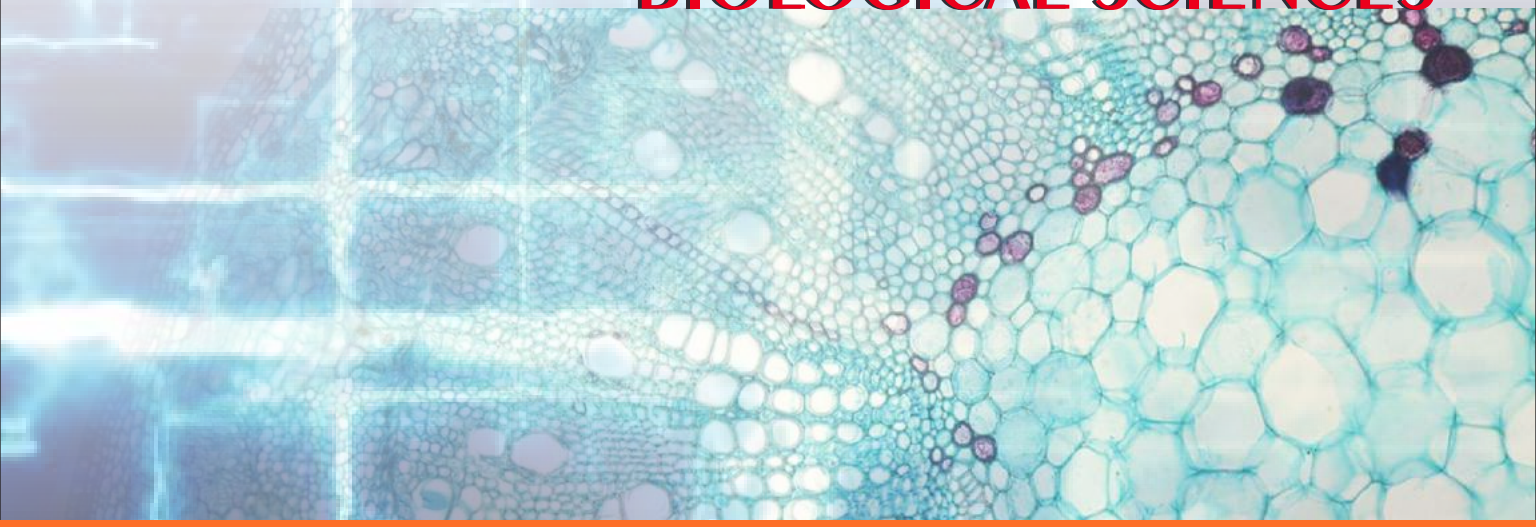
ASHOKA UNIVERSITY

Department of BIOLOGICAL SCIENCES



BIOLOGY HANDBOOK

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BIOLOGY HANDBOOK

THE BIOLOGY PROGRAM

Ashoka is India's leading liberal arts research university. The education at Ashoka emphasizes foundational knowledge, thorough academic research based on rigorous pedagogy, and hands-on experience with real-world challenges.

Ashoka University envisions its Biological Science programme to be the cornerstone of its Natural Sciences Programme. Built on the foundations of Chemistry and Physics and drawing upon the resources of other disciplines such as Data Sciences, Climate and Environmental Studies, and Social Sciences and Humanities, the Biological Science programme at Ashoka will seek unique directions in and catalyse the emergence of new areas of research.

This handbook brings to you our philosophy of teaching and training in the diverse areas of life sciences, along with a list of current faculty and their research areas and accomplishments, details of teaching and research infrastructure, the and undergraduate and post-graduate curricula with syllabi.

INTRODUCTION TO THE BIOLOGICAL SCIENCES PROGRAMME

Bioscience at Ashoka has adopted multi-dimensional approaches to study biology across various scales. These range from molecules to cells, tissues to individuals, and organisms to ecosystems. With a foundation laid in Chemistry and Physics, this programme also involves understanding and learning from other disciplines such as Data Sciences, Climate and Environmental Sciences, Social Sciences, and Humanities. Students and faculty at Ashoka are equal partners in this journey. Our collective aim is to generate new knowledge and explore its applications to address social problems.

While breadth across all scales of size and complexity in the life sciences is important for education and training in the undergraduate and post-graduate levels, we do give sufficient attention to the depth that is needed for productive research outcomes. In this direction, we have recently established The Trivedi School of Biosciences with the help of a generous donation from Mr. Ashok Trivedi. The school promotes advanced research in Synthetic Biology, Data Science, and emerging areas in disease biology. The school envisages state-of-the-art infrastructure, strengthening faculty numbers in complementary thematic areas, and continuous support and mentorship in the pursuit of high-quality research capable of generating meaningful social impacts.

The strength of Ashoka lies in its highly qualified faculty across all disciplines. Our bioscience faculty come trained from all over the world and are some of the best in their respective fields, with expertise in areas that are not represented in India. Our faculty also:

- Innovate in biology education.
- Carry out experimental, computational/mathematical/theoretical biology research.
- Collaborate with affiliated faculty from other disciplines such as physics, chemistry, mathematics, and data science who work on biological problems; the affiliated faculty also contribute to teaching the students in the Biological Sciences programme.

OVERVIEW OF UNDERGRADUATE PROGRAM

Students of Ashoka start by querying the growth of human thought, the origin and growth of the human civilization in general, and the Indian civilization in particular. They are introduced to the origin of scientific inquiry and study the relationships and inter-dependencies between science and other domains of human creativity and critical thinking. On this foundation, the fundamental principles of physics are taught to all students, in a way that brings in both, the elegance of the principles of the natural world, and the complexity that still needs be unraveled. Subsequently, students are introduced to the chemical, biological, and human worlds, not as independent disciplines, but as a continuum of the physical world. Mathematics is taught as a language that connects all these disciplines of science and also as an abstract method by which we understand our surroundings.

Our model of education is concept-based and inquiry-driven, as opposed to the more traditional content-based models. Faculty at Ashoka pursue research in those areas that are related to the topics they teach to undergraduate students. Our vision is to integrate research and teaching at all levels of science education. The Sciences at Ashoka will be rooted in experiments, but will not take the rigid "objectives, apparatus, method, and conclusion" form. Students learn through both, courses taught in the classrooms, and by employing experimental methods in research labs of the faculty. Students are also exposed to frontiers of science through seminars, symposia, and national and international conferences that are routinely organized on the campus of Ashoka.

The undergraduate program in Biology is targeted at students who have strong interests in Biology (Biology Majors) as well as those who are interested in learning more about Biology or for meeting their scientific temperament needs (Biology Minors). Courses are taught keeping in mind that some students may or may not have prior exposure to basic concepts of Biology.

All students majoring in the Sciences will have an opportunity to learn how to design an experiment and to implement that design, figuring out the art of the approximation, understanding the power of simple models and how to conceptualize them, and developing the ability to convert an idea into mathematical or computational forms. The contents of the courses themselves are equivalent in every way to those that are taught at the best universities outside of and within India. The Sciences at Ashoka will be rooted in experiments, but these will not take the rigid "objectives, apparatus, method, conclusion" form. At Ashoka, students will transfer concepts learnt in class into experimental thinking, verifying for themselves the power and generality of scientific principles.

Courses for Biology majors will provide a strong foundation for research and careers in the biological sciences, medicine, pharmaceutical and biotech industry, teaching, and other related fields. A prospective Biology major student is required to complete 11 core courses in Biology and 5 of the several optional courses offered in the Sciences along with the mandatory 7 foundation courses.

OVERVIEW OF P h.D. PROGRAM

Ashoka University's Ph.D. program is designed to maintain global standards in education, training, productivity, and academic freedom. The Ph.D. program in Biological Sciences is characterized by state-of-the-art laboratories and computational infrastructure, generous support to carryout field work, accomplished faculty as research mentors, and generous scholarship remunerations to all students. The unique liberal arts environment of the campus allows Ph.D. students to work on inter-disciplinary research projects drawing on the expertise of faculty members within and beyond the biology department.

The four broad thematic areas that characterize our research are:

1. Biophysics and Biochemistry
2. Cell and Developmental Biology
3. Computational and Mathematical Biology
4. Ecology and Evolutionary Biology

All Ph.D. students undertake complementary course work to enable them to carry out research in the areas of their interest. Ashoka gives maximum importance to training Ph.D. students in research methodology, integrity, ethics, and written/oral communication. In addition, all Ph.D. students will have an opportunity to gain teaching experience by helping the faculty in teaching undergraduate students.

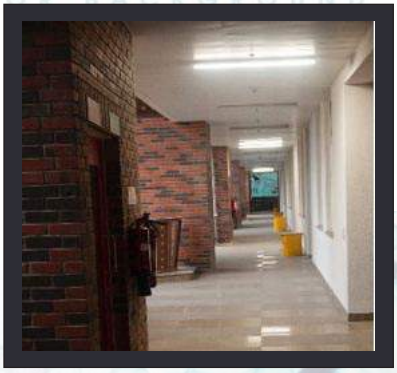
ADVANCED DIPLOMA

The Biology Department also offers a structured program for students who are interested in learning advanced concepts in biology and gain experience in some of the modern and interdisciplinary areas of biology. This is in the form of an advanced diploma for students who have finished 3 years of undergraduate in biology and related area. The program is for one year. The major emphasis is to give opportunity to students to learn some of the advance and contemporary topics in biology along with a hand-on experience in conducting research. Students with a major in a different disciple (chemistry/physics/maths/computer science) are also eligible to join the Biology program. There is an opportunity to carry out interdisciplinary research in a number of areas in Biology. The program has been designed keeping in mind appropriate courses to fill knowledge in gap areas and offer significant research opportunities

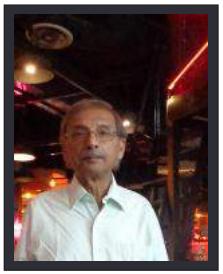
UG LABS WITH STATE-OF-ART FACILITIES AND SAFETY FEATURES

UG LABS

SAFETY FEATURES OUTSIDE LABS



THE FACULTY



Alok Bhattacharya is Professor of Biology. He is the recipient of Robert McNamara Fellowship (World Bank), Rockefeller Biotechnology Career Development Award, Shanti Swarup Bhatnagar Prize and JC Bose Fellowship, and is a fellow of Indian National Science Academy and Indian Academy of Sciences. He also served as one of the Vice Presidents of INSA. Following his Ph.D. at Jawaharlal Nehru University, India, he trained at the National Cancer Institute and Harvard Medical School, USA. He spent a large part of his independent career at the Jawaharlal Nehru University, New Delhi, where his scientific interests were in the area of infectious diseases, biology of parasitic pathogens and genomics. He is credited with helping to set up one of the first teaching and research programs on Bioinformatics and Computation Biology in India. His current research interests are rare diseases, computational genomics and biology of pathogenic parasites.

Contact: alok.bhattacharya@ashoka.edu.in

Publications:

- Pinotsis N, Zielinska K, Babuta M, Arolas JL, Kostan J, Khan MB, Schreiner C, Salmazo A, Ciccarelli L, Puchinger M, Gkougkoulia EA, Ribeiro EA Jr, Marlovits TC, **Bhattacharya A,** Djinovic-Carugo K. Calcium modulates the domain flexibility and function of an α-actinin similar to the ancestral α-actinin. Proc Natl Acad Sci USA. 2020 Sep 8;117(36):22101-22112.
- Awasthi K, Srivastava A, Bhattacharya S., **Bhattacharya A.** 2020. Tissue-specific expression of the sialic acid metabolic pathway: Role in GNE myopathy. J Muscle Res Cell Motil. 2020 Oct 7. doi: 10.1007/s10974-020-09590-7

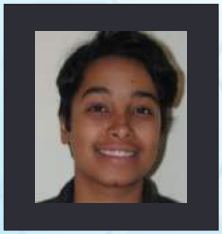
Shahid Jameel is Director, Trivedi School of Biosciences since October 2020. He is a recipient of the Shanti Swarup Bhatnagar Prize in Medical Sciences for his work on human viruses and is also an elected Fellow of all three science academies in India. He was also a Rockefeller Foundation Biotechnology Career Fellow and a Wellcome Trust International Senior Research Fellow. Shahid obtained a Ph.D. in Biochemistry at Washington State University, USA, and did postdoctoral work was in Virology at the University of Colorado Health Sciences Center, Denver, USA. In 1988 he set up the Virology Group at the International Centre for Genetic Engineering and Biotechnology, New Delhi, India and led it for 25 years. His research at ICGEB on human viruses – hepatitis E, HIV/AIDS and SARS – focused on virology, immunology and pathogenesis, and contributed to vaccine development. In 2013, Shahid was appointed Chief Executive Officer of the DBT/Wellcome Trust India Alliance, a biomedical research charity, which he led towards excellence in research management, public engagement and science communication.

