarf variety that boosted production during Green Revolution.

12. Why is Janaki Ammal considered a pioneer in Indian botany?

(CCSU 2020)

Ans. First Indian woman to earn a PhD in Botany (Michigan, 1931).

Key achievements:

- Chromosome studies of sugarcane-*Saccharum spontaneum* hybrids.
- Authored "Chromosome Atlas of Cultivated Plants".
- Worked at Royal Horticultural Society, UK before returning to India.

13. Write Short note on Acharya Charaka

Ans. Acharya Charaka, ancient Indian physician is referred to as the **Father of Indian medicine**. He is best known for his work (2nd century BCE to 2nd century CE). in compiling the **Charaka Samhita**, an ancient Sanskrit text on Ayurveda

14. Write Short note on Acharya Sushruta'

Ans. Acharya Sushruta's principal work (6th century BCE to 7th century CE) is the **Sushruta Samhita**, an ancient Sanskrit text on medicine and surgery.

15. Write Short note on Acharya Vagbhatta

Ans. Acharya Vagbhatta, was an ancient Indian physician and author who made significant contributions to the field of Ayurveda, particularly through his two major works, the **Ashtanga Hridaya** and the **Ashtanga Sangraha**.

16. Write Short note on Acharya Bangsen

Ans. Bangsen Samhita of **Acharya Bangsen** contains information on various Ayurvedic formulations.

17. Write Short note on Jagadish Chandra Bose

Ans. Jagadish Chandra Bose was an Indian scientist who made many important contributions to physics, biology, and plant physiology. He showed that plants can respond to electrical stimuli. He invented the *crescograph*, a device for measuring the growth of plants.

18. Write Short note on Birbal Sahni

Ans. Birbal Sahni (Father of Palaeobotany in India) made significant contributions to the study of plant fossils in India. He was also a founder of the **Birbal Sahni Institute of Palaeobotany in Lucknow**.

19. Write Short note on M.O.P. Iyengar

Ans. M.O.P. Iyengar (Father of Indian Phycology) made significant contributions to the study of algae in India. He described a new genus of algae from India and named it ***Frittschiella*** in honor of his guide Prof. F.E. Fritsch.

20. Write Short note on Shiv Ram Kashyap

Ans. Shiv Ram Kashyap (Father of Indian Bryology) made significant contributions in the areas of liverworts. He wrote a famous book "**Liverworts of Western Himalayas and Punjab Plains**".

21. Write Short note on K.C. Mehta

Ans. K.C. Mehta was famous plant pathologist of India. His pioneering work was on annual recurrence of wheat rust in the Northern plains of India.

22. Write Short note on P. Maheshwari

Ans. P. Maheshwari popularly known as the **Father of Embryology in India** was born in 1904 in Jaipur. He wrote a book on Plant Embryology entitled "**An Introduction to the Embryology of Angiosperms**".

23. Write Short note on Dr. M.S. Swaminathan

Ans. Dr. M.S. Swaminathan is popularly known as the **Father of the Green Revolution in India**. He developed several high-yielding dwarf wheat varieties like **Sonora 64, Lerma Rojo-64 A, Malvika, Sonalika, Sharbati Sonora**, and **Kalyan Sona** that enhanced the wheat production manifolds.

24. Write Short note on Arun Kumar Sharma

Ans. Arun Kumar Sharma, made contribution in the field of cytogenetics, cell biology, and cytochemistry, left an indelible mark on the scientific community. He is regarded as the **Father of Cytology in India**.

25. Write Short note on Prof. V. Puri,

Ans. Prof. V. Puri, a legendary **Plant Morphologist** from north India was born in 1909 in Nagina (Bijnor) Uttar Pradesh. He was professor and Head of Botany Department at C.C.S. University Meerut (1969-1972)

26. Write Short note on Professor R. Mishra

Ans. Professor R. Mishra, Father of Ecology in India, was born in 1908 in the town of Dobhi, situated in the Jaunpur district of Uttar Pradesh. He was associated with "**Tropical Ecology**."

