# Graduate attributes in Botany

The key attributes of a botany honours graduate may include the following:

**Fundamental aptitude:** Botany graduates are anticipated to possess a comprehensive understanding of the fundamental principles and theories in the field of botany and plant science. These essential concepts are based on the most current knowledge in the field that are subject to change. They need to be revised regularly and within specific timeframes.

**Communication skills:** To demonstrate a proficiency in communication that meets the minimal levels expected of a scientific graduate in the country. They are required to comprehend and grasp materials including comprehensive analysis and coherent arguments. Graduates are required to possess a high level of proficiency in articulating and conveying their ideas, findings, and concepts to a broad audience.

**Thinking ability:** Botany graduates are required to hold a solid understanding of critical thinking, which includes knowledge of cognitive biases, mental models, logical fallacies, scientific methods, and the ability to develop well-reasoned scientific arguments.

**Psychological capacity:** To have fundamental psychological aptitude necessary to confront the broader society, as well as the ability to interact with individuals and pupils from diverse sociocultural, economic, and educational backgrounds. Psychological skills encompass several techniques such as feedback loops, self-compassion, self-reflection, goal-setting, interpersonal interactions, and emotional control.

**Problem-solving attitude:** They are expected to possess problem-solving methodologies that are applicable across various fields of study, such as Occam's Razor.

**Analytical observant:** Able to construct persuasive arguments and identify logical fallacies, contradictions, circular reasoning, and other faults in erroneous arguments.

**Research skills:** Having a strong ability to carefully observe and analyse their natural environment, fostering a sense of curiosity. Graduates are required to create a scientific experiment using statistical hypothesis testing and other forms of a priori reasoning, such as logical deduction.

**Collaboration:** Possessing the ability to work effectively in teams, fostering constructive partnerships with individuals from various socio-cultural backgrounds.

**Digital Literacy:** Keeping digital literacy skills in order to participate in and enhance their core competency through e-learning resources such as MOOCs and other digital platforms for lifetime

learning. Graduates should possess the ability to identify instances of data fabrication and fake news through the application of logical scepticism and analytical reasoning.

**Moral and ethical consciousness:** To exhibit responsibility as citizens of India and possess a comprehensive understanding of the moral and ethical standards upheld by the country and the global community. They are expected to clearly articulate their fundamental ethical principles with sufficient precision in order to differentiate between actions that are deemed illegal and criminal according to the Indian constitution. Priority should be placed on academic and research ethics, encompassing equitable Benefit Sharing, Plagiarism, Scientific Misconduct, and other related areas.

**Leadership preparedness:** Having knowledge of the decision-making process and fundamental managerial abilities in order to enhance their leadership capabilities. Skills may encompass the ability to articulate a clear and compelling aim, vision, and mission, as well as the capacity to cultivate charisma and inspire others as a leader.

# Program Learning Outcomes (POs) in B.Sc with Botany as Major (NEP 2020)

The student who completes their studies with a Bachelor of Science degree with Botany as Major should be able to-

- Generate a strong knowledgebase in the subject of Botany, as well as related subject areas, ensuring their fundamental competency in these fields. The students will demonstrate the capability to categorise primary plant groups and analyse the distinguishing features of lower (e.g. algae and fungus) and higher (angiosperms and gymnosperms) plants, and elucidate diverse plant processes and functions, metabolic activities, concepts of genes and genome, as well as how the functioning of organisms is impacted at the cellular, tissue, and organ levels.
- Learn various hands-on techniques enabling them practically equipped for biotechnological industries.
- Showcase their proficiency in the experimental techniques and methodologies specific to their specialised field of Plant biology.
- Demonstrating their analytical proficiency i.e. their expertise in comprehending research and resolving practical issues.
- Utilize scientific methodologies to solve varied questions which involves establishing hypotheses, collecting data, and critically analysing the facts to determine the extent to which their scientific work corroborates their hypotheses.
- Develop enhanced critical thinking skills and acquire problem-solving aptitudes. Students will be gaining a deeper comprehension of fundamental concepts and their practical applications in scientific principles.
- Be advanced with digital skills and integrate core principles with modern technologies.
- Improve their ethical and moral views and develop the ability to address psychological vulnerabilities.
- Acquire collaboration and cooperation skills to work as a team thereby effectively contributing to institutions, industry, and society.