Anup Padmanabhan is Assistant Professor of Biology and an Intermediate Fellow of the DBT/Wellcome Trust India Alliance. He did his PhD in Biological Sciences at the National University of Singapore, and was a Research Fellow at the Mechanobiology Institute, Singapore. His lab investigates the dynamics of shape change in cells during physiological processes such as embryo development and microbial infections. He employs various genetic, cell biology tools as well live microscopy to study cytoskeleton regulation underlying these shape changes.

Contact: anup.padmanabhan@ashoka.edu.in

Recent Publications:

- **Padmanabhan A**, Ong HT, Zaidel-Bar R. (2017) Non-junctional E Cadherin Clusters Regulate the Actomyosin Cortex in the C.elegans Zygote . Current Biology. 27(1):103-112
- Desai S, **Padmanabhan A**, Harshe S, Zaidel-Bar R and Kenney L (2019) Salmonella biofilms program innate immunity for persistence in C. elegans. PNAS 116 (25) 12462-12467
- Agarwal P, Ong HT, Toyama Y, **Padmanabhan A**, Dasgupta S, Krajnc M, and Zaidel-Bar R. (2018) Syncytial germline architecture is actively maintained by contraction of an internal actomyosin corset. Nature Communications 9, 4694. microscopy tools.



Bittu Kaveri Rajaraman is Associate Professor of Biology and Psychology, and is the current Head of the Psychology Department. He received a PhD from Harvard University in neuroscience, and was then a DST-Kothari postdoctoral fellow at the Center for Ecological Sciences, Indian Institute of Science, and an INSPIRE Faculty Fellow at the Central University of Hyderabad. He works on the evolution of neural and behavioural systems of communication, the neuroethology of temporal pattern recognition in insects, and quantitative and economic cognition more broadly in zebrafish, dogs and humans.

Contact: bittu@ashoka.edu.in

Publications:

- **Rajaraman K.**, Godthi V., Pratap R. and Balakrishnan R. 2015. A novel multimodal duet in a paleotropical bushcricket. Journal of Experimental Biology 218: 3042-3050. Online ISSN: 1477-9145; Print ISSN: 0022 0949. Impact Factor: 2.9 (2015), 5 year Impact Factor 3.2.
- **Rajaraman K.**, Mhatre N., Jain M., Postles M., Balakrishnan R. and Robert D. 2013. Low pass filters and differential tympanal tuning in a paleotropical bushcricket with an unusually low frequency call. Journal of Experimental Biology. 216: 777-787. Online ISSN: 1477-9145; Print ISSN: 0022-0949. Impact Factor: 3 (2013); 5 year Impact Factor 3.3.

Gautam I. Menon is Professor of Physics and Biology, and also an adjunct Professor at the Tata Institute of Fundamental Research, Mumbai. Prior to joiningAshoka University, he spent two decades as Professor with the Theoretical Physics and Computational Biology groups at the Institute of Mathematical Sciences, Chennai, where he was the founding Dean of the Computational Biology group. He completed a Ph.D. from the Indian Institute of Science, Bangalore followed by post-doctoral work at the TIFR, Mumbai and Simon Fraser University in Vancouver. His interests span mathematical and computational modelling of chromatin, motor transport, cytoskeletal organization, and infectious diseases. He has been awarded the Swarnajayanti Fellowship of the DST and the DAE-SRC Outstanding Researcher Fellowship as well as been named an outstanding referee of the American Physical Society. “He leads the BharatSim project at Ashoka, which is developing both a detailed agent-based model for disease spread as well as a high-quality synthetic population for India. He is one of the developers of INDSCI-SIM, a detailed epidemiological model for COVID-19 spread in India.”

Contact: gautam.menon@ashoka.edu.in

Recent Publications:

- Nandi S, Potunuru UR, Kumari C, Nathan AA, Gopal J, **Menon G I**, et al. (2020) Altered kinetics of circulating progenitor cells in cardiopulmonary bypass (CPB) associated vasoplegic patients: A pilot study. PLoS ONE 15(11): e0242375. https://doi.org/10.1371/journal.pone.0242375
- Shakti N Menon, P. Varuni and **Gautam I Menon** Information Integration and Collective Motility in Phototactic Cyanobacteria'PLoS Comp. Bio e1007807 (2020)
- Ankit Agrawal, Nirmalendu Ganai, Surajit Sengupta and Gautam I. Menon Non-equilibrium biophysical processes influence the large-scale architecture of the cell nucleus Biophys. J. 118(9), 2229-2244 (2020)

Sudipta Tung has joined Ashoka University as a Wellcome Trust-DBT India Alliance Early Career Fellow. He is broadly interested in investigating the ecological and evolutionary dynamics at the organismal and sub-organismal level in spatially structured and unstructured populations. His research utilizes both theoretical and experimental approaches. His current work involves understanding ecological and evolutionary responses to diverse nutritional mismatches and their impacts on biomedical disorders. Prior to joining Ashoka, he was working as a B4 postdoctoral fellow at Harvard University on dissecting out the genetic basis of differential autodiploidization propensity in budding yeast, Saccharomyces cerevisiae. He had completed my Ph.D. from Indian Institute of Science Education and Research (IISER)- Pune.

Contact: sudipta.tung@ashoka.edu.in

Recent Publications:

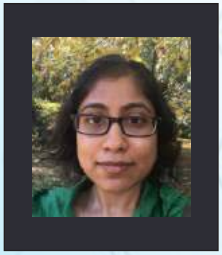
- **Tung, S.**, Rajamani, M., Joshi, A., Dey, S. 2019. Complex interaction of resource availability, life-history and demography determines the dynamics and stability of stage-structured populations. Journal of Theoretical Biology 460. 1-12.
- **Tung, S.**, Mishra, A., Gogna, N., Sadiq, M. A., Shreenidhi, P. M., Sruti, V. S., Dorai, K., Dey, S. 2018. Evolution of dispersal syndrome and its corresponding metabolomics changes. Evolution 72, 1890-1903.

Imroze Khan is Assistant Professor of Biology, a SERB Early Career Fellow and an Intermediate Fellow of the DBT/Wellcome Trust India Alliance. He did his PhD from IISER Kolkata in Evolutionary Biology and was a Postdoctoral Fellow at National Centre for Biological Sciences, Bangalore. His primary academic interest lies in understanding how organisms adaptively evolve against/with infection and disease, combining diverse approaches ranging from experimental evolution and life history analyses to genetics and genomics.

Contact: imroze.khan@ashoka.edu.in

Recent Publications:

- **Khan I***, Prakash A and Agashe D* (2019). Pathogen susceptibility and fitness costs explain variation in immune priming across natural populations of flour beetles. **Journal of Animal Ecology**. 88. 1332-1342
- **Khan I**, Prakash A, Issar S, Umarani M, Sashidharan R, N Jagadeesh, Lama P, Venkatesan R & Agashe D* (2018). Female density-dependent chemical warfare underlies fitness effects of group sex ratio in flour beetles. **The American Naturalist**. 191. 00-00.

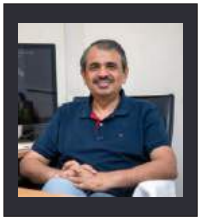


Kasturi Pal is Assistant Professor of Biology. She did her PhD at the University of California at Riverside, USA and postdoctoral work at the University of Texas Southwestern Medical Center, Dallas and the Scripps Research Institute, La Jolla, USA. Dr. Pal's research interests are dissecting the roles of G-protein coupled receptor signaling in hematopoietic and cardiovascular system, for which she uses a variety of biochemical, cell and molecular biological approaches.

Contact: kasturi.pal@ashoka.edu.in

Recent Publications:

- **Pal K**, Nowak R, Billington N, Li R, Ghosh A, Sellers J, Fowler V. (2020). Megakaryocyte migration defects due to nonmuscle myosin IIA mutations underly thrombocytopenia in MYH9-Related Disease. **Blood**. 135(21):1887 1898 https://doi.org/10.1182/blood.2019003064.
  * Cover image of Blood [May 21st, 2020]
- **Pal K**, Hwang SH, Somatilaka B, Badgandi H, Jackson P, Defea K, Mukhopadhyay S. (2016). Smoothened and β-arrestins cooperate to determine steady state and sonic hedgehog mediated removal of the G-protein coupled receptor Gpr161 from the primary cilium. **J Cell Biol**. 212(7): 861-75.



L.S. Shashidhara is Dean (Research) and Professor of Biology at Ashoka University. He is President of the International Union of Biological Sciences (IUBS), the first Indian in its 100 years history and was elected as Associate Member of the European Molecular Biology Organization (EMBO). He is a recipient of the CSIR Technology and Shanti Swarup Bhatnagar Prizes, a JC Bose National Research Fellowship, and fellowships all the three Science Academies of India. Shashidhara received his Ph.D. from the University of Cambridge, UK and started his independent research career at the Centre for Cellular and Molecular Biology (CCMB), Hyderabad, following which he moved to IISER Pune at its inception and contributed to its growth. He specializes in Genetics, Molecular Biology and Evolutionary Biology, and identified key mechanisms that specify organ development and regulate growth control during embryonic development. The scope has expanded to study evolutionarily conserved mechanisms in human epithelial cancers. He is involved in national efforts to understand manifestation of cancer in Indian populations using multi-omics approaches.

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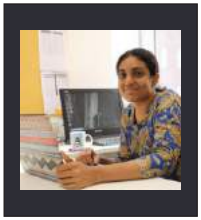
Recent Publications:

- Ghose, A., Bhattacharya, S., Karthikeyan, A.S., Kudale, A., Monteiro, J.M., Joshi, A., Medigeshi, G., Kang, G., Bal, V., Rath, S., **Shashidhara, L.S**., John, J., Chaudhuri, S. and Nagarkar, A. (2020). Community prevalence of antibodies to SARS-CoV-2 and correlates of protective immunity in five localities in an Indian metropolitan city. **MedRxiv**. doi: https://doi.org/10.1101/2020.11.17.20228155.
- Vaid, P., Puntambekar, A., Banale, R., Reddy, R., Unde, R., Namewar, N., Kelkar, DA., **Shashidhara, LS**., Koppiker, CB. and Kulkarni, M (2020). Stromal Tumor Infiltrating Lymphocytes (sTILs) as a putative prognostic marker to identify a responsive subset of TNBC in an Indian Breast Cancer Cohort. **MedRxiv.** doi: https://doi.org/10.1101/2020.08.19.20177865.

Recent Publications:

- Chakladar M, Nair, MG., Prabhu, JS., Sridhar, TS., Kelkar, D., Kulkarni, M., **Shashidhara, L.S.** (2020). PTPN11 / SHP2 negatively regulates growth in breast epithelial cells: implications on tumorigenesis. **BioRxiv.** doi: https://doi.org/10.1101/2020.07.30.228445.
- Nagarkar, S., Wasnik, R., Govada, P., Cohen, S.M. and **Shashidhara, L.S**. (2020). Promoter proximal pausing limits Yki-induced tumorous growth in Drosophila. **Genetics**. **216**, 67-77. https://doi.org/10.1534/genetics.120.303419.
- Groth, C., Vaid, P., Khatpe, A., Prashali, N., Ahiya, A., Andrejeva, D., Chakladar, M., Nagarkar, S., Paul, R., Kelkar, D., Eichenlaub, T., Herranz, H., Sridhar, T.S., Cohen, S.M., and **Shashidhara, L.S**. (2020) Genome-wide RNAi screen for context-dependent tumor suppressors identified using in vivo models for neoplasia in Drosophila. G3: **Genes, Genomes**, **Genetics**. 10, 2999-3008.https://doi.org/10.1534/g3.120.401545.
- Kulkarni, A., Kelkar, D.A., Parikh, N., **Shashidhara, L.S.**, Koppiker, C.B. and Kulkarni, M. (2020). Meta-analysis of prevalence of Triple-Negative breast cancer and its clinical features at incidence in Indian patients with breast cancer. **JCO Global Oncology** 2020 :6, 1052-1062. https://doi.org/10.1200/go.20.00054



Shivani Krishna is Assistant Professor of Biology. She did her PhD in ecology at IISER, Thiruvananthapuram, and postdoctoral work was in insect ecology and behaviour at the University of Haifa, Israel. She uses multiple approaches combining tools from mathematics, physics and ethology to understand the consequences of plant-animal interactions, structural features of habitats, vegetation richness and diversity in relation to pollination and herbivory patterns.

