

UNIVERSITY OF DELHI

CNC-II/093/1/EC-1273/25/
Dated: 31.07.2025

NOTIFICATION

Sub: Amendment to Ordinance V

(ECR 38-3, 38-4, 38-5, 38-6 and 38-7/ dated 17.01.2025
& ECR 07-4/ dated 23.05.2025)

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

The Syllabi of the following Programmes for Semester-VII and Semester-VIII under the Faculty of Science based on Undergraduate Curriculum Framework 2022, are notified herewith for the information of all concerned:

1. BSc. (Hons.) Anthropology for Sem-VII and Sem-VIII- As per **Annexure-1**
2. BSc. (Hons.) Biomedical Science for Sem-VII and Sem-VIII - As per **Annexure-2**
3. BSc. (Hons.) Botany for Sem-VII & VIII - As per **Annexure-3**
4. BSc. (Hons.) Zoology for Sem-VII/VIII - As per **Annexure-4**
5. BSc. (Hons.) Geology for Sem-VII and Sem-VIII - As per **Annexure-5**


REGISTRAR

**DEPARTMENT OF ANTHROPOLOGY
UNIVERSITY OF DELHI**



Syllabus

**B.Sc (Hons) Anthropology 2025
UGCF-NEP
Semester VII and VIII**

Department of Anthropology
University of Delhi
UGCF-NEP Syllabus
B.Sc. (Hons) Anthropology, IV year, Semester VII and VIII

B.Sc. (Hons) Anthropology IV year, Semester VII and VIII				
	Semester-7	Credits	Semester-8	Credits
	Discipline Specific Core (DSC)		Discipline Specific Core (DSC)	
	Ethnic and Cultural Diversity of India	4(3L+1P)	Demographic Anthropology	4(3L+1P)
	Choose Three Papers from DSE OR Two DSE and One GE OR One DSE and Two GE	4 credits x 3=12 credits	Choose Three Papers from DSE OR Two DSE and One GE OR Choose One DSE and Two GE	4 credits x 3=12 credits
	Discipline Specific Elective [DSE]		Discipline Specific Elective [DSE]	
	Primate Behavior	4(3L+1P)	Ergonomic Anthropology	4(3L+1P)
	Anthropology of Development	4(3L+1T)	Health, Illness and Culture	4(3L+1P)
	Epidemiology and Public Health	4(3L+1P)	Anthropology of Technology	4(3L+1T)
	Genetics of Health and Disease*	4(3L+1P)	Anthropology of Public Policy	4(3L+1T)
	Research/Academic Project/Entrepreneurship#	6	Research/Academic Project/Entrepreneurship#	6
	Generic Elective		Generic Elective	
	Choose from the Pool of given GE Papers		Choose from the Pool of given GE Papers	
		22		22

**This paper can only be taken by those who had opted Human Population Genetics in Semester-6*

**This paper can only be taken by those who had opted Anthropology of Health and Wellbeing in Semester-5*

***Fieldwork in Semester-4, 6 and 8 are essential and an important aspect of Anthropology and must be conducted in area outside Delhi and NCR region for duration as mentioned in the syllabus*

As per the University of Delhi guidelines

ANTHROPOLOGY : Semester VII

DISCIPLINE SPECIFIC CORE--(DSC) Ethnic and Cultural Diversity of India

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
DSC -19: Ethnic and Cultural Diversity of India	4	3	0	1	10+2 Pass	Nil

Course Objectives

- To introduce students to significant aspects of diversity in the ethnic composition of Indian population and the cultural diversity of the people of India.
- It would also deal with the origin, evolution and foundation of social life in India and familiarize the students with village life, rural India and changes in urban India.

Learning Outcomes

- To understand the people of India on the basis of genetic, linguistic, cultural, economic and social life.
- Understand the factors contributing to the unity in Indian civilization regardless of its enormous diversity.
- Understand the ethnic elements in Indian populations and the critical concepts of tribe, caste, class and gender in view of Indian social reality.

Syllabus

45 Hours

Unit 1 : Diversity in Indian Social Structure

12 Hours

Concept of Varna, Jati, Caste, Gender hierarchies. Changes in Indian Caste System, Sanskritization, Dominant caste, Great tradition and little tradition. Universalization and Parochialization. Urbanization and changes in the urban social structure.