# POs in B.Sc with Botany as Major (NEP 2020)

**PO 1.** **Generate a strong knowledgebase in the subject**

**PO 2.** **Learn hands-on techniques for industrial applications**

**PO 3.** **Showcase the proficiency in the experimental techniques**

**PO 4.** **Demonstrating the analytical proficiency**

**PO 5.** **Utilize scientific methodologies to solve varied questions**

**PO 6.** **Develop enhanced critical thinking skills**

**PO 7.** **Be advanced with digital skills**

**PO 8.** **Improve their ethical and moral views**

**PO 9.** **Acquire collaboration and cooperation skills to work as a team**

## Course Learning Outcomes (COs)

### Plant diversity (BOT-H-CC1-1-Th, BOT-H-CC1-1-P)

CO 1. Acquire an understanding of various algal and fungal groups including their diagnostic characters, examples and economic value.

CO 2. Accomplish an idea of lichens, as well as a curiosity for the adaptive characteristics of these organisms.

CO 3. Demonstrate a grasp of bryophytes, their life history and economic importance.

CO 4. Gain knowledge of the morphology and reproduction procedures of pteridophytes, and gymnosperms

CO 5. Develop a foundation on the origin of plant cells and importance of plants as food, fuel etc.

CO 6. Acquire a grasp of angiosperm morphology, especially of flower and fruits.

CO 7. Grasp practical knowledges to the collection, systematic study and identification of plants.

## COs-POs Mapping

### Plant diversity (BOT-H-CC1-1-Th, BOT-H-CC1-1-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | √ | √ | | √ | | √ | √ |
| CO2 | √ | | | √ | √ | √ | | √ | √ |
| CO3 | √ | | | √ | | √ | | √ | √ |
| CO4 | √ | | | √ | √ | √ | √ | √ | √ |
| CO5 | √ | | | √ | | √ | | √ | √ |
| CO6 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO7 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

### Plant systematics (BOT-H-CC2-2-Th, BOT-H-CC2-2-P)

CO 1. The theory of plant systematics and recognize the significance of herbarium and virtual herbarium

CO 2. Evaluate the importance of herbaria and botanical gardens

CO 3. Interpret the rules of ICN in botanical nomenclature

CO 4. Learn the concepts associated with Numerical taxonomy and Phylogenetic classification.

CO 5. Generalize the characteristics of the families under the classification scheme developed by Bentham and Hooker.

CO 6. Grasp practical knowledges to the collection, systematic study and identification of plants.

## COs-POs Mapping

### Plant systematics (BOT-H-CC2-2-Th, BOT-H-CC2-2-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | √ | | √ | | √ | √ |
| CO2 | √ | | | √ | √ | √ | √ | √ | √ |
| CO3 | √ | | | √ | √ | √ | | √ | √ |
| CO4 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO5 | √ | | | √ | √ | √ | √ | √ | √ |
| CO6 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

### Economic Botany (BOT-H-CC3-3-Th, BOT-H-CC3-3-P)

CO 1. Develop a fundamental understanding of economic botany and be able to link to the environment, populations, communities, and biological ecosystems.

CO 2. Gain an in-depth comprehension of the development of the concept of organization of apex new crops and varieties, the significance of germplasm diversity, and the problems associated with access and ownership.

CO 3. Have a fundamental understanding of the taxonomic diversity and notable families of plants that are of practical utility.

CO 4. Raise people's awareness of and appreciation for the plants and plant products that they come into contact with in their daily lives.

CO 5. Recognize the wide variety of plant species and the varieties of plant products that are used by humans.

## COs-POs Mapping

### Economic Botany (BOT-H-CC3-3-Th, BOT-H-CC3-3-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | | √ | | √ | √ |
| CO2 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO3 | √ | | √ | √ | √ | √ | | √ | √ |
| CO4 | √ | | √ | √ | √ | √ | √ | √ | √ |
| CO5 | √ | √ | √ | √ | √ | √ | | √ | √ |

## Course Learning Outcomes (COs)

### Plant Anatomy and Embryology (BOT-H-CC4-3-Th, BOT-H-CC4-3-P)

CO 1. Develop an awareness of the ideas and fundamentals of plant internal structure.

CO 2. Study the internal anatomy underlying plant systems and organs.

CO 3. Acquire a critical grasp of the development of the ideas behind the organization of the root apex and the shoot.

CO 4. Conduct an investigation of the composition of various plant sections and the interactions between them.

CO 5. Conduct an analysis of the capacities of plants to adapt and protect themselves.