Contact: shivani.krishna@ashoka.edu.in

Recent Publications:

- Somanathan, H., **Krishna, S.**, Jos, E., Gowda,V., Kelber, A., Borges,R.M. (2020) Nocturnal bees feed on diurnal leftovers and pay the price of day-night lifestyle transition. Frontiers in Ecology and Evolution, doi:10.3389/fevo.2020.566964
- **Krishna, S.** & Keasar T. (2019) Bumblebees forage on flowers of increasingly complex morphologies despite low success. Animal Behaviour, 155, 119-130

Shubahsis Haldar is Assistant Professor of Biology. He did his PhD from Indian Institute of Chemical Biology, Kolkata and postdoctoral research at Max Planck Institute of Biochemistry (Germany) and University of California and Columbia University (USA). His research is in Biophysics with a keen interest in single molecule technologies. At Ashoka he established the first covalent magnetic tweezers in India, which have several applications in Physics, Chemistry and Biology.

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Recent Publications:

- **Haldar, S.***, Tapia-Rojo, R., Eckels, E.C., Valle-Orero, J., & Fernandez, J.*, **(2017)** "Mechanical Folding by the Trigger Factor Chaperone" **Nature Communication 8 (1): 668.**
- Banerjee, S., Chakraborty, S., Sreepada,A., Banerji, D., Goyal, S., Khurana, Y. and **Haldar, S.*, (2020)** "Cutting-edge single molecule technologies unveil new mechanics in cellular biochemistry" **Annual Reviews of Biophysics** (Just accepted)

Sougata Roy is Assistant Professor of Biology. He did his PhD from the University of Montreal, and postdoctoral work in multidisciplinary areas of research as EIPOD (EMBL Interdisciplinary) Fellow at the Sanger Institute, EMBL and the Department of Chemistry, Cambridge University, UK. He uses unicellular phytoplankton model systems to understand the physiological relevance of circadian clocks.

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Our lab uses unicellular phytoplanktons to understand

a. The circadian regulation of physiology (photosynthesis, oxygen evolution, bioluminescence etc.) and metabolism under stress,.

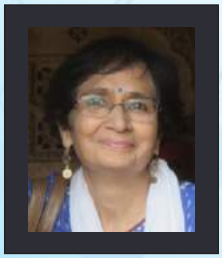
b. The diversity in clock organization.

c. Circadian regulation of protein synthesis and posttranslational modification

d. Understanding how the circadian systems can be modified to generate clock engineered algal cells with enhanced metabolic abilities

Publications

- CLICK-enabled analogues reveal pregnenolone interactomes in cancer and immune cells. **Sougata Roy#**,
- James Sipthorp, Bidesh Mahata, Jhuma Pramanik, MarcoL. Hennrich, Anne-Claude Gavin, Steven V. Ley, Sarah A. Teichmann#. (under review). biorxiv.org/search/sougata%252Broy (# Corresponding author)
- **Translation and translational control in dinoflagellates. Sougata Roy**, Rosemary Jagus and David Morse.Microorganisms 6 (2). 30; doi:10.3390/microorganisms6020030.



Sudha Bhattacharya is an Indian National Science Academy (INSA) Senior Scientist in the Department of Biology. She did her PhD from the Indian Agricultural Research Institute, New Delhi, and postdoctoral research at Stanford University, Boston Biomedical Research Institute, and the National Institutes of Health, USA. She spent a large part of her independent career at the Jawaharlal Nehru University, New Delhi. Her scientific interests are in gene organization and expression, rare genetic disorders and parasitic infection.

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Recent Publications:

- Naiyer S, Kaur D, Ahamad J, Singh SS, Singh YP, Thakur V, Bhattacharya A, **Bhattacharya S**. Transcriptomic analysis reveals novel downstream regulatory motifs and highly transcribed virulence factor genes of Entamoeba histolytica.BMC Genomics. 2019 Mar 12;20(1):206.
- Singh SS, Naiyer S, Bharadwaj R, Kumar A, Singh YP, Ray AK, Subbarao N, Bhattacharya A, **Bhattacharya S**. Correction: Stress-induced nuclear depletion of Entamoeba histolytica 3'-5' exoribonuclease EhRrp6 and its role in growth and erythrophagocytosis. J Biol Chem. 2018 Dec 14;293(50):19510.

Basudeb Maji is an Assistant Professor of Biology at Trivedi School of Biosciences. He is also an Assistant Professor in the Department of Chemistry at Ashoka University. He received his Ph.D. from the Indian Institute of Science, Bangalore and he was a Postdoctoral Fellow at Harvard Medical School and MIT. His research group works on microbial CRISPR-based adaptive immunity, functional genomics, and synthetic biology to address various genetic and infectious diseases. He primarily uses protein engineering, chemogenetics, and chemical biology methods to understand cellular physiology in the context of diseases for chemopreventive development.

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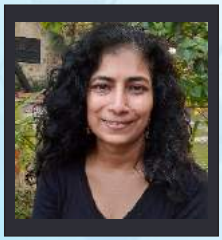
Recent publications.

- **B Maji**, SA Gangopadhyay, M Lee, M Shi, P Wu, R Heler, B Mok, D Lee, B Paul, V Dančík, MF Mesleh, A Vetere, LA Marraffini, DR Liu, PA Clemons, BK Wagner and A Choudhary. A high- throughput platform to identify small molecule inhibitors of CRISPR-Cas9. Cell, 2019, 167, 1067- 1079. Highlighted in more than 12 science media reports.
- **B Maji**[a], CL Moore[a], B Zetsche, SE Volz, F Zhang, MD Shoulders and A Choudhary. Multi-dimensional chemogenic control of CRISPR-Cas9. Nature Chemical Biology, 2017, 13, 9-11. [a]Equal contribution. (Highlighted by Nat. Chem. Biol. News & Views. doi: 10.1038/nchembio.2243.)
- M Lee[a], **B Maji**[a], D Manna[a], J Small, B Wagner, A Choudhary. Native zinc catalyzes selective and traceless release of small molecules in β-cells. Journal of the American Chemical Society, 2020,142, 6477-6482. [a]Equal contribution.
- D Manna, **B Maji**, S. Gangopadhyay, and A Choudhary. A singular system with precise dosing and spatiotemporal control of CRISPR-Cas9. Angew. Chem. Int., 2019, 58, 6285-6289.



Rama Akondy is an Associate professor of Biology in the Trivedi school of Biosciences. She received her PhD from the National Institute of Immunology (New Delhi, India) and worked at Emory university (Atlanta, USA) first as a post-doctoral researcher and then as junior faculty. Immunological memory, the ability of the immune system to 'remember' a previous encounter with a pathogen and respond to it better upon re-encounter, forms the basis of vaccination. Rama's primary area of interest is understanding immunological memory in humans by observing how our immune system reacts to viruses, vaccines and tumors.

Recent Publications

- **Akondy RS**, Fitch M, Edupuganti S, Yang S, Kissick HT, Li KW, Youngblood BA, Abdelsamed HA, McGuire DJ, Cohen KW, Alexe G, Nagar S, McCausland MM, Gupta S, Tata P, Haining WN, McElrath MJ, Zhang D, Hu B, Greenleaf WJ, Goronzy JJ, Mulligan MJ, Hellerstein M, Ahmed R. (2017). Origin and differentiation of human memory CD8 T cells after vaccination. Nature. Dec 21;552(7685):362-367.
- McElroy AK, **Akondy RS**, McIlwain DR, Chen H, Bjornson-Hooper Z, Mukherjee N, Mehta AK, Nolan G, Nichol ST, Spiropoulou CF. (2020). Immunologic timeline of Ebola virus disease and recovery in humans. JCI Insight. 2020 May 21;5(10).

Balaji Chattopadhyay is an Assistant Professor of Biology at the Trivedi School of Biosciences. He completed his PhD from Madurai Kamaraj University and pursued postdoctoral research at the National Centre for Biological Sciences, India, and the National University of Singapore, Singapore. Balaji's lab investigates topical questions in biotic evolution, wildlife conservation and human health falling within the One Health paradigm. His research integrates genomic, biological and environmental data to study the effect of climate change on wildlife and understand its implication towards emerging zoonotic diseases.

Contact: balaji.chattopadhyay@ashoka.edu.in

Recent Publications:

- **Chattopadhyay B**, Garg KM, Ray R, Mendenhall IH, Rheindt FE. 2020. Novel de novo genome of Cynopterus brachyotis reveals evolutionarily abrupt shifts in gene family composition across fruit bats. Genome Biology and Evolution. evaa030, https://doi.org/10.1093/gbe/evaa030
- Shingate P, Ravi V, Prasad A, Tay BH, Garg KM, **Chattopadhyay B**, Yap LM, Rheindt FE, Venkatesh B. 2020. Chromosome-level assembly of the horseshoe crab genome provides evidence for three rounds of whole genome duplication. Nature Communications, 11:1–13.
- **Chattopadhyay B**, Garg KM, Mendenhall IH, Rheindt FE. 2019. Historic DNA reveals Anthropocene threat to a tropical urban fruit bat. Current Biology, 29: R1269–R1300.
- **Chattopadhyay B**, Garg KM, Ray R, Rheindt FE 2019. Fluctuating fortunes: genomes and habitat reconstructions reveal global climate mediated changes in bats' genetic diversity. Proceedings of Royal Society B, 286, https://doi.org/10.1098/rspb.2019.0304

ACTIVITIES OF THE BIOLOGY DEPARTMENT

Seminars, Workshops and Conferences

The Department of Biology has organised several seminars, workshops, and conferences since its inception. These have attracted audiences ranging from high school students to international and national policy makers. Some of the conferences and meetings held last year were: Muscle and Diseases; Recent Advances in Understanding Disease Biology; Seminar Series on Ecology and Evolution; and Genetics and Evolution: Intertwined Strands. These have been significant in forging collaborations and providing a platform for students and faculty to exchange scientific ideas.

Darwin-Wallace Symposium

The Darwin-Wallace student symposium is held every year in the month of November/December to give undergraduate students an opportunity to discuss and present their research on diverse aspects of ecology and evolution, ranging from climate change and biodiversity, to the evolution of antibiotic resistance and modelling disease spread.

Biology Colloquium

During the academic year, we organise weekly colloquia with international and national speakers from different universities and specialisations within biology (on topics ranging from molecular genetics to ecosystems ecology). We ensure that the list of invited speakers reflect our inclusive outlook. Furthermore, we ensure that the majority of these talks reach beyond disciplinary boundaries; this encourages students to pursue interdisciplinary research. These weekly colloquia are followed by informal interaction sessions with the speakers over pizza or a coffee. This tradition provides our students with an opportunity to ask questions related to the speakers' personal journeys, research trajectories, and the challenges that they have encountered.

A MESSAGE FROM ASHOKA'S STUDENT-LED SOCIETY OF BIOLOGY, THE BIOSOC:

The Ashoka Biology Society is a student-driven initiative that brings together all aspects of the biological sciences to celebrate them and make them more accessible to the student community. We are passionate about different areas of biology and committed to sharing our interests to create a more robust biological discourse on campus. We believe that science and biology are for everybody, and strive to connect people within the community with each other. We welcome everyone – whether you are already adept or simply curious though yet-unacquainted with biology – we aim to nurture a love for biology at every level.