Unit 2 : Rural and Peasant Society**11 Hours**

Approaches to the study of peasants; economic and political organization, social organization, agriculture and impact of market economy on villages. Folk-urban continuum, peasantry, Tribe-caste continuum, Tribal situation in India, tribal movement and quest for identity.

Unit 3: Ethnic and Genetic Diversity of India**11 Hours**

Critical appraisal of the contributions of Risley, Guha and Sarkar towards understanding ethnic distinctness in the Indian populations. Proto-historic racial elements in India. Recent studies on Indian genetic diversity.

Unit 4 : Linguistic Diversity of Indian Population**11 Hours**

Linguistic elements in Indian population- Indo-Aryan, Dravidian, Austro-Asiatic and Tibeto-Burman linguistic groups in India.

Practical**30 Hours**

1. Documentation of lived experiences of Indian social structure such as caste, tribe, religion by the students including understanding of Indian Society and its social problems.
2. Collection of primary data on ethnic diversity of Delhi
3. Visits to suburban areas to practically experience the rural/peasant society to understand the peasant economy its impact
4. Project on ethnic and cultural diversity in India

Core Readings

1. Bose, N.K. 1961. *The Structure of Hindu Society*. Delhi Orient Longman .
2. Cohn S. Bernard: 2000. *India: The Social Anthropology of Civilization*. Delhi: Oxford University Press.
3. Guha BS 1941, 1944. *The Racial Elements in Indian Populations*. Oxford Pamphlet in Indian Affairs
4. Gupta, Dipankar (ed). *Social Stratification*. Delhi: Oxford University Press.
5. Karve, Irawati 1961. *Hindu Society : An Interpretation* . Poona : Deccan College
6. Majumder, P.P and Basu, A 2015. A Genomic View of the Peopling and Population Structure of India, *Cold Spring Harbor Perspectives in Biology*, doi: 10.1101/7:a008540

Suggested Readings

1. Mandelbaum, D.G., 1970. *Society in India : Changes and Continuities*. Bombay : Popular Prakashan.

2. Reich, D., Thangaraj, K., et al 2009. Reconstructing Indian population history. *Nature*, 461(24): 489-495
3. Redfield, R. (1989). *The Little Community and Peasant Society and Culture*. University of Chicago Press.
4. Trautmann, T.R. 2011. *India: Brief history of Civilization*. Oxford University Press: Delhi.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE–(DSE) Primate Behavior

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
DSE - Primate Behavior	4	3	0	1	Class XII pass	NIL

Course Objectives

- To understand the behavior of non-human primates and its social structure to distinguish it from human
- To understand the non-human primate behaviour as a model for interpreting human behavioural evolution.

Learning Outcomes

- Understand the behavioral patterns of non-human primates as a model for understanding human behavior.
- Study behavioural evolution of living non-human primates.

Syllabus : **45 Hours**

Unit 1 : Fundamentals of Primatology **12 Hours**

Primate definition and characteristic features, Evolutionary History, Primate Radiation, Primate classification and Taxonomy, Ethno-primateology and the Anthropology of the Human-Primate Interface

Unit 2 : Social Structure and Organization of Primates **12 Hours**

Grouping, Kinship and Family among the non-human primate, Variations in Group Size, Territoriality, Aggression, Competition and resource defense, Inter and Intra-group competition and competitive exclusion foraging strategies.

Unit 3 : Primate Cognition and Communication **11 Hours**

Primate Cognition, language Communication patterns among the non-human primates: Visual, olfactory, vocal and tactile. Social context and function of primate communication primate communication as precursor to human communication, Cognitive abilities, tool use, Intelligence among primates

Unit 4 : Culture and Learning Among Primates

10 Hours

Mother-infant relationship and dynamics of evolution of culture among the primates Enculturation among the Non-human primates. Mechanisms of social learning, Cooperation and altruism, Primate culture as a precursor to human culture

Practical;

30 Hours

1. Prepare a field report on Primate behavior by collecting empirical data from the field area. It will include the following
2. Observation, collection and recording of primate behavioral data in a controlled and their natural set up.
3. Behavioral sampling using focal and scan methods
4. Interpret behavioral data in the context of social behavior, primate cognition and communication.
5. Write an analytical report based on the data collected