CO 6. Understand the fundamental processes of the fertilization in angiosperm

CO 7. Analyze and recognize the different organs of plant involved in reproduction.

CO 8. Evaluate the structural organization of flower and the process of pollination.

CO 9. Understand the concept and evidences of Apomixis & Polyembryony.

## COs-POs Mapping

### Plant Anatomy and Embryology (BOT-H-CC4-3-Th, BOT-H-CC4-3-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | √ | √ | | √ | √ |
| CO2 | √ | | | √ | √ | √ | | √ | √ |
| CO3 | √ | | | √ | | √ | | √ | √ |
| CO4 | √ | | √ | √ | | √ | √ | √ | √ |
| CO5 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
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| CO9 | √ | | | √ | √ | √ | | √ | √ |

## Course Learning Outcomes (COs)

### Phycology (BOT-H-CC5-4-Th, BOT-H-CC5-4-P)

CO 1. Learn different groups of algae with their diagnostic and reproductive features.

CO 2. Know life cycle patterns of various representative algal members.

CO 3. Assess the ways in which algae and algal products can be used as source of food and fuel.

CO 4. Understand the cultivation methods of algae including photo-bioreactors and open ponds

CO 5. Learn the strategies of biofuel production and carbon capture and sequestration using algae

CO 6. Collect and identify algae from natural habitats.

## COs-POs Mapping

### Phycology (BOT-H-CC5-4-Th, BOT-H-CC5-4-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | | √ | | √ | √ |
| CO2 | √ | | | √ | √ | √ | √ | √ | √ |
| CO3 | √ | | √ | √ | √ | √ | √ | √ | √ |
| CO4 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO5 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO6 | √ | | √ | √ | √ | √ | | √ | √ |

## Course Learning Outcomes (COs)

### Archegoniates (BOT-H-CC6-4-Th BOT-H-CC6-4-P)

CO 1. Demonstrate a grasp of archegoniatae, bryophytes, pteridophytes, and gymnosperms.

CO 2. Acquire an in-depth knowledge of the morphology, anatomy, and reproduction procedures of bryophytes, pteridophytes, and gymnosperms

CO 3. Understand the evolution of different groups of plants and how they adapted to their new habitat.

CO 4. Proficiently demonstrate the appropriate experimental techniques and methods for study of the Bryophytes, Pteridophytes, and Gymnosperms.

## COs-POs Mapping

### Archegoniates (BOT-H-CC6-4-Th BOT-H-CC6-4-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | | √ | √ | √ | √ |
| CO2 | √ | √ | √ | √ | √ | √ | | √ | √ |
| CO3 | √ | | | √ | √ | √ | | √ | √ |
| CO4 | √ | | √ | √ | | √ | | √ | √ |

## Course Learning Outcomes (COs)

### Palaeobotany (BOT-H-CC7-4-Th BOT-H-CC7-4-P)

CO 1. Demonstrate the fundamentals of plant fossils and conditions of fossilisation.

CO 2. Understanding of fossil pteridophytes and their role in plant evolution studies.

CO 3. Acquire a grasp of megafossil assemblages in Indian Gondwana system.

CO 4. Develop critical understanding on pollen structure and morphology

CO 5. Demonstrate proficiency in the experimental techniques and methods of applied palynology viz. forensic palynology, aeropalynology, melissopalynology etc.

## COs-POs Mapping

### Palaeobotany (BOT-H-CC7-4-Th BOT-H-CC7-4-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | | √ | | √ | √ |
| CO2 | √ | | | √ | √ | √ | √ | √ | √ |
| CO3 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO4 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO5 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

### Pharmacognosy and Ethnobotany (BOT-H-CC8-4-Th BOT-H-CC8-4-P)

CO 1. Be familiar with the fundamental pharmacognosy and its importance in modern medicine, crude drugs and Classification of drugs.

CO 2. Have in depth knowledge on pharmacologically active constituents and biosynthesis of various secondary metabolites.

CO 3. Learn the procedure of chemical, microscopic and histochemical tests for identification of medicinal herbs.

CO 4. Propose new strategies to implement the knowledges of ethnomedicine, taking into consideration the practical concerns that are relevant to India.

## COs-POs Mapping

### Pharmacognosy and Ethnobotany (BOT-H-CC8-4-Th BOT-H-CC8-4-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | √ | √ | √ | | √ | √ | √ | √ |
| CO2 | √ | | √ | √ | √ | √ | | √ | √ |
| CO3 | √ | | √ | √ | √ | √ | √ | √ | √ |
| CO4 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

### Mycology (BOT-H-CC9-5-Th BOT-H-CC9-5-P)

CO 1. Understand the general characteristics, cell structure, thallus organization, and reproduction of fungi, including modern identification tools like Fungal DNA Barcoding.