There are several ways in which we encourage people to engage with biology – be it through excursions to ecological sites; our weekly bio-science talks and movie screenings; volunteering with biodiversity surveys on campus; attending discussions on popular topics; or even writing for our editorial or social media platforms. In addition, we encourage student suggestions, and are excited to hear new ways in which we can bring our love of biology to the Ashoka community and the world!

We look forward to seeing you around!

RESEARCH FACILITIES

Ashoka University has state-of-the-art research facilities which support experiments that may range from single-molecule studies to organismal and ecological studies. Our undergraduate laboratories are fully equipped with advanced instrumentation and promote a unique open scientific culture. The facilities available to members of Ashoka University's biology department include:

1. Open Lab Facility

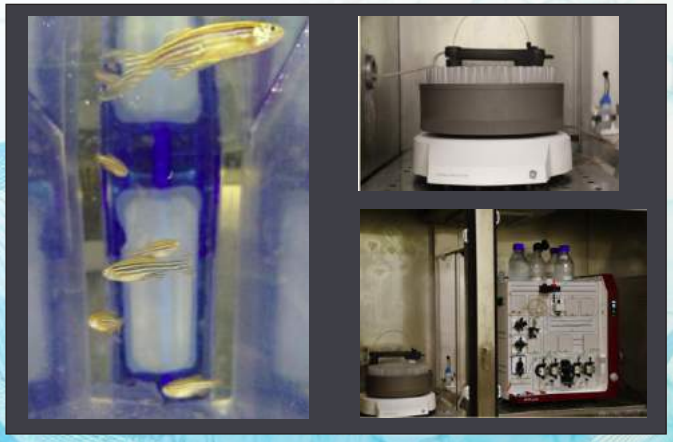
At Ashoka, there are no boundaries between individual labs, i.e., we have an 'open lab' culture. This promotes scientific and intellectual interactions by increasing the synergy among research groups and opens up collaborative approaches to address biological questions. Our research facility is fully equipped to help our undergraduate students, PhDs, and faculty members to take their studies and research forward. Our open lab facilities make learning more experiential and enjoyable.

2. Insect Culture Facility

The insect facility is equipped with rearing and growth chambers, microscope stations for sorting and typing insects, piped CO2, plate anesthesia, dissection, and electrophysiology rigs.

3. Fish Facility

The fish facility facilitates work of researchers who wish to utilize fish as a model organism for any kind of research along with daily care of the animals and aquarium systems. Currently, this involves a large fish housing system with automated cleaning, temperature monitoring, and pH and salinity maintenance. The fish are maintained on a 14:10 light: dark cycle and they are fed once daily from a culture of brine shrimp.



4. Plant Research Facility

Our plant research facility has an environmentally controlled greenhouse (with fan and pad cooling system) and a shade house. The facility provides plant material required for undergraduate experiments and research with different plant and insect species grown under enclosed conditions. It also houses an algal growth chamber with programmable light intensity setup that can go as high as 330µmoles/m2/s.

5. Analytical Instrumentation Facility

This facility houses:

- Single-molecule covalent magnetic tweezers that can apply physiological forces on a single biomolecule
- A real-time PCR system (Proflex)
- Preparative instrumentation facility
- High-speed centrifuge
- FPLC system
- Plate reader (Cladiostar)

6. Ashoka Imaging Facility

Seeing is indeed believing! Recent advances in light microscopy have revolutionized our understanding of various sub-cellular biological phenomena at nanometer resolutions. The Ashoka imaging facility supports the department's diverse microscopy needs through a variety of microscope systems. Currently, the facility houses the following instruments :

- Olympus BX63 Upright epi-fluorescence
- FemtoJet Microinjector on an Olympus IX53 inverter microscope
- Leica Polarizing microscope (at the Soft Matter Research Lab, Physics Department)
- Olympus SZX16 stereo-zoom epifluorescence microscope
- Olympus IX81 with W1 Spinning Disc confocal Microscope

Additionally, the department is also equipped with multiple dissection scopes for Drosophila and C. elegans manipulation.

ELIGIBILITY & REQUIREMENT FOR DIFFERENT DEGREES

Biology Major and Minor

Anyone can opt for a Biology Major or Minor degree independent of their past background. To pursue a Major in Biology at Ashoka, one must complete a total of 15 courses. This includes 7 core theory courses (RC), 4 lab courses, and any 4 electives (ELE). Courses offered by the Department of Biology, or cross-listed with the Department of Biology (even CTS; code BIO) can be counted.

To pursue a Minor in Biology at Ashoka, one must complete 6 courses that are either offered by or cross-listed with the Department of Biology. This includes 4 RCs and 2 electives. Lab courses can count as electives but are not mandatory.

Advanced Diploma in Biology (ASP)

There are two streams for joining the biology ASP programme. Those who have completed the requirement for the Biology Major with 92 credits can join ASP with Biology as a Major. In the second stream, those who have completed their Major in computer science/physics/chemistry/mathematics with 92 credits and want to pursue ASP with Biology as a Major can also be admitted in this programme.

Please note that the programme is recommended for those students who wish to pursue interdisciplinary graduate study in the subject.

In order to obtain this degree, students must complete a minimum number of 32 credits (or whatever is prescribed) and a dissertation.

Ph.D. Programme

Anyone with an MSc or equivalent degree in any branch of science/engineering/medicine can join the PhD programme at the Department of Biology. Admissions are through an entrance test and interview. The mode of these tests can change from time to time. Interested candidates are requested to look for the announcements every year.

The requirements for successful completion of the programme and eligibility for a Ph.D. degree are:

- Completion of the course work with a grade point average of at least B+
- Successful participation as a teaching assistant in two courses
- Passing the comprehensive written examination with .....% of marks
- Clearing the oral qualifying examination
- Giving two departmental seminars
- Publishing their thesis work as a research paper in which they are the first author
- Submission of dissertation
- Acceptance of the thesis by examiners and successful oral defence.

The progress of the thesis is monitored by an advisory committee.

ETHICAL POLICY OF THE DEPARTMENT

The Department of Biology believes in creating a productive environment for everyone and all students are expected to adhere to the policies outlined in this section. These are in addition to the other rules that are applicable at the university level.

All work submitted for credit is expected to be the student's own work. In any situation where information derived from published sources is directly used, it is the responsibility of the students to provide proper citations. Quotations must be properly placed within quotation marks and must be fully cited. In addition, all paraphrased material must be completely acknowledged. Whenever ideas or facts are derived from another student's research, sources must be indicated.

Research results: Students are expected to record the results of all their research honestly and accurately. Falsification of research results includes misrepresentations, distortions, or serious omissions of data or reports on research and is considered a serious violation of academic honesty. In addition, all the students are expected to follow all the regulations in place in relation to use of recombinant DNA, animal experimentation, human experimentation, hazardous material, and stem cells. In case of any questions please contact your teacher and/or head of the department.

COURSE CATALOGUE

This is a compiled list of courses of different categories that have been offered by the faculty of the Department of Biology in the past. This does not guarantee a yearly repetition. Foundation courses cannot be counted towards a major or minor. CTS (maximum 1) can be counted as an elective for Majors only.

Foundation Courses (FCs)

1. Principles of Science
2. Environmental Studies

Critical Thinking Seminars

1. Survival Strategies
2. Diversity of Life

List of Abbreviations used here

FC -Foundation Course
RC - Required Course
ELE -Elective Course

COURSES OFFERED BY THE DEPARTMENT

For New Course (2nd Semester): Each student should register for all 11 core courses (7 Introduction to Biology courses and 4 lab courses) and a minimum of 4 electives.

For Old Course: Each student should register for all 11 core courses (7 Introduction to Biology courses and 4 lab courses) and a minimum of 4 electives.

Please note,
In **blue**, are the RC laboratory courses. In **red**, are the RC theory courses.in **green**, are the ELE theory courses for majors and minors.

Semester	Core courses (Old)	Elective (Old)	Core courses (New) 2nd semester onwards	Electives (New)
1st semester (August -Nov) (Monsoon)	Fcs		Fcs	
2nd Semester (Spring)	**Basic genetics** **Biology Practical 1:** Exploring life in the neighbourhood	**Survival Strategies**	**Introduction to Biology 1 Genetics and Evolution** **Laboratory Course 1: Life in the neighbourhood**	**Survival Strategies**
3rd Semester	**Introduction to Cell and Molecular Biology** **Chemical basis of life** **Biology practical 2**		**Chemical basis of life Introduction to Biology 2:** **Cell Biology Introduction to Biology 3:** **Molecular Genetics and Molecular Biology** **Laboratory Course 2: Molecular Biology and Biochemistry** (Genetics and Evolution is a pre-requisite)	

Semester	Core courses (Old)	Elective (Old)	Core courses (New) 2nd semester onwards	Electives (New)
4th Semester (Spring)	Evolutionary biology	Advanced Molecular biology	Ecology Introductory Physiology	Microbiology and Biotechnology
	Biology practical 3		Laboratory Course 3: Cell Biology and Genetics	Introduction to Neuroscience
5th semester (Monsoon)	Ecology Microbiology	Biophysics and structural biology	Biostatistics and Bioinformatics	Developmental Biology (Genetics and Evolution will be the pre-requisite)
	Biology Practical 4	Statistics and Bioinformatics	Laboratory Course 4: Ecology and Evolution (Genetics and Evolution is a pre-requisite)	Understanding Structure and Function
	Biostatistics and Bioinformatics	Introduction to Neuroscience		Mathematical and Computational Biology (Introduction to computer) programming is recommended)
		Advanced Cell Biology		
		Plant Biology (Developmental Biology is a pre-requisite)		Animal Physiology /Biology (introductory physiology is a pre-requisite)
		Physiology Applied Microbiology		Immunology

Semester	Core courses (Old)	Elective (Old)	Core courses (New) 2nd semester onwards	Electives (New)
6th semester (Spring)		Immunology		Evolutionary Cognition (introduction neuroscience is a
		Development Biology		Force and Motion in Biology
		Advanced Neuroscience		Evolutionary Genetics (Genetics and Evolution is the prerequisite)
		Evolutionary Cognition (Pre-requisite: introduction to Neuroscience		Ecological and Epidemiological dynamics
		Computational and Mathematical Biology		Advanced Neuroscience (introduction neuroscience is a pre-requisite)
				Plant Biology (Developmental Biology is a pre-requisite)
		Advanced Biochemistry		Disease Biology (immunology is a pre-requisite)

Semester	Core courses (Old)	Elective (Old)	Core courses (New) 2nd semester onwards	Electives (New)
7th semester			Genomics, proteomics and NGS (BIO 4206)	
			Specificity in gene expression and cell signalling (BIO 4226/6230)	Any one 4 credit course within or outside the Department
			Biology Research I (BIO 4606)	
8th semester			Research Methodology and Ethics (BIO 6603/4209)	Timing in Biology (BIO-4028)
				Ecological and epidemiological dynamics (BIO 4026) Or Any one 4 credit optional course offered in 6th semester or outside the Department
			Biology Research II (BIO4607)	

IMPORTANT:
a. For a minor, any 4 out of 7 RC's are mandatory
b. In addition to the 4 RC's, a minor must complete 2 ELE courses.
c. For a major, all lab courses and RC theory courses are compulsory.
In addition to the 4 labs and 7 RC's, majors must complete 4 ELE courses within 3 years. For minors the requirement is 4 RCs and 2 ELEs.

DETAILS OF COURSES IN BIOLOGY

(BIO-1002) Exploring life in the Neighborhood Lab 4 credits

(Prerequisite: None)

Introduction: The goal of this course is to introduce students to their local ecosystem and biological world by involving both fieldwork and lab work. The course will also have open ended exercises, wherein students will be encouraged to come up with small questions and seek answers by experimentation.

Course details:

- Our neighborhood: Diversity around us: e.g. Birds of Ashoka
- Spot and track: How do they behave? (focal follow)
- Aligning with ants
- See the unseen I: Planktonic world diversity
- See the unseen II: Microbes around us
- Hypothesis testing and introduction to basic statistics
- Conflict in nature: Sex and conflict, battle of sexes
- Prey and predator interactions
- In the time of health and sickness: Infection and disease
- Organisms and environment: plants and their habitat adaptations
- Organisms and their chemical pursuits: Chemical world of our tiny neighbors:
- Group projects and presentations

(BIO-2212) Cell and Molecular Biology Lab 4 credits

(Prerequisites- Genetics Theory, registered in Cell and Molecular Biology Theory)

Introduction: 'The laboratory classes are designed to provide the students with hands-on-experience of some common molecular biology techniques. The laboratory learnings will complement some of the concepts studied during the theory course to have a comprehensive knowledge. However, it is an independent course in itself and is designed not only to understand the basic mechanism of biological processes but also will be beneficial to appreciate the use of biotechnological tools and techniques in academic research and industrial applications.'

