**DISCIPLINE SPECIFIC CORE COURSE (DSC-20): Integrative Plant Biology**

**CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

| Course title & Code | Credits | Credit distribution of the course | | | Eligibility criteria | Pre-requisite of the course (if any) |
|---|---|---|---|---|---|---|
| | | Lecture | Tutorial | Practical/ Practice | | |
| **Integrative Plant Biology DSC-20** | **4** | **2** | **0** | **2** | Semester VII | Nil |

**Learning Objectives:**

- This course would involve study of plants to enhance the understanding of organism/s and/or traits from organismal to molecular levels integrating various core disciplines of plant biology including, but not restricted to, morphology, anatomy, development, taxonomy, inheritance, physiology, biochemistry, molecular and cell biology, genomics, proteomics and bioinformatics studies along with an evolutionary context.
- Additional areas would include interactions of plants with other organisms in an ecosystem, biotic and abiotic challenges and plant responses, transgenic studies (basic and applied) and an ecological or environmental perspective.
- The course would enable development of critical thinking skills among students and enhance their problem-solving abilities. This is an important component of the course since students in the 8$^{th}$ semester would be involved with research at the under-graduate level and would also be eligible to apply for Ph.D. programs after B.Sc. (Hons.) – with Research in Botany.

**Learning Outcomes:**

- The course would allow students to integrate various sub-disciplines that have been studied over the preceding seven semesters to develop a holistic understanding of plant systems transgressing various subject areas within plant biology. The course would include two main approaches/components:
    - Integrated case studies on selected plants from algae to angiosperms including all aspects of their growth, development and applications as outlined above.
    - Selected trait- or process-based studies of plants to understand the biological, evolutionary and molecular determinants of the traits.

- Both these approaches would involve study of research and review articles that discuss contemporary questions in plant biology by integrating multiple approaches towards understanding a plant system, in addition to textbooks.
- The course design would allow students to study important paradigms in plant sciences, and train them in experimental design, data interpretation and adoption of multi-disciplinary approaches to solve scientific questions.

**Theory: 30 hours**

**Unit 1: Model organisms/ plant systems and trait based studies 7 hours**

Introduction, brief timeline development of *Arabidopsis* as a model system, features of model organisms ; vital information for model organisms (Microbial - Bacterial (*E.coli*), viral - TMV(any other ); Plant systems : *Chlamydomonas, Neurospora, Marchantia, Physcomitrella, Equisetum, Cycas, Gnetum, Nicotiana sp., Daucus carota*).

Case studies on plants from algae to angiosperms

a. The renaissance and enlightenment of *Marchantia* as a model system
b. *Cuscuta* the Merchant of Proteins
c. The origin of a land flora.
d. Introduction to Systems approach for plants, basic concepts in building networks, computational tools, platforms and pipelines in systems biology ; Pan-omics.
e. Important components of plant evolution – chloroplast acquisition, multicellularity and land colonization.
f. Plant biotic interactions in the Sonoram Desert, current knowledge and future research perspectives.

**Unit 2: Plant Developmental processes, environmental stress (biotic & abiotic) and adaptations 10 hours**

Water stress; High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis Related (PR) proteins; Reactive oxygen species (ROS) –Production and scavenging mechanisms; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates. Photosynthesis: a case study, Lighting the way: Compelling open questions in photosynthesis research, Perspectives on improving photosynthesis to increase crop yield, Air plant genomes shed light on photosynthesis innovation , Alternative electron pathways of photosynthesis power green algal $CO_2$ capture.

Plant Developmental processes and adaptations: Molecular mechanisms underlying leaf development - morphological diversification ( and beyond); stomata structure and function, Changes in root: shoot ratio, Aerenchyma development, Cuticle development and function, Genetic control of branching patterns in grass inflorescences, Floral Adaptation in plants, Anther

development—The long road to making pollen, Evolution and patterning of the ovule in seed plants, Soil minerals affect taxon-specific bacterial growth.

**Unit 3: Genetic and molecular circuitry** **05 hours**

a. Molecular motors (Kinesin, dyneins, myosins) and Regulatory RNAs (Attenuators, Riboswitches, siRNAs,miRNAs, lncRNAs, eRNAs), relevant case studies for each.

b. RNA biology in Plants - Beyond transcription: compelling open questions in plant RNA biology

c. Small RNA-mediated DNA methylation during plant reproduction.

d. Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops.

**Unit 4: Emerging areas in plant biology and Applied Botany:** **8 hours**

Farming in the Ocean, Drug Discovery, Biomass conversion into valuable products, Cultivation of medicinal plants, Food testing for adulterants, millets, molecular taxonomy.

Learning outcome: The course would enable the development of critical thinking skills among students and enhance their problem-solving abilities. This is an essential component of the course since students to be involved in research. Artificial Intelligence and Machine Learning in plant biology ; Nanotechnology in plant sciences; Introduction to synthetic Biology, metabolic pathway engineering, case studies of *Mycoplasma laboratorium*, Golden Rice

**PRACTICALS:** **60 hours**

1. Grow a model organism (of choice) in the college (in vitro cultures / garden / greenhouse etc.)

2. Design and conduct an experiment on the model organism (e.g., Antibiotic sensitivity assay in *E.coli,* oxygen evolution in aquatic plants besides *Hydrilla*)

3. Calculate mitotic index and duration of stages in mitosis in temporary preparation of normal and colchicine treated root tips.

4. Adaptations in plants; study cuticle, stomata, aerenchyma development in plants (micrographs/ temporary sections from available material).