CO 2. Analyze the classification and life cycle patterns of major fungal groups, such as *Chytridiomycota*, *Zygomycota*, *Ascomycota*, *Basidiomycota*, and *Oomycota*.

CO 3. Evaluate the symbiotic associations of fungi, including the growth forms of lichens and the ecological significance of mycorrhizae.

CO 4. Comprehend the applied role of fungi in biotechnology, the food industry (fermentation, mycoprotein), agriculture (biofertilizers), and mycoremediation.

CO 5. Demonstrate practical proficiency in basic mycological techniques, such as media preparation, sterilization, and the isolation of fungi using culture plate techniques.

CO 6. Conduct microscopic examinations of fungal reproductive structures (e.g., *Rhizopus*, *Agaricus*, *Aspergillus*) and identify fungal specimens collected during field trips.

## COs-POs Mapping

### Mycology (BOT-H-CC9-5-Th BOT-H-CC9-5-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | | | | |
| CO2 | √ | | | √ | | | | | |
| CO3 | √ | | | √ | | √ | | | |
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## Course Learning Outcomes (COs)

### Microbiology (BOT-H-CC10-5-Th BOT-H-CC10-5-P)

CO 1. Understand the history of the microbial world, systems of classification, and the distinguishing characteristics of Archaea, Bacteria, and viruses.

CO 2. Comprehend bacterial growth kinetics, the physical and chemical factors influencing growth, and the ultrastructure of bacterial cells including cell walls, endospores, and flagella.

CO 3. Analyze the mechanisms of bacterial genetic recombination (transformation, conjugation, transduction), and understand the functions of plasmids and the CRISPR-CAS system.

CO 4. Evaluate the economic and environmental importance of microbes, including their roles in bio-fuel production, bioremediation, microbial interactions, and food spoilage.

CO 5. Assess the principles of medical microbiology, including the control of microbes through physical/chemical agents and the mode of action of various chemotherapeutic agents and antibiotics.

CO 6. Demonstrate proficiency in fundamental experimental techniques such as pure culture isolation, media preparation, serial dilution, Gram staining, and biochemical characterization.

CO 7. Utilize laboratory instruments to quantitatively measure bacterial growth curves, conduct antibiotic sensitivity assays, and perform microbiological quality analysis (e.g., MBRT of milk).

## COs-POs Mapping

### Microbiology (BOT-H-CC10-5-Th BOT-H-CC10-5-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | | | | |
| CO2 | √ | | | √ | | | | | |
| CO3 | √ | | | √ | | √ | | | |
| CO4 | √ | √ | | | | √ | | | |
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| CO7 | | √ | √ | √ | √ | | | | √ |

## Course Learning Outcomes (COs)

### Biochemistry (BOT-H-CC11-5- Th BOT-H-CC11-5- P)

CO 1. Understand the biochemical foundations of plant biology, including covalent/non-covalent bonds, properties of water, pH, and buffers.

CO 2. Analyze the structure, properties, and stereochemistry of the foundational molecules of life: nucleic acids, proteins, carbohydrates, and lipids.

CO 3. Evaluate the classification, kinetics (Michaelis-Menten equation), and regulatory mechanisms of enzyme catalysis and inhibition.

CO 4. Comprehend the chemistry of cell membranes, ion transport mechanisms, and the basic pathways of signal transduction (e.g., G proteins, MAP-kinase cascade).

CO 5. Explain the principles of bioenergetics, the laws of thermodynamics, and the role of ATP in coupled and redox reactions.

CO 6. Demonstrate proficiency in fundamental experimental biochemistry techniques, including the qualitative and quantitative detection of organic acids, carbohydrates, and proteins.

## COs-POs Mapping

### Biochemistry (BOT-H-CC11-5- Th BOT-H-CC11-5- P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO3 | √ | | | √ | | √ | | | |
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| CO6 | | √ | √ | | √ | | | | √ |

## Course Learning Outcomes (COs)

### Cell and Molecular Biology (BOT-H-CC12-5- Th BOT-H-CC12-5- P)

CO 1. Understand the origin and evolution of eukaryotic cells, including the concept of the RNA world, ribozymes, and the endosymbiotic theory of organellar DNA.