Course details:

- Introduction and buffer preparation.
  This class will introduce the preparation of buffers that mimic cellular environment.
- Bacterial growth curve
  This session will allow students to understand the growth dynamics of simple organisms such as bacteria.
- Extracellular DNA isolation and its estimation and Characterization
  Bacteria can harbour extracellular DNA in the form of Plasmids and these can be used to clone genes of foreign origin. We will learn how we can isolate the Plasmid from the bacterial cells.
- DNA amplification in cell free system
  This is a kind of synthetic biology approach to amplify DNA in vitro. We will learn the details of this mechanism that is popularly known as Polymerase chain reaction.
- Cloning the amplified gene
  We will learn how to clone the PCR amplified gene into a vector.
- Transformation of foreign genetic material into bacteria
  Bacteria can uptake foreign DNA and this is facilitated by treating the bacteria to make it competent. We will learn the basics of how we can make bacterial cells competent and transform foreign DNA into these cells.
- Expressing, purifying and characterizing the protein from bacteria
  Here the students will learn how to do heterologous expression of proteins in bacteria and how to purify and characterize it.

(BIO-2202) Genetics Lab 4 credits

(Prerequisite - Genetics Theory)

Introduction: The laboratory practical classes are designed to provide the students with hands-on-experience of some basic as well as sophisticated techniques related to genetics. We will start with the practical analysis of bacterial genetics, to be followed by classical Mendelian genetics and then move on to screen and analyze mutants. We will be mainly concentrating on three widely used model organisms, E. coli, S. pombe and C. elegans.

Course details:

- Mendel's Laws, Brief Historical perspective - the garden pea experiment; Genetic Model Systems – Bacteria, Fission, C. elegans
- Meiosis - Set up mating - S. pombe sporulation on YPD plates -Haploid organisms; mono hybrid cross; Discuss dihybrid cross / punnet square Isolate spores and carry out Random spore analysis - Dilute and Plate Discuss tetrad dissection
- Replica plate into selective media; Discuss crosses in Diploid organism -demonstrate C. elegans; Homozygous / heterozygous.
- Mutants - Alleles - Genotypes and Phenotypes - isolate spores and plate them on YES plate - Linkage, epistasis; dominance; recessive alleles - their segregation
- Genetic Screens – Forward genetic screen – students may try a UV mutagenesis screen using fission yeast and hunt for temperature sensitive mutants. – Reverse genetic screen - RNAi screens – Discussion only – explain the rationale and methodology of genome wide screens.
- Introduction to C. elegans Genetics - Stages of Development; students get hands on experience with manipulating C. elegans
- Manipulating C. elegans - continue to practice- identify stages, males and hermaphrodites. Discuss
- RNAi – Students will use C. elegans to learn RNAi by feeding methods; Proper controls – efficiency of RNAi; quantification. (Students to follow up the next day to check and quantify the results).Techniques to Visualize cells and sub-cellular contents
- Genome editing techniques - Recombination in S. pombe and Crispr-Cas9 in C.elegans - demonstration & discussion Blue white screening via E. coli transformation

(BIO-3012) Ecology and Evolution Lab 4 credits

(Prerequisite: Evolutionary biology)

Introduction: Students will be introduced to quantitative methods of research in ecology and evolution including experimental design, data collection, analysis, interpretation and scientific writing using field and laboratory studies. They will work with plant and animal models from local ecosystems to empirically test concepts in population growth, competition, resource utilization, foraging behaviour, communication, ecological parameters on bacterial growth (e.g. pH & temperature). The course aims at giving an experience of concepts and methods discussed in theory courses of ecology and evolutionary biology. Towards the end of this course, students will be able to design and implement appropriate methods for sampling individuals, populations and communities and ask questions on their diversity, stability and productivity. Modules dealing with behavioral experiments will also demonstrate potential errors that arise due to observer bias, significance of blinded methods and other potential ways to improve the reliability of the data collected.

Course details:

Patterns of morphological variation using geometric morphometric analysisModels of spatial distribution: a test using dispersion of leaf gallsTesting the optimal foraging theory: flowers as resources and pollinators as foragersResource co-limitation in plantsPersonalities (intra-individual variation) in group living spiders: prey capture dynamicsIsland biogeography and species richnessMicrobial evolution under stressSexual Selection and mate harmIndependent research projects and poster presentations

(BIO-1200) Basics of Genetics Theory 4 credits

(No Prerequisite)

Introduction:

How an organism's structure and function is regulated? The answer to this question lies within the inherited DNA. Genetics have evolved phenomenally since Mendel first introduced the concept of genes during the mid-1800s. Today genetics is used in all phases of life from food to medicines, new discoveries tend to manipulate genetics not only to diagnose and find better cure for deadly diseases like cancer but also to design smart plants and microbes to enhance the quality and quantity of food and secondary metabolites such as biofuel. Hence a thorough knowledge of genetics is an absolute requirement for biologists to comprehend the complex living organisms.

This course will help you to acquire a thorough knowledge about the principles and concept of genetics. We will start with the seminal discoveries chronologically that led to our understanding of genetics today. Specifically, you will learn in details about inheritance of the genetic materials and traits, structure and function of chromosomes and genes, mapping genes on the chromosome. We will then move on to study the key areas of genetic variation and molecular genetics and focus on model organisms used for genetic studies. Subsequently we will learn about the inheritance of complex traits and population genetics.

Course Details:

- Discovery of the basic principles of inheritance. ◆Mendelian Inheritance
- Chromosomal basis of mendelism ◆Sex-linked inheritance ◆Linkage and mapping
- Extension to Mendelian genetics ◆Cellular reproduction
- Extra chromosomal inheritance ◆Chromosomal variation and its implications
- Mendelian principles applied to human genetics ◆Genetics of bacteria and virus
- Properties of the genetic materials ◆Model organisms to study genetics ◆Molecular genetics
- Introduction to Quantitative genetics: Inheritance of complex traits

(BIO-2210/BIO-6210) Intro to Cell and Molecular Biology Theory 4 credits

(Prerequisite - Genetics Theory)

Introduction: Cell is the fundamental unit of life. It carries out all (well... almost all!) the physiological processes essential for its survival and propagation. Within the cell, each of these processes is accomplished by molecular-machines. What are these processes and how do these mini machines carry out the cellular functions? How do these cellular machines know the right place and the right time to carry out appropriate functions? In this introductory Cell and Molecular Biology course, we will start by exploring some of the essential processes at the cellular level and understand how the relevant molecular machines manage to carry out these processes with such amazing fidelity and efficiency. The primary focus of this course will be on eukaryotic cells, but as and when needed we will draw comparisons with prokaryotic cellular processes to appreciate their similarities and distinctness. By the end of this course, the participant is expected to have a good conceptual grasp on basic cellular mechanisms, the molecular machineries involved, and their functional regulation within a cell.

Course details:

- Introduction to Cellular Organization and Processes ◆Organization of Genetic material in the cell
- Replication – Prokaryotes & Eukaryotes ◆Transcription – Prokaryotes & Eukaryotes
- Translation – Prokaryotes & Eukaryotes ◆ER, Golgi and Plasma Membrane – Protein Modification and Transport
- Protein Quality Control ◆Cytoskeleton – Structure and Dynamics ◆ Cellular Tracks and Force Generating Motors
- Endocytosis and Exocytosis ◆Movement – Cellular motility ◆Cell Division – Prokaryotes & Eukaryotes
- Cell Adhesion – Cell-Matrix and Cell-Cell Adhesions ◆Cell Death ◆Epithelial-Mesenchymal Transitions (EMT)
- Cancers and Tumors ◆Cellular aspects of Metazoan Development

(BIO-2010/BIO-6010) Evolutionary Biology Theory 4 credits

(No Prerequisite)

Introduction: This is a basic evolution course designed specifically for undergraduates and PhD students without any prior training in evolutionary biology, where the primary goal is to encourage the evolutionary thinking among students. I will start with very basic concepts and then slowly pace up to more advanced topics. During the course, I will primarily emphasize on two major aspects – (1) How do biologists infer the processes that contribute to evolution? (2) Why is the understanding of evolutionary patterns and processes critical for diverse areas of biological research? In addition, I will also briefly discuss (1) how do we read the primary scientific literature? (2) How do we write about science? At the end of this course, I hope that the students will develop a broad understanding of the key concepts and theories in evolutionary biology, including principles of natural selection and variation, sexual selection, population genetics, quantitative genetics, speciation and biodiversity, molecular evolution, co-evolution, and life history evolution. Finally and most importantly, I do not expect all the students to become professional evolutionary biologists – but whether they become astrobiologist, athletes, bureaucrats, entrepreneurs, movie stars or medical practitioners, I hope that if they ever think about biology, they will be capable of appreciating the lens of evolutionary processes.

Course details:

- The History of Evolutionary Thought ◆Evidence for Evolution; Origin of life
- The theory of natural selection ◆Random Events in Population Genetics
- Natural selection and random drift in molecular evolution ◆Two- and multi-locus population genetics
- Quantitative genetics ◆Adaptive evolution ◆ Evolution of sex ◆Sexual selection ◆Evolution of eusociality
- Evolutionary theory of aging ◆Mechanisms of Speciation ◆Phylogeny
- Evolutionary patterns and processes: Classification and evolution ◆Evolutionary Biogeography
- Life-history evolution ◆ Coevolution ◆History of life; Extinction and radiation
- Evolution of genes and genomes ◆Evolutionary medicine; Antibiotic resistance ◆Reading materials

(BIO-2300/6300) Chemical Basis of Life 4 credits

(No Prerequisite)

Introduction: The course aims at introducing basic concepts of chemistry in biology and provides a framework to understand basic biomolecular interactions and their mechanism. It will emphasis on studying amino acids, proteins, enzymes as biological catalysts and understanding the chemistry of enzymatic transformations. This course constitutes topics that cover lipids, carbohydrate, sugar, molecular metabolism, and membrane biochemistry.

Course details:

- Introduction of Cellular Chemistry / Chemistry of Life ◆Carbohydrate Chemistry ◆ Lipid and Fatty acids
- Amino acids and Proteins ◆ Protein structure ◆Protein folding and chaperone
- Enzymology part 1: Introduction ◆Enzymology part 2: Thermodynamic principles
- Enzymology part 3: Enzyme kinetics ◆Vitamins and cofactors
- Biological membranes 1 (types and structure of lipids, phospholipids) ◆Biological membranes 2 (fluid mosaic model)
- Transport of Proteins through membrane ◆ Glycolysis, TCA cycle, Glyconeogenesis and glycogenolysis
- Amino acid and Fatty acid metabolism ◆Nucleotide Biosynthesis ◆Protein expression and purification

(BIO-3020/BIO-6020) Ecology 4 credits

(No prerequisites, but completion of Evolutionary biology is strongly recommended)

Introduction: The course will cover a range of topics from individuals to ecosystems with an emphasis on theoretical foundations and recent developments in the field. We will begin with how ecological understanding is achieved, how conditions and resources influence individual species and then move to processes at higher levels of organization and end with rethinking some of the big questions in ecology. The topics covered will incluse physiological ecology, population ecology, species interactions, community ecology, succession and disturbance; ecosystem ecology, and biogeochemistry. Topics introduced in the lectures will be followed by in class-activities (and simulations) and discussions. For discussion sessions, I will suggest classic and recent research papers and students will lead discussions based on those. The course will allow to reflect on uncertainty and variation in natural processes from individual behaviour to ecosystem services. It is recommended strongly to take evolutionary biology course prior to this, since this course will build on some of the modules covered in that course.