27. What is the resolving power of a light microscope?

(CCSU 2021)

Ans. The resolving power of a light microscope is its ability to distinguish two closely spaced objects as separate entities.

- It is typically about 0.2 micrometers (μm), meaning objects closer than this cannot be distinguished.
- It depends on the wavelength of light and the numerical aperture of the objective lens.

28. Why is oil immersion used in light microscopy?

(CCSU 2022)

Ans. Oil immersion is used to increase the numerical aperture of the objective lens by reducing light refraction between the glass slide and the lens.

- The immersion oil has a refractive index similar to glass.
- This allows more light to enter the lens, improving resolution and image clarity.

29. Differentiate between bright field microscopy and phase contrast microscopy.

(CCSU 2019)

Ans.

Feature	Bright-Field Microscopy	Phase Contrast Microscopy
Light Source	Direct transmitted light	Uses phase-shifted light
Contrast Mechanism	Natural contrast or staining	Optical differences in refractive index
Sample Requirement	Often stained (dead cells)	Live, unstained cells
Image Appearance	Low contrast for transparent cells	High contrast images of internal structures

30. Name two stains used for bacterial capsule visualization.

(CCSU 2020)

Ans. Two stains used for visualizing bacterial capsules are:

1. India Ink (Negative stain)
2. Congo Red (Negative stain)

Note: Capsules appear as clear halos around stained cells because they do not take up the dye.**31. What is the role of ultramicrotomy in TEM sample preparation?**

(CCSU 2023)

Ans. Ultramicrotomy is the process of cutting ultra-thin sections (50-100 nm thick) of biological or material samples using an ultramicrotome.

- These thin sections are essential for transmission electron microscopy (TEM) because electrons cannot penetrate thick samples.
- It ensures high-resolution imaging of internal structures like organelles or nanomaterials.

32. Write a note on principle and working of autoclave.

(CCSU 2024, 2018)

Ans. Autoclave sterilization works on the principle of moist heat under pressure.

- Water boils at a higher temperature when pressure is increased (usually 121°C at 15 psi).
- This high-pressure steam kills bacteria, viruses, fungi, and spores by denaturing proteins and destroying cell structures.
- It is commonly used for sterilizing culture media, glassware, and surgical instruments.

33. Why is laminar airflow critical in tissue culture work?

(CCSU 2021)

Ans. Laminar airflow provides a sterile, particle-free environment using HEPA filters and unidirectional airflow.

- It prevents contamination from dust, microbes, and airborne particles during tissue culture.
- Ensures aseptic conditions while handling explants, media, and instruments.

34. What is the function of a refrigerated centrifuge?

(CCSU 2022)

Ans. A refrigerated centrifuge is used to separate biological components like cells, organelles, and proteins at low temperatures (usually 4°C).

- Cooling prevents heat-induced degradation of temperature-sensitive samples like enzymes, hormones, or DNA/RNA.
- Commonly used in molecular biology, biochemistry, and clinical labs.

35. How does a hot air oven differ from an autoclave?

(CCSU 2019)

Ans.

Feature	Hot Air Oven	Autoclave
Sterilization Type	Dry heat	Moist heat (steam under pressure)
Temperature	160–180°C for 1–2 hours	121°C at 15 psi for 15–20 minutes
Mode of Action	Oxidation of cell components	Protein denaturation
Uses	Glassware, metal instruments	Culture media, liquids, textiles

36. Give two examples of anaerobic culture systems.

(CCSU 2020)

Ans. Two examples of anaerobic culture systems are:

1. **GasPak Anaerobic Jar** - Uses chemical sachets to remove oxygen and generate anaerobic conditions.
2. **Anaerobic Chamber (Glove Box)** - A sealed workstation filled with inert gases (like nitrogen or hydrogen) for culturing anaerobic microbes.

37. Why is a blank tube used in spectrophotometry?

(CCSU 2023)

Ans. A blank tube is used to calibrate the spectrophotometer and zero the instrument before measuring sample absorbance.