CO 2. Analyze the phases and regulation of the eukaryotic cell cycle, including the mechanisms of mitosis, cytokinesis, and the role of regulatory proteins like MPF.

CO 3. Evaluate the structures, chemical properties, and replication mechanisms of genetic material (DNA and RNA) through historical experiments.

CO 4. Comprehend the central dogma of molecular biology, including the processes of transcription, the genetic code, and translation (protein synthesis).

CO 5. Understand advanced molecular techniques and their applications, such as vectors (plasmids), gene cloning steps, PCR, genomic libraries, and DNA fingerprinting.

CO 6. Demonstrate proficiency in laboratory techniques related to cell and molecular biology, including DNA extraction, quantitative estimation, and practical workouts.

## COs-POs Mapping

### Cell and Molecular Biology (BOT-H-CC12-5- Th BOT-H-CC12-5- P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | √ | | | |
| CO2 | √ | | | √ | | √ | | | |
| CO3 | √ | | | √ | | √ | | | |
| CO4 | √ | | | √ | | √ | | | |
| CO5 | √ | √ | | √ | | | √ | | |
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## Course Learning Outcomes (COs)

### Phytopathology (BOT-H-CC13-6- Th BOT-H-CC13- 6-P)

CO 1. Understand the fundamental concepts of plant pathology, including disease cycles, etiology, pathogenesis, and plant disease epidemiology.

CO 2. Analyze the mechanisms of plant defense, including structural and biochemical barriers, recognition receptors, and types of immunity such as PAMP-triggered immunity (PTI) and effector-triggered immunity (ETI).

CO 3. Examine the symptoms, causal organisms, and disease cycles of significant plant diseases such as late blight of potato, black stem rust of wheat, and citrus canker.

CO 4. Evaluate the various strategies for plant disease management, encompassing molecular diagnosis, integrated pest management (IPM), plant health legislation, and biotechnological interventions.

CO 5. Demonstrate proficiency in phytopathological laboratory techniques, including sterilization, media preparation, pathogen isolation, pure culture maintenance, and microscopic histopathology of diseased specimens.

## COs-POs Mapping

### Phytopathology (BOT-H-CC13-6- Th BOT-H-CC13- 6-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | | | | |
| CO2 | √ | | | √ | | √ | | | |
| CO3 | √ | | | √ | | | | | |
| CO4 | √ | √ | | √ | | √ | | | |
| CO5 | | | √ | | √ | | | | √ |

## Course Learning Outcomes (COs)

### Plant Physiology (BOT-H-CC14-6-Th BOT-HCC14- 6-P)

CO 1. Understand plant-water relations, including water potential, root absorption, the cohesion-tension theory of sap ascent, and the mechanisms of transpiration and stomatal movement.

CO 2. Analyze the chemical properties of water, inorganic mineral nutrition (macro and micro), mechanisms of mineral absorption, and identify various mineral deficiency symptoms in plants.

CO 3. Evaluate the mechanisms of photosynthesis, including light harvesting, electron transport, carbon assimilation pathways (C3, C4, and CAM), and the significance of photorespiration.

CO 4. Classify aerobic and anaerobic respiration, and comprehend the electron transport chain, oxidative phosphorylation, and factors affecting respiratory pathways.

CO 5. Assess plant growth and development by analyzing the physiological effects of phytohormones (auxins, gibberellins, cytokinins, ABA, ethylene) and the role of phytochromes in tropism, dormancy, and germination.

CO 6. Demonstrate proficiency in experimental plant physiology techniques, such as quantitatively determining the loss of water per stoma and evaluating the relationship between transpiration and evaporation.

## COs-POs Mapping

### Plant Physiology (BOT-H-CC14-6-Th BOT-HCC14- 6-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | √ | | | |
| CO2 | √ | | | √ | | | | | |
| CO3 | √ | | | √ | | √ | | | |
| CO4 | √ | | | √ | | √ | | | |
| CO5 | √ | √ | | | | | | | |
| CO6 | | | √ | | √ | | | | √ |

## Course Learning Outcomes (COs)

### Genetics (BOT-H-CC15-6-Th BOT-HCC15- 6-P)

CO 1. Understand the principles of Mendelian inheritance, its extensions (such as epistasis and polygenic inheritance), and the patterns of autosomal and sex-linked inheritance.