Towards the end of this course, students will be able to (a) understand how ecologists empirically study processes occurring at various scales and apply evolutionary thinking to these processes (b) integrate proximate and ultimate factors to understand natural processes (c) quantitatively synthesize ecological research (d) explore applications of ecological concepts such as conservation, landscape management.

Course details:

- Introduction to ecology and evolutionary backdrop
- Conditions: life at extreme conditions, adaptations, temperature-size rules
- Resources: plant and animal resources, ecological niches, ecogeographical rules

Course details:

- Lifecycles: Birth, death and growth, dispersal and migration, intraspecific competition,
- Population dynamics: Density-dependence, growth models, metapopulations and patch dynamics
- Interspecific competition: mechanisms, experiments and models; niche partitioning, exploitation, allelopathy
- Species interactions: Predator-prey interactions, herbivory, foraging and game theory, arms race
- Mutualisms and antagonisms: Pollination, seed dispersal, symbiosis, parasitism, decomposition
- Behaviour ecology of species interactions: Economics of decision making, resource defense and learning
- Community structure in time and space: Successional mechanisms, patterns and gradients of species richness, disturbance, spatial heterogeneity, Island Biogeography
- Ecosystems ecology: Primary productivity, decomposition, flow of energy and matter through ecosystems, biogeochemical cycles

(BIO-3501/6501) Biostatistics and Bioinformatics 4 credits
(No Prerequisite)

Introduction: This course is application oriented with a focus on understanding and making use of data in biology. The systematic acquisition of data made possible by advances in genomics and proteomics technologies has created a gap between the available data and its analysis leading to insights from the data. In addition, the data from multiple sources can be used to generate hypothesis and answer important questions. Computational and theoretical approaches to understanding biological systems are an essential step in closing this gap. Since statistics plays an important role in data analysis lectures on relevant topics of statistics are part of the course.

Course details:

Statistics

- Introduction: Basic probability, random variables, expectation, variance
- Data distribution: Random variables and distribution
- Statistical inference & Sampling: Population and samples, Central limit theorem, t distribution
- Hypothesis testing: Type I and Type II error and power, confidence intervals,
- Multiple hypothesis testing: False discovery rate, family wise error rate
- Hypothesis testing in practice: Hypothesis tests for categorical variables (chi-square, Fisher's exact)
- Bootstrap simulation, permutation tests

Bioinformatics

- Biological data and databases
- Biological data mining
- Nucleic acid and protein sequence analysis
- Concept of annotation
- Sequence alignment
- Finding remote homologs and motifs
- Protein and RNA structure analysis
- Next generation sequencing and principles of NGS data analysis.
- Principles of phylogenetic analysis

(BIO-3423/6423) Physiology 4 credits
(Prerequisite: Biochemistry, Cell & Molecular Biology)

Introduction: The overall learning objective of this course will be to understand the concepts regulating tissue/organ functions necessary for achieving homeostasis in living organisms. The students will learn how basic concepts in cell biology, biochemistry and biophysics work in conjunction to regulate organ functions. The topics will cover nerve-muscle physiology, sense organs, cardiac cycle, blood coagulation, digestion, excretion of nitrogenous waste, integumentary system. The topics covered in this course include:

- Introduction to Human Body
- Bone and skeleton system
- Integumentary system
- Neurons and nerve impulse conduction
- Blood and circulation
- Heart
- Lymphatic system
- Digestion and metabolism
- Endocrine system and reproduction
- Urinary system

(BIO-3413/6413) Applied Microbiology 4 credits
(Prerequisite: Genetics Theory)

Introduction: In this introductory microbiology course we will start by exploring the general concepts of microbiology and the diverse microbial lifestyle on earth. We will discuss various aspects of microbial diversity such in – their cellular architecture, genome organization, cellular processes, form and lifestyle. In the second half of the course we will examine our own 'love-hate' relationship with the microbes and deliberate why certain microbes became successful in causing diseases but not others, and how we have engineered microbes to drive our food and biotechnology industry.

Course details:

- Introduction to Microbial physiology & diversity ◆Cellular architecture of prokaryotic microbes
- Cellular architecture of Viruses ◆Cellular architecture of Eukaryotic microbes
- Microbial genetics ◆Gene regulation in microbes ◆Microbial Cell Biology
- The Human microbiome ◆ Social Interactions in microbes ◆Microbes as pathogens
- Studying microbial pathogenesis ◆Control of microorganisms ◆ Anti-microbials◆Medical Microbiology

◆Basic Food Microbiology ◆ Biotechnology/Industrial microbiology ◆Waste-water microbiology

(BIO-3433/6433) Developmental Biology 4 credits
(Prerequisite: Biochemistry, Genetics, Cell & Molecular Biology)

Introduction: The Course will follow Animal development (invertebrates and vertebrates) from the egg to the embryo to certain specific tissues/organs. Basic concepts of developmental biology as also principles and mechanisms that help form and shape the organism will be taught and discussed.

- Introduction to positional information, axes, coordinates and morphogen gradients
- Commonly used Experimental methods in developmental biology
- Generation and Interpretation of gradient information and Pattern formation
- Physics and Mathematics of morphogen gradients and their interpretation
- Modes of cell-cell interactions during tissue organization: Self-organization, lateral inhibition, induction, and recruitment
- Growth and differentiation ◆Evolution of body plan ◆Stem cell biology and tissue repair
- Literature (papers, reviews, lectures) will be made available online and throughout the course recent papers in the area of developmental biology will be read to update the class on recent research discoveries. While Plant development is taught in a separate course, some comparison will be discussed here.

(BIO-3304/6304) Advanced Biochemistry 4 credits
(Prerequisite: Biochemistry, Cell & Molecular Biology)

Introduction: In this course, we will learn how biochemical principles regulate a variety of physiologically relevant cellular phenomenon like transport across biological membranes, endocytosis and exocytosis. This course also aims to understand how biochemical pathways process complex macromolecules like carbohydrates, lipids, proteins and nucleotides to maintain energy requirements in physiological systems.

Course details:

- Composition and architecture of membranes. Membrane dynamics, membrane biogenesis
- Types of membrane transport (osmosis, diffusion, facilitated diffusion, active transport)
- Role of membrane lipids and proteins in cell signaling (Tyrosine kinase and GPCR signaling)
- Endocytosis (lysosomal degradation of endocytosed proteins) and exocytosis
- Bioenergetics
- Glycolysis, TCA cycle, gluconeogenesis and glycogenolysis
- Beta oxidation of fatty acids, ketone bodies
- Urea cycle
- Cholesterol biosynthesis
- Oxidative phosphorylation and electron transport chain in mitochondria (details of mitochondria structure)
- Biosynthesis and degradation of nucleotides
- Vitamins and co factors.
- Pathways, Metabolic network and regulation of metabolism

(BIO-3443/6443) Immunology 4 credits
(Prerequisite - Cellular and Molecular Biology)

Introduction: This course will introduce students to molecules, cells and organs that shape invertebrate and vertebrate immune system. Students will learn about the structural features of components of the immune system and mechanisms involved in its development and function. Subsequently, we will discuss evolutionary pathways and constraints that have led to the development of functional innate and adaptive immunity. We will trace the conserved and unique features of the immune response across species and adaptive changes in pathogens that have shaped the evolution of the immune system. Together, this course will provide important insights into the development and function of immune system, integrating emerging concepts from classical immunology and evolutionary biology to understand how organisms resist or endure infections and diseases.

Course details:

- Introduction: Rise of immunological thoughts
- Concepts of immunity from Natural history examples of host-pathogen interactions
- The immune framework; evolution, ecology and organisation of immune tissues the need for immunity, innate and adaptive immunity, pathogen niches and effector responses, organisation of immune components
- Target recognition strategies in the immune system; innate, adaptive and MHC repertoires target identification, non-clonal and clonal receptors, self/non-self-discrimination, contexts of signals, control of immune context of antigenic targets
- MHC structure-function, polymorphisms, classes, presentation pathways
- Developmental rules in the immune system; innate versus adaptive immune cell differentiation, embryogenesis and immune development, sites and lineages, checkpoints and signals, proliferation and differentiation balances, unique characteristics of lymphocyte differentiation programmes
- Evolutionary processes underlying immune responses I: Natural selection and immunity
- Evolutionary processes underlying immune responses II: Sexual selection and immunity
- Evolutionary constraints, physiological regulatory networks, and integrators underlying immune responses
- Resource-based trade-offs with immune responses: Energetics of immunity
- T cell immune responses TCRs and their signaling, proliferation and differentiation, effector and memory response balances, regulation of commitment to distinct cytokine groups in T cell responses, CD8 T cell response control, regulatory T cells
- B cell immune responses structures and functions of antibody/BCR molecules, BCR-mediated signalling, accessory signals, germinal centres, isotype class switching, somatic hyper mutation, differentiation of memory B cells versus plasma cells
- Immunity in heath and disease Ideas of 'health' and 'disease', immunity to infections, integration of innate and adaptive components in regulating immune responses to infections, mucosal immunity, non-infection targeted immune inflammation, autoimmunity and allergy
- Conserved and unique features of the immune response across species and populations
- Immune mechanisms as a function of rapidly evolving pathogens: perspective within- and across-populations
- Molecular evolution and immune pathways: Integrating proximate and ultimate mechanisms
- Evolutionary genetics of immunity and implications for infectious disease
- Microbiome, hormones and immune system regulation

(BIO-2103/BIO-6103) Introduction to Neuroscience 4 credits

(No Prerequisite)

Introduction: The goal of this class is to enable students to understand how a biological system mostly composed of salty proteinaceous water bounded by fat is able to signal information, perform complex computations and produce behaviour. We will start by understanding how single neurons can perform computations and can be understand in the same framework as electronic circuitry. We will understand then how complex information processing and calculation can happen as a result of the ways in which multiple neurons signal to and connect to one another. We will then look at how the brain is organized, and study the nervous systems of humans and other animals, approaching this through the lens of the various tools that neuroscientists have historically used to study neuronal connectivity and the brain. We will cover the electrical properties of nerve cells and voltage dependent membrane permeability; channels, transporters, neurotransmitters and their receptors; synaptic transmission; the brain and its development and plasticity. We will also study complex brain functions and the neural basis of complex cognition, learning and information processing. We explore the ways in which the neuronal processes underlying behaviour have been deduced from various animal models of behaviour, and ways in which genetics and the environment shape the systems that produce behaviour during development. We will explore sensory perception and motor movement. We then turn to the question of how we learn, how we absorb new material, at the neural basis of complex and interesting phenomena such as motivation, emotion, cognition, consciousness, attention. We will end with an exploration of how neural systems can exhibit pathology, how neurodegeneration and trauma can impact the system, and how medication and drugs work. This course eventually hopes to make clear the relationship between brain and behaviour.

Course details:

- What is a neuron? ◆How do neurons function? ◆How do neurons process information?
- What is a neural circuit? ◆How do neurons communicate? ◆Synapses, medications and drugs
- What is in a human brain? ◆ What is in the human spinal cord? ◆Experimental neuroscience
- Genetics and neural development ◆Trauma, neurodegeneration ◆ Neural regeneration and repair
- Animal behaviour ◆ Human and animal brains ◆Sensory perception and movement
- Learning and memory ◆Motivation, reward and learning ◆ Nature and Nurture
- Emotion and “rationality”, ◆Communication, language ◆Decision making ◆Attention and sleep
- Consciousness! ◆Mood, depression, anxiety ◆Schizophrenia, Parkinsons and Alzheimers

(BIO-3114/BIO-6114) Advanced topics in Neuroscience 4 credits
(Prerequisites - Introduction to Neuroscience)

Introduction: The goal of this class is for students to explore various topics in neuroscience that give one a sense of the possible framework of computation through electrical signaling by wet, messy, living systems. The introduction to neuroscience course should have already given you all a sense of how single neurons perform basic computations of addition and subtraction and how elementary circuits might perform more complicated computations. We will explore how these multi neuron circuits work in this course not through textbook material or conventional teaching, but rather through reading primary scientific material, which you should already be familiar with.In this class, we will put together a series of topics in neuroscience for further study. A rough set of topics is provided below, but we can explore really any other system that people are interested in. In every week, one class will involve teaching, and the other will involve discussion and presentations. In the second class, students take turns contributing to the collective understanding of the field by presenting individually selected readings, based on your own interest. Then we will collectively discuss advances in each field, relying on looking up fresh primary research papers together.