- It contains all components of the sample except the analyte (e.g., solvent, buffer, reagents).
- It eliminates background absorbance from the medium or container, ensuring accurate measurement of the test sample.

38. List two natural matrices used for cell immobilization.

(CCSU 2019)

Ans. Two natural matrices used for cell immobilization are:

1. Alginate (Sodium alginate)
2. Gelatin

These are biodegradable, non-toxic, and widely used for entrapping cells or enzymes.

39. What are the advantages of immobilized enzyme systems?

(CCSU 2020)

Ans. Advantages of immobilized enzyme systems include:

- **Reusability:** Immobilized enzymes can be used multiple times, reducing cost.
- **Stability:** They are more stable against changes in pH and temperature.
- **Ease of separation:** Easily separated from the reaction mixture, simplifying purification.
- **Continuous operation:** Suitable for continuous bioreactor processes.

40. Name two industrial products produced using fed-batch fermentation. (CCSU 2021)

Ans. Two industrial products produced using fed-batch fermentation are:

1. Insulin (by recombinant *E. coli*)
2. Glutamic acid (an amino acid used as a flavor enhancer)

Fed-batch is used to control nutrient levels and avoid inhibitory byproducts during production.

Section B: Short Answer Type Questions

41. Write Short note on Light Microscope

Ans. A light microscope is any microscope that uses visible light to illuminate and image a specimen. Three Dutch spectacle makers—Hans Jansen, his son Zacharias Jansen, and Hans Lippershey—have received credit for inventing the compound microscope about 1590. The most familiar type of microscope is the optical, or light, microscope, in which glass lenses are used to form the image. Optical microscopes can be simple, consisting of a single lens, or compound, consisting of several optical components in line. The hand magnifying glass can magnify about 3 to 20 $\times$. Single-lensed simple microscopes can magnify up to 300 $\times$ —and are capable of revealing bacteria—while compound microscopes can magnify up to 2,000 $\times$. A simple microscope can resolve below 1 micrometre (μm ; one millionth of a metre); a compound microscope can resolve down to about 0.2 μm .

42. Write Short note on Phase contrast microscopy.

Ans. Phase contrast microscopy, first described in 1934 by Dutch physicist Frits Zernike, is a contrast-enhancing optical technique that can be utilized to produce high-contrast images of transparent specimens, such as living cells (usually in culture), microorganisms, thin tissue slices, lithographic patterns, fibers, latex dispersions, glass fragments, and subcellular particles (including nuclei and other organelles).

Transmission electron microscope (TEM), type of electron microscope that has three essential systems: (1) an electron gun, which produces the electron beam, and the condenser system, which focuses the beam onto the object, (2) the image-producing system, consisting of the objective lens, movable specimen stage, and intermediate and projector lenses, which focus the electrons passing through the specimen to form a real, highly magnified image, and (3) the image-recording system, which converts the electron image into some form perceptible to the human eye. The image-recording system usually consists of a fluorescent screen for viewing and focusing the image and a digital camera for permanent records. In addition, a vacuum system, consisting of pumps and their associated gauges and valves, and power supplies are required.

43. Write Short note on Scanning electron microscope (SEM).

Ans. Scanning electron microscope (SEM), type of electron microscope, designed for directly studying the surfaces of solid objects, that utilizes a beam of focused electrons of relatively low energy as an electron probe that is scanned in a regular manner over the specimen. No elaborate specimen-preparation techniques are required for examination in the SEM, and large and bulky specimens may be accommodated. It is desirable that the specimen be rendered electrically conducting; otherwise, a sharp picture will not be obtained. Conductivity is usually

achieved by evaporating a film of metal, such as gold, 50–100 angstroms thick onto the specimen in a vacuum

44. Write Short note on autoclave.

(CCSU 2024)

Ans. An autoclave is a machine that provides a physical method of sterilization by killing bacteria, viruses, and even spores present in the material put inside of the vessel using steam under pressure. The autoclave works on the principle of moist heat sterilization where steam under pressure is used to sterilize the material present inside the chamber. The water boils at 121°C at the pressure of 15 psi or 775 mm of Hg.