CO 2. Analyze linkage, crossing over, and gene mapping (e.g., three-point test cross), and comprehend the mechanisms and evolutionary significance of chromosomal aberrations, aneuploidy, and polyploidy.

CO 3. Evaluate the molecular mechanisms of eukaryotic transcription, translation, post-translational modifications, point mutations, DNA repair, and transposable elements.

CO 4. Comprehend population genetics (Hardy-Weinberg equilibrium) and assess advanced applied topics such as genetic testing, gene therapy, precision medicine, and GMOs.

CO 5. Utilize bioinformatics and digital tools for genomic analysis, including database querying (GenBank, NCBI, BLAST), sequence alignment, and predicting protein structures using tools like AlphaFold.

CO 6. Demonstrate proficiency in cytogenetic laboratory techniques, including mitotic chromosome squash preparation, determining the mitotic index in *Allium cepa*, and identifying chromosome morphology.

## COs-POs Mapping

### Genetics (BOT-H-CC15-6-Th BOT-HCC15- 6-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | | | | | |
| CO2 | √ | | | √ | | √ | | | |
| CO3 | √ | | | √ | | | | | |
| CO4 | √ | √ | | | | | | √ | |
| CO5 | √ | | | √ | | | √ | | |
| CO6 | | | √ | | √ | | | | √ |

## Course Learning Outcomes (COs)

### Plant Geography, Ecology and Evolution (BOT-H-CC16-7-Th & BOT-H CC16-7-P)

CO 1: Describe the phytogeographical distribution of plants, endemic types and factors, and migration mechanisms in different ecological zones.

CO 2: Classify biomes and understand habitat and niche, ecotones, edge-effect, carry capacity, and ecological succession.

CO 3: Evaluate the level of biodiversity and understand conservation strategies including in-situ, ex-situ, seed-banks, and cryopreservation.

CO 4: Comprehend evolutionary theories, simplified phylogeny of plant groups, speciation mechanism, and phylogenetic tree construction.

CO 5: Perform quadrat studies to determine minimal size, frequency, density, and abundance of species in the field.

CO 6: Conduct comparative anatomical studies of leaves from polluted and less polluted areas to assess environmental impact.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | | | √ | | | |
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| CO3 | √ | | √ | | | √ | | √ | |
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| CO6 | | | √ | √ | √ | √ | | | √ |

## Course Learning Outcomes (COs):

### Biostatistics (BOT-H-CC17-7-Th & BOT-H-CC17-7-P)

CO 1: Understand the basic concepts, uses, and limitations of biostatistical methods in plant science research.

CO 2: Learn sampling techniques and differentiate between experimental and surveying methods of data collection.

CO 3: Apply methods of presentation of biological data, including tabular classification and graphical representation.

CO 4: Calculate measures of central tendency (mean, median, mode) and dispersion (mean deviation, standard deviation, standard error).

CO 5: Formulate and test statistical hypotheses using Student's t-test (paired/unpaired), Chi-square test, Z-test, and F-test.

CO 6: Understand probability rules, calculate coefficients of correlation, and compute regression lines for biological data.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | | | √ | | | |
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## Course Learning Outcomes (COs)

### Plant Biotechnology (BOT-H-CC18-7-Th & BOT-H-CC18-7-P)

CO 1: Comprehend the scope and history of plant biotechnology and strategies from ancient to recent molecular approaches.

CO 2: Understand gene transfer techniques, including Agrobacterium-mediated, viral vectors, and direct physical/chemical means.

CO 3: Examine genomic libraries, GMOs, transplastomic lines, legal issues, bio-safety, and ethical challenges surrounding GM crops.

CO 4: Analyze modern biotechnological tools such as genome editing (CRISPR-Cas), gene silencing, and systems/synthetic biology.

CO 5: Demonstrate hands-on plant tissue culture techniques, callus establishment, suspension culture, and protoplast isolation.

CO 6: Execute molecular biology protocols including E. coli plasmid isolation, total protein extraction, gel electrophoresis, and SDS-PAGE.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | | | √ | | | |
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| CO3 | √ | | | | | √ | | √ | |
| CO4 | √ | | | √ | | √ | √ | | |
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| CO6 | | √ | √ | √ | √ | | | | √ |

## Course Learning Outcomes (COs)

### Plant Metabolism (BOT-H-CC19-7-Th & BOT-H-CC19-7-P)

CO 1: Understand anabolic and catabolic pathways, enzyme regulation, and the role of regulatory enzymes in plant metabolism.