Course details:

- The simplest circuit: the retina ◆Receptive fields in the eye ◆ Feature detection in the retina and advanced visual circuits
- Auditory circuits ◆ Evo-devo-neuro: comb jellies and cniderians
- Operant conditioning and learning ◆Appetitive conditioning versus fear conditioning: a review of circuitry
- Auditory localization in owls and bats: delay lines and coincidence detectors
- Magnetic sensation in p igeons/ants
- Electrical sensation in electric fish ◆Interoceptive awareness ◆Attention/ Decision making
- Binocular rivalry and consciousness experiments in humans ◆Echolocation and grid cells in bats
- Place cells in rats and monkeys ◆Bonding and attachment, in mice, voles ◆Mirror neuron circuitry
- Predator avoidance and predation ◆Group behaviour and sociality
- Deprived vs enriched environments
- Song and pattern generation in zebrafinches and crickets
- Pattern generation in walking
- Circadian rhythms, synchrony
- Navigation circuitry ◆Population coding

(BIO-3104/6104) Evolutionary Cognition 4 credits

(Prerequisites - Introduction to Neuroscience)

Introduction: The goal of this course is to delve into the complicated question of how cognition has been shaped by Evolution. This question has been addressed by various disciplines, including the fields of "Evolutionary Psychology", "Sociobiology" and "Physical Anthopology". The common problem with the construction of the framework of these fields is the chain of untested assumptions underlying it, and the development of ideas unmoored to the physiological basis of either evolution or cognition. We will break down each model used to teach Evolutionary Psychology to critically examine each system, and each system feeds into a larger understanding of what is involved in the evolution of cognitive abilities. This course looks at the question of whether there are aspects of behaviour and cognition that do and do not seem to have evolved in particular evolutionary contexts. The first step in our critical examination is to understand what evolution does and does not mean in a Darwinian framework; as well as whether and how cognition can be defined and accurately assessed. We look at what aspects of behaviour are hardwired, and what is plastic. We understand that evolution pertains to genetic changes, and get a quick understanding of what genetics constitutes. We then learn about epigenetics, gene expression, how the framework of genes and their expression drives physiological development of an embryo, how the brain develops as a subset of the body from a genetic framework, and about the relative ridigity and plasticity of parts of the brain during development and in adulthood. We then visit various questions in evolutionary cognition, focussing on the historical debates between the people who began extending the framework of evolution to understand behaviour and cognition. The learning goals for this class are to primarily learn how to distinguish an evidence-based understanding of evolutionary cognition from what have been called "just-so" stories, which clog the public and even scientific realm.

Course details:

- What is evolution, what is cognition, how do these relate to each other?
- What evidence do we have for evolution? ◆How does genetics relate to evolution?
- What are epigenetics and development and how do they mediate between genetics and behaviour?
- The evolution of humans, and language, the notion of a module.
- How does linguistics relate to the assessment of cognition?
- Nature and Nurture in cognition ◆Ants and humans: Socio-biology and its troubled past.
- Evolutionary Cognition and its history of racism ◆Gender and cognition: Spelke/Pinker debate
- Cooperation and conflict among kin and non-kin ◆Kin selection and Inclusive fitness theory
- Sexual selection ◆Cheater detection, altruism and mirror neurons
- Further conserved modules in evolutionary cognition

(BIO-3313/6313) Biophysics and Structural Biology 4 credits

(Prerequisite: For biology students Biochemistry is the Prerequisite, for others knowledge of basic cellular biology is necessary, such as understanding of DNA, RNA, and protein)

Introduction: This course will emphasize on the role of physics or physical principles on biology. This will not only focus on biological phenomenon (like protein diffusion, ligand-receptor binding), but also provide hands on experience on high end research technologies such as covalent magnetic tweezers or fluorescence correlation spectroscopy. It will also train students on respective data analysis.

Course details:

- Introduction of Biomolecules [Proteins, Carbohydrate, lipids, Nucleic acids]
- Biophysics of water and salt
- Electrochemistry (common ion effect, Ostwald's dilution law, Dielectric Constant)
- Protein diffusion, ligand-receptor binding and crowding effects
- Cytoskeleton: Actin and microtubules
- Motor proteins ◆Protein degradation pathways ◆Mechanical transduction ◆Cell adhesion and migration
- Basic biophysical technologies (UV-Vis, Circular Dichroism, Fluorescence Spectroscopy)
- Hands on experience on magnetic tweezers and data analysis ◆Hands on experience on single molecule FCS to determine size and aggregation propensity of proteins

(BIO-3233) Advanced Cell Biology 4 credits

(Prerequisite: Biochemistry, Cell & Molecular Biology)

Intoduction: This course will focus on molecular regulation of cell physiology such as intracellular trafficking, nuclear transport, cell cycle, dynamics of cell cytoskeleton (actin, tubulin and intermediate filaments), cell migration, extracellular matrix and cell adhesion and signaling from intracellular compartments. We will cover the following topics:

- Cytoskeleton and molecular motors ◆ Nuclear trafficking ◆Cell Cycle
- Extracellular matrix and Cell adhesion ◆Cell migration ◆Signal transduction ◆Cancer biology
- Apoptosis and autophagy ◆Organelle communication ◆Techniques in cell biology

(BIO-3223/4216/6223) Advanced Molecular Biology 4 credits
(Prerequisite Genetics and Introduction to Cell and Molecular Biology)

Introduction: This course will provide basic as well as advanced understanding of the concepts and tools that are used in molecular biology. Advanced molecular biology course will start with the basic details and exception of the central dogma of biology. Then we will discuss how to evaluate and design key cutting-edge research in the field of molecular biology.

Course details:

- Introduction to central dogma ◆DNA replication errors and repair ◆Recombination and transposition
- Chromatin structure and epigenetics ◆Transcription ◆Translation
- Regulation of gene expression (including post transcriptional gene silencing)
- rDNA tools and techniques (REs, Vectors, hosts and cloning)
- Construction of DNA and cDNA libraries and screening them
- Blotting techniques (southern, northern and western)
- Introduction to NGS
- Genomics, Transcriptomics and Proteomics

BIO-XXXX) Molecular Genetics and Molecular biology 4 credits
(Prerequisite Genetics and evolution)

Introduction: How an organism's structure and function is regulated? The answer to this question lies within the inherited DNA. Genetics have evolved phenomenally since Mendel first introduced the concept of genes during the mid-1800s. Today genetics is used in all phases of life from food to medicines, new discoveries tend to manipulate genetics not only to diagnose and find better cure for deadly diseases like cancer but also to design smart plants and microbes to enhance the quality and quantity of food and secondary metabolites such as biofuel. Hence a thorough knowledge of genetics is an absolute requirement for biologists to comprehend the complex living organisms.

Specifically, you will learn in details structure and function of chromosomes and genes, mapping genes on the chromosome. We will then move on to study the key areas of genetic variation and molecular genetics and focus on model organisms used for genetic studies. Subsequently we will learn about the inheritance of complex traits and population genetics. This course will provide basic as well as advanced understanding of the concepts and tools that are used in molecular genetics and molecular biology. Then we will discuss how to evaluate and design key cutting-edge research in the field of molecular biology.

Course details:

- Genes and chromosomes ◆Sex-linked inheritance ◆Linkage and mapping
- Genetics of bacteria and virus ◆Properties of the genetic materials ◆Chromatin structure and epigenetics
- Introduction to central dogma ◆DNA replication ◆Transcription and its regulation
- Translation ◆Recombination and transposition ◆ rDNA tools and techniques (REs, Vectors, hosts and cloning)
- Construction of DNA and cDNA libraries and screening them

(BIO-4028) Timing in Biology 2 credits

(Prerequisite: Genetics and Evolution and Introductory Physiology)

Introduction: Living organisms adapt to the surrounding environment by coordinating different biological tasks with the 24 h rotation of the earth with the help of a cell-based clock, termed as the circadian clock. Circadian clock generates self-sustaining endogenous rhythms in physiology, behaviour and metabolism that have wide implications in eukaryotes and prokaryotes. This course will give a brief overview of how circadian clocks generate temporal rhythms.

Course details:

- Biological rhythms and its examples
- Circadian rhythms and its characteristics
- Phase response curves
- The Genetics and Molecular Biology of Circadian Clocks
- The Circadian Systems of Cells

(BIO-4206) Genomics and NextGen Sequencing 2 credits

Intoduction: Understanding structure, expression and dynamics of a genome allows us to correlate structure with function and help to find molecular correlates of different phenotypic characteristics. Recent developments of high throughput technologies have opened unprecedented level of dissecting a genome that has opened up new ways of deciphering genotype-phenotype correlation. We will expose the students to these new ways of understanding genomes and show how the genomic data can be used to understand functional features.

Course Details:

- Definition and introduction to high through-put approaches to biology
- DNA sequencing technologies
- Next Generation Sequencing (NGS) and d technology platforms
- Strategies for sequencing entire genomes
- Genome assembly and annotation
- Application of genomics 1: Single nucleotide variation, Copy number variation, Disease susceptibility and diagnosis
- What is proteomics and basic methods?
- Large scale proteomics analysis, use of mass spectrometers

(BIO-4226) Specificity in gene expression and cell signaling 2credits
(Prerequisites: Cell and molecular biology and biochemistry)

Introduction: Cell signaling or signal transduction pathways are fundamental mechanisms used across biological systems to effectively relay information within extracellular and intracellular milieu. Understanding such cellular information processing strategies have led to the discovery of numerous drugs which are used for pharmacological perturbation of deleterious pathways in multiple diseases. This course will provide students a broad perspective on how cell signaling mechanisms significantly affect physiology and pathophysiology.

Learning outcome: In this course the students will learn how components of signaling pathways (receptors, ligands, channel proteins and second messengers) regulate physiological functions and phenomenon like host-pathogen interaction, innate and adaptive immunity and embryonic development. The overall goal will be to appreciate the vast diversity in signaling mechanisms and crosstalk between different pathways.

Course Details:

1. Introduction to Biological signaling

2. Signaling tool box and methods for deciphering signaling pathways

3. Second messengers, calcium, cAMP and lipids 4.Ca2+ and its involvement in cytoskeletal dynamics and exocytosis

5. Signaling in neurons and cardiovascular system 6.Signaling in embryonic development

7. Cell signaling in innate and adaptive immune systems 8.Cancer signaling

9. Host-pathogen interaction 10. Quorum sensing, two component system and communication in bacteria

11. Endoplasmic stress response and unfolded protein response

(BIO-3453/6453) Plant Biology 4 credits
(Prerequisite - Introduction to Cell and Molecular Biology)

Introduction: The human society is absolutely dependent on the plant community, whether it is oxygen, food or medicines. This course will give the students a basic as well as in-depth knowledge of plant biology. We will learn about the details of its anatomy, development, biochemistry, stress, metabolism, physiology and breeding. We will also understand how the modern genetic, molecular biology and genome editing tools have helped to generate better plants.

Prerequisite: The following courses are required for registration.

- Genetics" theory and practical
- Cell and molecular biology" theory and practical
- Microbiology" theory
- Biochemistry" theory
- Physiology" theory

Course details:

- Ancestor of plants ◆Plant cells (anatomy of plants) ◆Plant nutrition ◆Transport in plants (water and nutrients)
- Photosynthesis in C3 and C4 plants ◆Plant respiration ◆Genomes of model plants
- Plant secondary metabolites and defense ◆Plant growth and development
- Light control and response in plants ◆Plant hormones ◆Flowering and its control in plants
- Plant stress and abscisic acid ◆Plant breeding ◆Plant molecular biology and biotechnology

(BIO-6614) Graduate Seminar Course in Biological Sciences 4 credits

Introduction: Communication is key in science. The primary objective of this course is to help graduate students learn to review, critique and discuss scientific literature. This module is designed to help Ph.D. students improve their presentation skills in their individual research topics as well as subjects beyond their primary expertise. In this era of multi-disciplinary research, this skill will be extremely valuable.

Course Details:

This module is designed as one in recent research papers (or manuscripts) in life sciences are allotted to students. The students then present a seminar on this paper including suitable literature search and critical analysis. The research paper will be further discussed with their fellow graduate students and lecturers. This seminar style approach is very conducive to spreading new information and getting graduate students aware of and interested in other associated disciplines. The seminars given by students are open to UG students and other faculty members.