45. Write Short note on Laminar Air flow.

Ans. A Laminar Air flow hood/cabinet is an enclosed workstation that is used to create a contamination-free work environment through filters to capture all the particles entering the cabinet.

A High Efficiency Particulate Air (HEPA) Filter is the most important part of a LAFHHEPA filter removes 99.97% of 0.3µ or larger sized particles, thus removing most of the 0.5µ or larger sized airborne microorganisms. The ultraviolet light lamp, inside the laminar airflow chamber, kills germs and bacteria that escape the naked eyes.

46. Write Short note on centrifuge

Ans. A centrifuge is a lab instrument for the density-based separation of fluids, gas, or liquid. Refrigerated Centrifuges is used to analyze DNA, RNA, PCR, and antibodies because its temperature range is between -20 and -40 degrees Celsius.

47. Write Short note on Colorimeter.

Ans. Colorimeter refers to a device used in colorimetry that aids in the absorption of a particular wavelength of light by a specific sample solution. Colorimetry is used to evaluate the water's purity and screen for the presence of chemicals like cyanide, iron, fluorine, chlorine, molybdenum, etc.

48. Write Short note on spectrophotometer

Ans. A spectrophotometer is an instrument that measures the amount of photons (the intensity of light) absorbed after it passes through sample solution. With the spectrophotometer, the amount of a known chemical substance (concentrations) can also be determined by measuring the intensity of light detected. Depending on the range of wavelength of light source, it can be classified into two different types: UV-visible spectrophotometer: uses light over the ultraviolet range (185 - 400 nm) and visible range (400 - 700 nm) of electromagnetic radiation spectrum. IR spectrophotometer: uses light over the infrared range (700 - 15000 nm) of electromagnetic radiation spectrum.

49. Write a note on Immobilization methods.

(CCSU 2024)

Ans. Immobilization of enzymes (or cells) refers to the technique of confining/anchoring the enzymes (or cells) in or on an inert support for their stability and functional reuse. By employing this technique, enzymes are made more efficient and cost-effective for their industrial use. Some workers regard immobilization as a goose with a golden egg in enzyme technology. Immobilized enzymes retain their structural conformation necessary for catalysis.

50. Write short note on Fermentation

Ans. Fermentation is a metabolic process where microorganisms like yeast or bacteria convert sugars into other products, such as alcohol or acids, and gases like carbon dioxide. This process is essential in making foods and beverages like bread, beer, wine, and yogurt.

51. Write Short note on Fermenters

Ans. Fermenters A Fermenter is a device that is used to carry out the fermentation process utilising microorganisms, which is why it is also known as a “Fermenter or Bioreactor.” It contains all of the components required for the commercial synthesis of compounds such as antibiotics, enzymes, and drinks in a variety of sectors.

- **Ethanol** (Alcohol): Used in beer, wine, and spirits; produced by yeast.
- **Lactic Acid**: Found in yogurt, cheese, and pickles; produced by lactic acid bacteria.
- **Acetic Acid**: Key component of vinegar; produced by acetic acid bacteria.
- **Carbon Dioxide** (CO₂): Creates bubbles in carbonated drinks and helps bread rise; produced by yeast and bacteria.
- **Butyric Acid**: Contributes to the flavor of some cheeses; produced by specific bacteria.
- **Propionic Acid**: Gives Swiss cheese its distinctive holes and flavor; produced by certain bacteria.
- **Kefir**: Fermented milk beverage with a tangy flavor; made using kefir grains.

Section C: Long Answer Type Questions

52. Compare TEM and SEM in terms of principle, resolution, and applications. (CCSU 2022)

Ans.