CO 2: Interpret photosynthetic processes, carbon assimilation pathways (C3, C4, CAM), and photorespiration energetics.

CO 3: Explain mitochondrial electron transport, ATP synthesis chemiosmotic mechanisms, and cyanide-resistant respiration.

CO 4: Analyze nitrogen metabolism, biological nitrogen fixation, nitrogenase structure, and genetic control of nodulation.

CO 5: Understand lipid metabolism, beta-oxidation, glyoxylate cycle, and the synthesis of terpenes, phenolics, and alkaloids.

CO 6: Perform paper chromatography to separate photosynthetic pigments and quantitatively estimate chlorophyll content.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
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## Course Learning Outcomes (COs)

### Natural Resource Management (BOT-H-CC20-7-Th & BOT-H-CC20-7-P)

CO 1: Understand the interrelationships among natural resources, resource utilization, and rural poverty in India.

CO 2: Examine forest resource management, including agro-forestry, social forestry, farm forestry, JFM, and Indian forest policies.

CO 3: Evaluate wetland degradation, recognize Ramsar sites in India, and propose conservation strategies.

CO 4: Comprehend coal/mineral reserves, future energy outlook, and renewable energy technologies (solar, wind, biofuel, wastes).

CO 5: Examine soil parameters such as soil texture, chemical properties, organic carbon, and field capacity.

CO 6: Conduct water quality analysis, comparing pH, salinity, and total dissolved solids (TDS) across various samples.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO1 | √ | | | | | √ | | | |
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## Course Learning Outcomes (COs)

### Research Methodology-1 (BOT-H-CC21-8-Th & BOT-H-CC21-8-P)

CO 1: Understand foundations of research, scientific methods, research problems, and hypothesis formulation.

CO 2: Differentiate between types of research, experimental designs, and manage research data following FAIR principles.

CO 3: Write comprehensive scientific reviews and defend them via professional PowerPoint presentations.

CO 4: Examine field and ecological data collection, including soil sampling, canopy estimation, and biodiversity indices computation.

CO 5: Understand principles and applications of light, dark field, phase-contrast, electron microscopy, and radioisotopes.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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## Course Learning Outcomes (COs)

### Research Methodology-2 (BOT-H-CC22-8-Th & BOT-H-CC22-8-P)

CO 1: Utilize computational botany and bioinformatics tools for biological database search, data retrieval, and sequence alignment.

CO 2: Comprehend major databases (NCBI, EMBL) and specific database applications (TAIR, Gramene, Sol).

CO 3: Construct molecular phylogenetic trees and perform bootstrapping using software tools such as MEGA.

CO 4: Perform PCR primer design, view 3D protein structures using RasMol/PyMOL, and understand gene prediction.

CO 5: Write research grant proposals in thrust funding areas, defend them, and learn research ethics, IPR, and plagiarism checking.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
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## Course Learning Outcomes (COs)

### Plant Breeding (BOT-H-CC23-8-Th & BOT-H-CC23-8-P)

CO 1: Define goals of plant breeding, conventional methods, and genetic resources under Vavilov's centers of origin.

CO 2: Analyze breeding methods for self-pollinated crops (mass selection, pedigree, bulk, backcross) and cross-pollinated crops.

CO 3: Understand the genetic basis of heterosis, hybrid vigor, and inbreeding depression in crop populations.

CO 4: Evaluate other breeding approaches such as clonal selection, mutation breeding, and polyploid breeding.

CO 5: Apply molecular markers (RFLP, RAPD, SSR, SNP) and marker-assisted selection (MAS) in plant breeding.

CO 6: Demonstrate emasculation and hybridization techniques and determine pollen sterility/viability.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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## Course Learning Outcomes (COs)

### Stress Biology (BOT-H-CC24-8-Th & BOT-H-CC24-8-P)

CO 1: Understand the definition and types of plant stresses (abiotic and biotic) and general stress response pathways.

CO 2: Analyze stress-sensing mechanisms in plants, including calcium modulation, phospholipid signaling, and homeostasis.

CO 3: Examine biotic stress signaling, including plant-pathogen interactions, PR proteins, and phytohormones (SA, JA, ethylene).

CO 4: Evaluate stress adaptation mechanisms, physiological/biochemical changes, and Crop Improvement strategies.

CO 5: Quantitatively estimate phenol and proline content in plant seedlings in response to stresses.