5. ROS scavenging experiment (in case not included in Stress Physiology)

6. Study of embryo mutants, homeotic mutants in floral development (ABCDE model) in *Arabidopsis*.

7. Tools for In silico analysis - KEGG, STRING, Cytoscape,

8. Case studies in integrative approaches to understanding plants :

Broad areas of study are listed below, one recent publication from selected field could be provided and students will prepare graphical abstracts, summary and present the same :

a. Environmental physiology

b. Gene regulation circuitry

c. Stress and adaptation

d. Plant cell biology

e. Plant growth and development

f. Photosynthesis and carbohydrate metabolism

g. Nutrient uptake, transport and metabolism

h. Effective resource utilisation (water; assimilates; nutrients)

i. Root – rhizosphere biology

j. Reproduction, seed and fruit biology

k. Defence and protection

l. Building genomic circuits

**SUGGESTED READINGS (Books):**


- Griffiths, A.J.F., Wessler, S.R., Carroll, S.B., Doebley, J. (2010). Introduction to Genetic Analysis. W. H. Freeman and Co., U.S.A. 10th edition.
- Watson J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. (2007). Molecular Biology of the Gene, Pearson Benjamin Cummings, CSHL Press, New York, U.S.A. 6th edition.
- Dickison, W.C. (2000). Integrative Plant Anatomy. Harcourt Academic Press, USA. 4. Taiz, L., Zeiger, E., Møller, I. M., & Murphy, A. (2018). Plant Physiology and Development (6th Ed.). Sinauer Associates.
- Hopkins, W. G., & Hüner, N. P. A. (2009). Introduction to Plant Physiology (4th Ed.). Wiley.
- Buchanan, B. B., Gruissem, W., & Jones, R. L. (2015). Biochemistry & Molecular Biology of Plants (2nd Ed.). Wiley.
- Davies, J.A. ( 2018) Synthetic Biology: A very short introduction, Oxford University Press
- Raghavan, V. (2000). Developmental Biology of Flowering plants, Springer, Netherlands.
- Ghosh, Z. and Bibekanand, M. (2008). Bioinformatics: Principles and Applications. Oxford University Press. Delhi. 4. Pevsner, J. (2009). Bioinformatics and Functional Genomics. Wiley-Blackwell. U.S.A. 2nd edition.
- Campbell, A.M. and Heyer, L.J. (2007) Discovering Genomics, Proteomics and Bioinformatics. Second edition. Pearson


**SUGGESTED READINGS (Selected Papers):**


- Bowman., et al (2022). The renaissance and enlightenment of *Marchantia* as a model system. *The Plant Cell*, 34(10), pp.3512–3542. doi:https://doi.org/10.1093/plcell/koac219.
- Paterlini, A., & Helariutta, Y. (2020). *Cuscuta* the Merchant of Proteins. Molecular Plant, 13(4), 533-535. https://doi.org/10.1016/j.molp.2020.01.007.
- Romanov, M. S., Bobrov, A. V. C., Iovlev, P. S., Roslov, M. S., Zdravchev, N. S., Sorokin, A. N., ... & Kandidov, M. V. (2024).Fruit and seed structure in the ANA-grade angiosperms:

Ancestral traits and specializations. *American Journal of Botany*, *111*(1), e16264. DOI: 10.1002/ajb2.16264.

- Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), pp.1352–1369. doi:https://doi.org/10.1038/s41477-022-01283-y.
- Eckardt et al. (2024) Lighting the way: Compelling open questions in photosynthesis research. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3914–3943, https://doi.org/10.1093/plcell/koae203
- Croce et al. (2024) Perspectives on improving photosynthesis to increase crop yield. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3944–3973, https://doi.org/10.1093/plcell/koae132.
- Willoughby, A.C. (2024) Air plant genomes shed light on photosynthesis innovation. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3897–3898, https://doi.org/10.1093/plcell/koae213.
- Gilles Peltier et al. (2024) Alternative electron pathways of photosynthesis power green algal $CO_2$ capture. *The Plant Cell*, Volume 36, Issue 10, October, Pages 4132–4142, https://doi.org/10.1093/plcell/koae143.
- Manavella et al. (2-23) Beyond transcription: compelling open questions in plant RNA biology. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1626–1653, https://doi.org/10.1093/plcell/koac346.
- Hiu Tung Chow, Rebecca A Mosher (2023) Small RNA-mediated DNA methylation during plant reproduction. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1787–1800, https://doi.org/10.1093/plcell/koad010.
- Nakayama et al. (2022) Molecular mechanisms underlying leaf development, morphological diversification, and beyond. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2534–254. https://doi.org/10.1093/plcell/koac118.
- Elizabeth A Kellogg. (2022) Genetic control of branching patterns in grass inflorescences. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2518–2533, https://doi.org/10.1093/plcell/koac080.
- D Blaine Marchant, Virginia Walbot (2022) Anther development—The long road to making pollen. *The Plant Cell*, Volume 34, Issue 12, December 2022, Pages 4677–4695, https://doi.org/10.1093/plcell/koac287
- Rudall, P. J. (2021) Evolution and patterning of the ovule in seed plants. *Biological Reviews*, *96*(3), 2021, 943-960. doi: 10.1111/brv.12684.
- Finley, B. K., Mau, R. L., Hayer, M., Stone, B. W., Morrissey, E. M., Koch, B. J., ... & Hungate, B. A. (2022) Soil minerals affect taxon-specific bacterial growth. *The ISME journal*, *16*(5), 1318-1326.
- Franklin, K. A., Sommers, P. N., Aslan, C. E., López, B. R., Bronstein, J. L., Bustamante, E., ... & Marazzi, B. (2016) Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives. *International Journal of Plant Sciences*, Volume *177, Issue* 3, 2016. Pages 217-234, https://www.journals.uchicago.edu/doi/pdf/10.1086/684261.
- Qamar U. Zaman (2024) Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. Trends in Biotechnology, Volume 42, Issue 5; P560-574 May 2024.