Feature	Transmission Electron Microscope (TEM)	Scanning Electron Microscope (SEM)
Principle	Electron beam passes through ultra-thin specimens.	Electron beam scans the surface of the specimen.
Image Formation	Based on electrons transmitted through the sample.	Based on secondary electrons emitted from the surface.
Resolution	Higher (~0.1–0.2 nm)	Lower (~1–10 nm)
Specimen Requirement	Ultra-thin sections (~50–100 nm), usually fixed and stained.	Surface-coated (with gold or carbon); not sectioned.
Type of Image	2D, detailed internal structure.	3D, surface topography.
Vacuum Requirement	High vacuum	High vacuum (some models allow low-vacuum operation)
Applications	Studying cell organelles, viruses, nanomaterials.	- Observing cell surfaces, pollen grains, materials, insects.

53. Explain sample preparation for SEM with emphasis on critical point drying. (CCSU 2021)

Ans. Steps in SEM Sample Preparation:

1. **Fixation** Preserves structure using chemicals like glutaraldehyde.
2. **Dehydration** Gradual replacement of water with ethanol or acetone.
3. **Critical Point Drying (CPD)**
 - Avoids distortion from surface tension during drying.
 - Water is replaced with a transitional fluid (e.g., CO_2).
 - The fluid is brought to its critical point (e.g., for CO_2 : 31°C and 74 atm) where it behaves as both gas and liquid.
 - This allows drying without surface tension, preserving structure.
4. **Sputter Coating** Coating with a thin layer of gold or platinum to make the sample conductive.
5. **Mounting** Sample is mounted on a metal stub using carbon tape or glue.

Importance of Critical Point Drying:

- Prevents collapse or shrinkage of delicate biological samples.
- Maintains true surface morphology for accurate imaging in SEM.

54. Explain the working of a laminar airflow hood with a diagram. (CCSU 2020)

Ans. Working Principle: A laminar airflow hood (LAF) is a workstation that maintains a sterile, particle-free environment by directing air through HEPA filters in a unidirectional flow (either horizontal or vertical).

- HEPA filter (High-Efficiency Particulate Air) removes 99.97% of particles $0.3\ \mu\text{m}$.
- Air is drawn through a pre-filter, then forced through HEPA filter using a fan.
- The clean air flows across the work surface to prevent contamination during sterile procedures like tissue culture or media preparation.

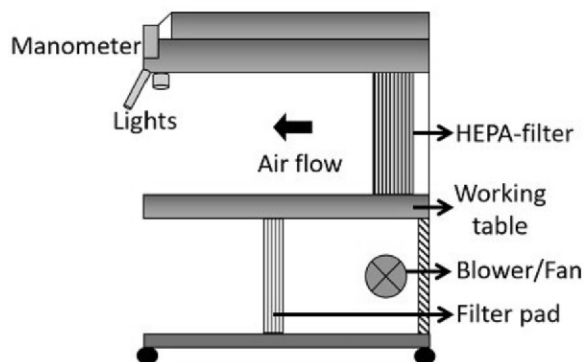
Key Features:

- UV light for sterilizing the chamber before/after use.
- Glass shield for protection.
- Stainless steel workspace (non-absorbent and easy to clean).

Applications:

- Microbiology and biotechnology labs.
- Plant and animal tissue culture.
- Preparation of sterile pharmaceutical products.

Horizontal Laminar Flow Cabinet



55. Compare batch, fed-batch, and continuous fermentation with examples. (CCSU 2022)

Ans.

Feature	Batch Fermentation	Fed-Batch Fermentation	Continuous Fermentation
Nutrient Supply	Added only at the beginning	Supplied in small quantities over time	Continuously supplied and removed
Operation Time	Closed system	Semi-closed system	Open system (steady-state)
Growth Phases	All growth phases observed	Prolongs log phase	Maintains log phase continuously
Control	Easier to manage	Requires careful monitoring	Complex control system needed
Example Products	Penicillin, wine	Insulin, glutamic acid	Ethanol, biomass production (algae)
Advantages	Simple, less contamination risk	High yield, extended productivity	Consistent product yield, efficient
Disadvantages	Low yield, downtime after each run	Risk of contamination increases	Costly setup, risk of washout

56. Discuss alginate-based immobilization of microbial cells. (CCSU 2019)

Ans. What is Immobilization?