Planned Weekly Schedule	
Week 1	Course Briefing and warm-up
Week 2	Manuscripts – Reading and Review
Week 3	Critique manuscripts - Writing
Week 4	Presentation – Building Content & Delivery
Week 5	Ecology & Evolution - In Class paper presentation
Week 6	Cell & Developmental Biology - In Class paper presentation
Week 7	Biochemistry & Biophysics- In Class paper presentation
Week 8	Disease Biology and Pathogenesis - In Class paper presentation
Week 9	Ecology & Evolution - In Class paper presentation
Week 10	Cell & Developmental Biology - In Class paper presentation
Week 11	Biochemistry & Biophysics - In Class paper presentation
Week 12	Disease Biology and Pathogenesis - In Class paper presentation
Week 13	Course Debrief and Review

(BIO-4606) Biology research-1 2 credits

(BIO-4607) Biology research-2 2 credits

Introduction: The 4th year biology program (ASP) has a mandatory research component both in the 7th and 8th semester. Overall, the students are expected to learn to carry out background search in their chosen area, design a scientific problem, plan and execute experiments and analyse the data. The students will learn different ethical principles applied to research and carry out their work in a safe manner. It is expected that this course will prepare a student for future advanced studies in any area of biology

FOUNDATION COURSES

Fc0305 FC course on Principle of Science 4 credits

Intoduction: The course narrates some of the key theoretical and technical developments in the evolution of the sciences. It offers a synoptic view of the history of science and technology till the Cold War – though there is greater emphasis on the modern sciences. While the evolution of scientific ideas will be discussed, the place of `science in history' will receive equal emphasis. The canvas of the course is presented below. But a couple of social themes that have an impact on science will be introduced as the course proceeds. For example, a class or two will be dedicated on the questions of impact of colonialism, gender and race.

Course Details:

- The Nature of Science

  What is science? Science as an institution. The methods of science. The cumulative tradition of science. Science as a means of production. Science as curiosity and as a source of ideas. The interaction of science and society.

- Early and Medieval Sciences ◆The separation of the sciences. ◆The sensation of temperature.
- The four elements. ◆The observation of the heavens. ◆The building of theories.
- The circulation of knowledge in the ancient and medieval worlds. ◆The fortuitous conjuncture – mathematics, alchemy and optics.
- The first scientific revolution ◆The First Phase: the renaissance. ◆The Agricultural Revolution.
- The Revolution in astronomy. ◆Navigation. ◆The Copernican Revolution.

The Scientific Revolution- the second phase: The first bourgeois revolution. Galileo Galilei

The Foundation of Dynamics. Scientific societies. The dynamics and justification of the Solar System. Celestial mechanics and the Newtonian system. The phenomena of the prism. The velocity of light. Newton's rings. Diffraction. Biological diversity and cataloguing life, Introduction to Linnaean system

The New Philosophy -The third phase: Science comes of age. Capitalism and the birth of modern science. Antecedents and consequences of the industrial revolution

Science and the revolutions.

- The French revolution and its effects on science. ◆The character of science in the industrial revolution.
- The eighteenth and nineteenth century advances of science. ◆The vacuum pump.
- The spring of the air. ◆The separate condenser. ◆The locomotive. Heat and energy.
- Engineering and metallurgy. ◆Science in the late Nineteenth century. Electricity and magnetism.
- Microscopy and discovery of cells, cell theory, and diversity in cell structure and function while maintaining common features
- Science in the twentieth century
- From Classical to Modern Physics: The New Physics: Waves, rays and radioactivity. Quantum Theory: Einstein and Bohr. General Relativity. The Standard Model. Physicists as Librarians. Woes and Wonders in 1900. Science as a Profession. Uses of New Physics.
- The new sciences of Life. Nature of living organisms, how life was formed and existence of life in other planetary system. Concept about chemical basis of life will be introduced. Understanding inheritance and birth of genetics, Mendel and his experiments, discovery of DNA and Molecular basis of genetics
- A discussion on biodiversity and possible loss due to climate change.

FC: Ecology & Environment 4 credits

Introduction: This course introduces students to the field of Environmental Studies. It is designed to provide an understanding of several critical issues of our times such as climate change, pollution of our environment, threats to biodiversity, water, food, and energy security, ecological justice, amongst others.

Students are introduced to the origin and evolution of planet Earth and how humans are altering the natural environment. Specific modules include ecology and ecosystem studies; history of our changing environment; biodiversity and conservation; climate change: its causes and impacts; environmental pollution; ecological justice; and socio-economic-legal aspects of the environment.

The course will familiarise students with these themes through lectures, readings from key works in Environmental Studies, and film screenings. Additionally students will perform several hands-on activities such as assessing changes to India's environment using satellite data, documenting local biodiversity, and using climate change models.

The course will be delivered through classroom lectures and discussions, film screenings, discussion of key readings, project-based learning activities and in-class and homework assignments.

Course Details:

- Origin and Evolution of the Earth. How and when did the Earth and the solar system form? What was early Earth like? How did it evolve over 4.56 billion years? How did it become habitable?
- A Brief History of Geologic Time Geologic time and major evolutionary events.
- The Human Age. Human Evolution. How environmental change influenced evolution.
- Ecosystems and Ecology. Introduction to ecological studies. A brief introduction to the ecological history of India including the environment during ancient, medieval, and colonial times.
- Biodiversity and Conservation. Biodiversity Hotspots, Threats to biodiversity, Biodiversity conservation.
- Climate Change. The science of Climate Change. Societal impacts of climate change. Policies and governance. Impacts of climate change in India.
- Our Changing Environment. Pollution in our environment. Air, Water, Soil, and Environmental Pollution. Rachel Carson's The Silent Spring, the Bhopal gas leak; Chernobyl, Uranium mining in Jadugoda.
- Mapping Environmental Change. Our changing environment. Mapping urban expansion, deforestation, changes in land use and land cover, natural and manmade disasters.
- Social Issues and the Environment. Sustainable development. Environmental Ethics. Consumerism and the environment.
- Environmental Law. Laws and Acts of India. The Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act.
- Environmental Justice / Ecology and Equity

Looking Ahead. What is the future of our planet in the “Anthropocene”?

CT 1083 Critical Thinking Seminar Course Survival Strategies 4 credits

Introduction: One way of understanding life is to identify and understand strategies that living organisms use in order to survive in nature, particularly when there are biotic and abiotic changes in the environment. Organisms use different strategies depending upon their nature as well as the environment. These strategies evolve towards better adaptation and help in the perpetuation of life. In this course, we will study the strategies used by different types of organisms and try to correlate these with evolution.

Student evaluation will be based on class participation, a research paper, and mid-semester and final examinations.

Course Details:

- Survival and Evolution: General principles
- Survival strategies
  - ♦ Microbes ♦Parasites: unicellular and multicellular ♦Insects ♦Flies ♦Plants ♦Animals
  - ♦Survival strategies in extreme environment ♦Desert ♦High altitude ♦Deep ocean
- Conclusion

Field methods in ecology and conservation science 4 credits

Introduction: The goal of this course is to introduce students to field methods in ecology and conservation science by involving both ecological fieldwork and lab work and social science research methods. The course will also have open ended exercises, wherein students will be encouraged to come up with small questions and seek answers by experimentation.

Course Details:

Timeline

Week 1	Orientation/Introduction to field ecology and conservation	Hypothesis testing, sampling designs and a short field trip Approach: Conservation problems, defining the problems, methods to quantify and solutions

Timeline

Week 2	Fragmentation & loss of species diversity (Social)	Theory: Property, Common property, Natural Resource Governance Methods: Introduction to interviews and surveys
Week 3	Invasive species (Social)	Theory: Managing Multi-use Landscapes Methods: Introduction to using participatory GIS
Week 4	Plastic Pollution	Theory: Behavioral change, Nudge Theory Methods: Randomized controlled trials
Week 5	Hunting/Fishing/Illegal wildlife trade	Theory: Illegal use of protected areas Participant observations
Week 6	Fragmentation & loss of species diversity (Marine/Terrestrial)	Theory: Island biogeography Metapopulations, Single large or several small Methods and analysis (using beetles and flies as models) :Insect species diversity using sticky traps, pitfall traps, sweep net sampling, wind direction measurements; diversity indices, rarefaction, species abundance models
Week 7	Invasive species (Marine/Terrestrial)	Theory: Ecological impacts of invasive species on native species. Methods and analysis (using plants as models): Quadrat sampling of invasive plants and native plants, point quarter method; transects, soil quality measurements
Week 8	Pollution (Air/Water/Land) / Pesticides and insecticides	Theory: Effects of pesticides and insecticides Methods and analysis (using bees as models): pan traps, visual observations (counts on flowering plants), Aspirator sampling, light intensity and humidity measurements

Timeline

Week 9	Hunting/Fishing/Illegal wildlife trade (or) Climate change/greenhouse emissions	Theory: Impacts of overfishing and illegal harvesting Methods and analysis(using fish/aquatic species as models): Sampling aquatic species (fishing nets), water turbidity, salinity and pH measurements
Week 10	Independent work	Identifying and proposing a chosen conservation problem to work for two weeks: questions, hypothesis and methods
Week 11	Independent work	Ecological and social science approach to a chosen conservation problem
Week 12	Independent work wildlife trade	Ecological and social science approach to a chosen conservation problem
Week 13	**Student presentations**	

COURSES CROSS-LISTED FROM/WITH THE DEPARTMENT

1. Exploring the Neighbourhood Lab (with ES)
2. Biophysics (with PHY)
3. Thermal and Statistical Physics (with PHY)
4. Introduction to Neuroscience (with PSY)
5. Advanced topics in Neuroscience (with PSY)
6. Evolutionary Cognition (with PSY)
7. Computational and Mathematical Biology (with CS)
8. Field methods in ecology and conservation science (with ES)
9. Introduction to Earth Sciences (with ES)
10. A Global History of Science (with HIS and ES)
11. CTS Critical Scientific Thinking (with CT and PSY)
12. Environmental Studies (with ES)
13. Ecology (with PHY)
14. Force and motion in Biology (PHY)

CROSS-LISTING POLICY

University-wide Policy

1. The individual departments are free to come up with their own policies regarding how many courses they will allow from other departments, but if no policy is specified then they will go with the default rule of 2 (for Minor), and 3 for Major.
2. LMS will consider a department that comes first in the code as the department that has given the course.
3. Any courses that have been cross-listed can be counted for 2 or 3 requirements (Major, Minors, etc.) provided it follows the department's cross-listing policy
4. A CTS is first a CTS, and then a course from a department, i.e. a CTS is a course that is considered arising from another department.

DEPARTMENT POLICY

The Department has no upper cap on the number of courses that you take from outside the department, as long as they are cross listed with BIO.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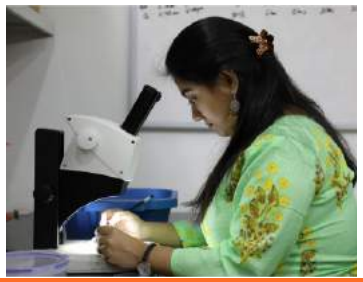
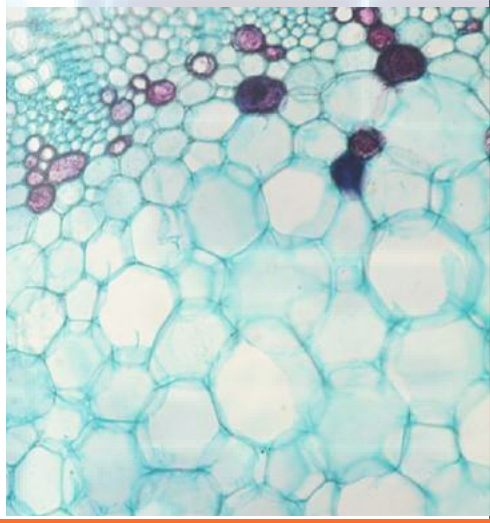
DARWIN-WALLACE STUDENT SYMPOSIUM

ASHOKA UNIVERSITY





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