CO 6: Perform experiments to study the effect of salt, water, or heavy metal stress on seed germination, seedling growth, and mitotic index.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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## Course Learning Outcomes (COs)

### Industrial Microbiology (BOT-H-CC25-8-Th & BOT-H-CC25-8-P)

CO 1: Explain the history, scope, and industrial importance of microbiology and bioreactors/fermenters operation.

CO 2: Understand principles of screening, media formulation, process optimization, and downstream processing of microbial products.

CO 3: Analyze microbial production of industrial enzymes (amylase, lipase), organic acids, beer, ethanol, and penicillin.

CO 4: Examine immobilization techniques of whole cells and enzymes and their large-scale industrial applications.

CO 5: Comprehend bioprocess economics, industrial waste management, and entrepreneurship development in microbiology.

CO 6: Conduct laboratory isolation of industrially useful microbes, screen for enzymes, and evaluate yeast/bacterial growth kinetics.

## COs-POs Mapping

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
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| CO3 | √ | √ | | √ | | √ | | | |
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## Course Learning Outcomes (COs)

### Mushroom Cultivation Technology (BOT-H-SEC-1-Th, BOT-H-SEC-1-P)

CO 1. Recognize multiple types and categories of mushrooms, their health beneficial values and idea of poisonous mushrooms.

CO 2. Showcasing several kinds of mushroom cultivation technologies including the knowledge and industrial designs and required appliances for cultivation of mushroom.

CO 3. Explore the procedures of multiple stages of mushroom cultivation and their variability in different types of mushrooms.

CO 4. Learn the management strategies to overcome the mushroom diseases and the postharvest processing technologies for increasing the shelf life.

CO 5. Assess the financial aspects related to the production of mushrooms and create innovative techniques and plans to boost the yield of mushrooms.

## COs-POs Mapping

### Mushroom Cultivation Technology (BOT-H-SEC-1-Th, BOT-H-SEC-1-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO2 | √ | | √ | √ | √ | √ | √ | √ | √ |
| CO3 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO4 | √ | | √ | √ | | √ | √ | √ | √ |
| CO5 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

### Biofertilizer & Biopesticides (BOT-H-SEC-2-Th, BOT-H-SEC-2-P)

CO 1. Know the role of microbes as biofertilizer and biopesticides and in mineral processing.

CO 2. Increase their comprehension of the idea of plant growth promoting rhizobacteria.

CO 3. Demonstrate the role of nitrogen fixing microbes as efficient biofertilizers.

CO 4. Recognize the many types of biofertilizers and biopesticides and their applications.

CO 5. Know the use of vesicular arbuscular mycorrhizal (VAM) and nitrogenous and phosphate biofertilizers to provide integrated management for improved crop production.

CO 6. Interpret and clarify the elements, patterns, and mechanisms of bacterial growth in crop production.

## COs-POs Mapping

### Biofertilizer & Biopesticides (BOT-H-SEC-2-Th, BOT-H-SEC-2-P)

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
|---|---|---|---|---|---|---|---|---|---|
| CO1 | √ | | | √ | √ | √ | | √ | √ |
| CO2 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
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| CO4 | √ | | √ | √ | √ | √ | √ | √ | √ |
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| CO6 | √ | √ | √ | √ | √ | √ | √ | √ | √ |

## Course Learning Outcomes (COs)

**Plant Tissue Culture and Horticultural Practices (BOT-H-SEC-3-Th BOT-H-SEC-3-P)**

CO 1. Develop aptitude on different types of plant tissue culture techniques.

CO 2. Understand the totipotency, organogenesis and embryogenesis concepts.

CO 3. Study the tissue culture techniques for production of useful metabolites.

CO 4. Examine the laboratory requirements and aseptic methods to implement tissue culture practices.

CO 5. Acquire an understanding of the concept of different types of horticultural techniques for the purpose of adding value.

CO 6. Know about various ornamental, fruit and vegetable crops and the post-harvest challenges encountered by them.

CO 7. Be familiar with the tricks of the trade and how to increase the longevity of the food.

CO 8. Learn different methods for the conservation of genetic resources related to horticultural plants including the role of micropropagation and intellectual property rights etc.

## COs-POs Mapping

**Plant Tissue Culture and Horticultural Practices (BOT-H-SEC-3-Th BOT-H-SEC-3-P)**

| POs \ COs | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 |
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| CO3 | √ | | √ | √ | √ | √ | √ | √ | √ |
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| CO7 | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| CO8 | √ | √ | √ | √ | | √ | | √ | √ |