Immobilization involves restricting the movement of cells or enzymes within a support or matrix while retaining their biological activity.

Alginate-Based Immobilization:

- Sodium alginate, a natural polysaccharide extracted from brown algae, is widely used for entrapment of microbial cells.

Procedure:

1. **Mixing:** Microbial cells are suspended in a sodium alginate solution (usually 2-4%).
2. **Bead Formation:** The mixture is dropped into a calcium chloride (CaCl_2) solution.
3. **Gelation:** Calcium ions crosslink the alginate chains to form calcium alginate beads, trapping the cells inside.
4. **Washing & Use:** The beads are washed and used in bioreactors or fermentation processes.

Advantages:

- Biocompatible and non-toxic.
- Gentle conditions preserve cell viability.
- Reusable and stable for extended fermentation runs.
- Suitable for aerobic and anaerobic microorganisms.

Applications:

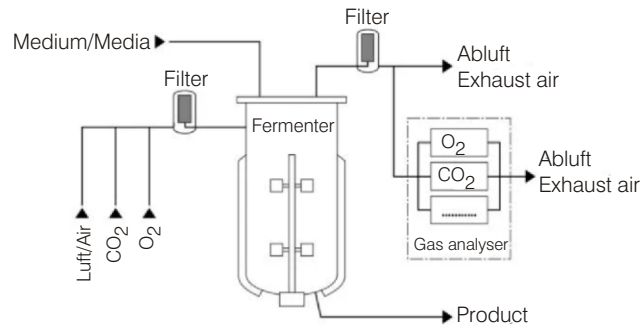
- Production of ethanol, acids, antibiotics, and enzymes.
- Bioremediation and wastewater treatment.

[Sodium Alginate + Cells] Drop into CaCl_2 Gel Beads Formed

57. Sketch a fermenter and mark its aeration and agitation systems.

(CCSU 2021)

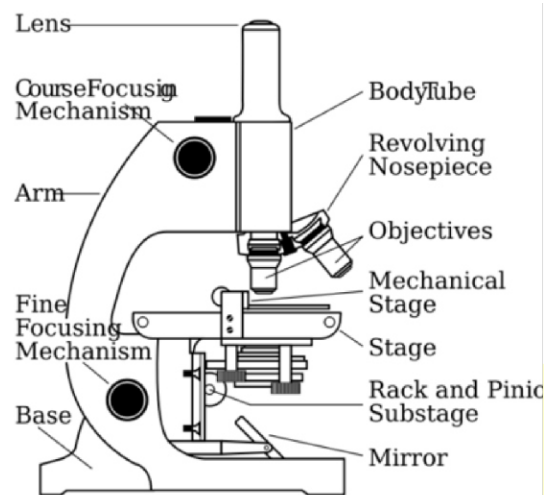
Ans.



58. Draw and label a compound microscope.

(CCSU 2020)

Ans.



59. Discuss the role of Atharva Veda in documenting medicinal plants.

(CCSU 2021)

Ans. The Atharva Veda (1200-1000 BCE) is among the oldest texts documenting medicinal plants in India. Its contributions include:

1. **Oshadhi Sukta (Hymn to Plants)**

- Reveres plants as divine healers (e.g., "Plants, you are mothers and healers").
- Lists hundreds of medicinal herbs with therapeutic properties.

2. **Key Medicinal Plants Mentioned:**

- Brahmi (*Bacopa monnieri*) - Memory enhancer.
- Aparajita (*Clitoria ternatea*) - Used for stress relief.
- Soma (Unknown species) - Used in rituals and medicine.

3. **Therapeutic Uses:**

- Antimicrobial: Neem (*Azadirachta indica*).

- Healing Wounds: Aloe vera.
- Digestive Aids: Haritaki (Terminalia chebula).

4. Ritualistic & Spiritual Healing:

- Plants like Tulsi (Holy Basil) were considered sacred.
- Chants (Mantras) were used to enhance plant healing properties.

Legacy:

- Basis for later Ayurvedic texts like Charaka Samhita.
- Influenced modern ethnobotany and herbal medicine research.

60. Describe the scientific contributions of Sir J.C. Bose in plant physiology. (CCSU 2022)

Ans. Sir Jagadish Chandra Bose (1858-1937) revolutionized plant physiology with his experimental innovations:

1. Discovery of Plant Electrophysiology

- Proved plants respond to stimuli (like animals) using electrical signals.
- Demonstrated "plant pain" through electrical impulse studies.

2. Invention of Crescograph (1901)

- A high-magnification device to measure plant growth (precision: 1/100,000 inch per second).
- Showed how plants react to light, temperature, and chemicals.

3. Key Experiments:

- **Effect of Poison:** Plants wilt when exposed to toxins, similar to animal distress.
- **Response to Music:** Plants grew faster with soothing sounds (early biophysics study).

4. Publications & Legacy:

- **Books:** Response in the Living and Non-Living (1902).
- **Impact:** Founded Bose Institute (1917), inspired modern plant neurobiology.

Conclusion:

Bose bridged botany and physics, proving plants have life processes comparable to animals.

61. Explain the Role of Sacred Groves in Ecological Conservation. (CCSU 2018)

Ans. Sacred groves (Devrai, Kavu) are forest patches protected by religious beliefs, playing a vital role in conservation:

1. Biodiversity Hotspots

- Preserve rare species (e.g., medicinal plants, endangered birds).
- Example: Myristica swamps in Kerala's sacred groves.

2. Soil & Water Conservation

- Prevent soil erosion with dense root systems.
- Recharge groundwater through natural percolation.

3. Climate Regulation

- Act as carbon sinks, reducing local temperatures.

- Maintain microclimates for agriculture.

4. Cultural & Scientific Value

- Ethnobotanical studies document traditional plant uses.
- Serve as gene banks for wild crop relatives.

Examples:

- Khasi groves (Meghalaya): Protect endemic orchids.
- Aravalli groves (Rajasthan): Prevent desertification.

Threats & Solutions:

- Deforestation, urbanization.
- Remedy: Legal protection (e.g., Biodiversity Act 2002).

Conclusion:

Sacred groves are nature's sanctuaries, blending ecology and culture for sustainable conservation.

62. Discuss the Contributions of Indian Women Botanists (e.g., Janaki Ammal). (CCSU 2021)

Ans. Indian women botanists broke barriers in plant sciences with pioneering work:

1. Dr. Janaki Ammal (1897-1984)

- First Indian woman PhD in Botany (University of Michigan, 1931).

Key Contributions:

- Sugarcane Hybridization: Crossbred Indian & African varieties for higher yield.
- Chromosome Studies: Authored "Chromosome Atlas of Cultivated Plants".
- Environmental Advocacy: Opposed deforestation in Silent Valley, Kerala.

2. Dr. E.K. Janaki Ammal (Notable Work in Cytogenetics)

- Researched brinjal (eggplant) genetics for disease resistance.

3. Dr. Archana Sharma (1932-2008)

Pioneer in Plant Cytogenetics:

- Studied rice and wheat chromosomes.
- First Indian woman Fellow of Royal Society (UK).

4. Dr. Suman Sahai (Modern Era)

- Founded Gene Campaign for farmers' rights over seeds.
- Advocated against GMO monopolies.

Challenges Faced:

- Gender bias in 1950s-70s scientific community.
- Limited funding for women-led research.

Legacy:

- Inspired girls in STEM (e.g., DBT's "Biotechnology Career Advancement for Women").
- Showcased women's role in agriculture and conservation.

Conclusion:

From Janaki Ammal's sugarcane hybrids to modern genetic research, Indian women botanists have been trailblazers in plant science.

63. How did M.S. Swaminathan contribute to the Green Revolution in India? (CCSU 2022)

Ans. M.S. Swaminathan, known as the "Father of the Green Revolution in India," played a pivotal role in transforming Indian agriculture during the 1960s and 1970s. His key contributions include:

- Introducing and promoting high-yielding varieties (HYVs) of wheat and rice, especially from Mexico and the Philippines.
- Advocating for the use of modern agricultural techniques such as chemical fertilizers, irrigation, and pesticides.
- Working with policy-makers to ensure infrastructure support, including credit facilities and distribution systems.
- Establishing research institutions like the Indian Council of Agricultural Research (ICAR) and leading the Indian Agricultural Research Institute (IARI).

His work significantly increased food grain production, making India self-sufficient in food and averting famines.

64. Evaluate Birbal Sahni's work in fossil botany. (CCSU 2019)

Ans. Birbal Sahni was a pioneering Indian paleobotanist who made foundational contributions to fossil botany. His key achievements include:

- Establishing the Birbal Sahni Institute of Palaeobotany in Lucknow in 1946, a premier institution for the study of ancient plant life.
- Studying and classifying plant fossils, particularly from the Gondwana period, which shed light on the evolution of plant life on the Indian subcontinent.
- Introducing modern techniques in fossil studies and linking paleobotany with geology and stratigraphy.
- His work helped understand India's prehistoric flora and contributed to the knowledge of continental drift and paleoclimatology.
- Sahni's research laid the foundation for future studies in paleobotany and earned him global recognition.

65. Comparison between Light microscope and Electron microscope

Ans.

Features	Light Microscope	Electron Microscope
Invented by	It is believed that Dutch spectacles makers Zacharius Jansen and his father Hans were the first to invent the compound microscope in the 16th century.	In 1931 physicist Ernst Ruska and German engineer Max Knoll.
Illuminating source	Illuminating source is the Light. Uses light (approx wavelength 400-700 nm) to illuminate the objects under view.	Illuminating source is the beam of electrons. Uses a beam of electrons (approx equivalent wavelength 1 nm) to make objects larger for a detailed view.

Principle	The image is formed by the absorption of light waves.	The image is formed by scattering or transmission of electrons.
Lenses used	Lenses are made of glass.	Lenses are made of electromagnets.
Vacuum	Not used under a vacuum	Operates under a high vacuum
Specimen type	Fixed or unfixed, stained or unstained, living or non-living.	Fixed, stained, and non-living.
Specimen observed	Both live and dead specimens can be observed.	Only dead specimens are possible to be observed.
Specimen preparation	Less tedious and simple.	It generally involves harsher processes, e.g. using corrosive chemicals. More skill required – both to prepare specimens and to interpret EM images (due to artifacts).
Preparation time	Specimen preparation takes usually few minutes to hours.	Specimen preparation takes usually takes few days.
	Condenser, Objective and eye piece lenses are made up of glasses.	All lenses are electromagnetic.
	It has low resolving power ($0.25\mu\text{m}$ to $0.3\mu\text{m}$).	It has high resolving power ($0.001\mu\text{m}$), about 250 times higher than light microscope.
	It has a magnification of 500X to 1500X.	It has a magnification of 100,000X to 300,000X.
Thickness of specimen	The object is $5\mu\text{m}$ or thicker.	The object is $0.1\mu\text{m}$ or thinner.
	Image is Colored.	Image is Black and White.
	Vacuum is not required.	Vacuum is essential for its operation.
	There is no need of high voltage electricity.	High voltage electric current is required (50,000 Volts and above).
	There is no cooling system.	It has a cooling system to take out heat generated by high electric current.
	Filament is not used.	Tungsten filament is used to produce electrons.
	Radiation risk is absent.	There is risk of radiation leakage.
	Specimen is stained by colored dyes.	Specimen is coated with heavy metals in order to reflect electrons.
	Image is seen by eyes through ocular lens.	Image is received in Zinc Sulphate Fluorescent Screen or Photographic Plate.
	It is used for the study of detailed gross internal structure.	It is used in the study of external surface, ultra structure of cell and very small organisms.