Core Readings

1. Seth, P.K. 2000. Behavioral Determinants of Rhesus Monkeys. In M K Bhasin Ed. *Studies on Man: Issues and Challenges*. Kamla Raj Publication P.1-21.
2. Glenn E. King. *Primate Behavior and Human Origins*, 2015, Routledge.
3. Warren G. Kinzey. *The Evolution of Human Behavior: Primate Models*. 1987, State University of New York Press

Suggested Readings

1. Fred Anapol, Rebecca Z. German, Nina G. Jablonski (Editors). *Shaping Primate Evolution: Form, Function, and Behavior* [1 ed.]. 2004, UK: Cambridge University Press
2. David A. Washburn, Duane M. Rumbaugh. *Primate Perspectives on Behavior and Cognition (Decade of Behavior)*. 2006, Washington, DC: American Psychological Association.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE–(DSE) Anthropology of Development

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
DSE - Anthropology of Development	4	3	1	0	Class XII pass	NIL

Course Objectives

- To understand the nature and scope of development, impact of development on traditional as well as complex societies.
- To delineate the theories of the development policies and planning
- To analyze the factors of social and cultural changes due to development

Learning Outcomes

- Students will have a theoretical understanding and will acquire the skills to examine the development discourse from anthropological perspective
- Learn how to devise a plan for the resettlement and rehabilitation of the project displaced people

Syllabus: **45 Hours**

Unit 1: Anthropology of Development **12 Hours**

Concept of Development, Indicators and Theories, Anthropology of Development: Aim and Scope, Contributions of Anthropology to Development

Unit 2: Development and Globalization **12 Hours**

Anthropology, Development and Post-Modern Challenges. Globalization and Social Development. Sustainable Development Goals

Unit 3: Development Plans and Policies **10 Hours**

Development Plans and Policies in India: Application of anthropological knowledge in planning and development. Community Development. Developmental Interventions: Role of NGOs and Civil Societies.

Unit 4: Development Discourse

11 Hours

Displacement, Rehabilitation, and Resettlement. Involuntary Resettlement. Dynamics of social and economic adaptation during resettlement. Case Studies

Tutorials

15 Hours

1. Prepare an evaluative study/ a project based on any contemporary development Program in India by employing various sources viz. books, journals, magazines, government reports newspaper articles, etc.
2. Presentation of the project and group discussion

Core Readings

1. Arce, Alberto and N. Long. 1999. *Anthropology, Development and Modernities*. London: Routledge.
2. Cernea, M., and S. Guggenheim, (eds) 1993. *Anthropological Approaches to Resettlement: Policy, Practice and Theory*. Boulder: Westview
3. Chambers, Robert, 2013. *Rural Development: Putting the Last First*, London: Longman
4. Dube, S.C. 1988. Modernization and Development: The Search for Alternative Paradigms. *United Nations Press*.
5. Gardner, Katy., and David Lewis. 1996. *Anthropology, Development and The Post - Modern Challenge*. London, Chicago, Illinois. Pluto Press

Suggested Readings

1. Madan, T.N. 1983. *Culture and Development*. OUP
2. Mair, Lucy. 1984. *Anthropology and Development*. London: Macmillan
3. Patnaik, S M 1996 Displacement Rehabilitation and Social Change : Inter India Publications
4. Nollan, R W 2019. Development Anthropology: Encounters in Real World. Routledge.
5. Escobar, Arturo. 1997. Anthropology and the Development. *International Social Science Journal*, Vol. 49, Issue 154. Pp. 497-515.
6. Escobar, Arturo. 1991. Anthropology and the Development Encounter: The Making and unmaking of Development Anthropology. *American Ethnologist*, Vol. 18, No. 4. Pp. 658-682.

7. Mathur H M. 1989. *Anthropology and Development in Traditional Societies*. New Delhi:Vikas Publishing House
6. Vidyarthi, L.P. 1986. "History of Applied Anthropology in India". In L.P. Vidyarthi(ed.) *Applied Anthropology in India*. New Delhi: Kitab Mahal. Pp. i-xxxviii.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE–(DSE) Epidemiology and Public Health

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical / Practice		
DSE - Epidemiology and Public Health	4	3	0	1	Class XII pass	Studied Anthropology of Health and Wellbeing

Course Objectives

- To understand the principles of epidemiology
- To learn the methods used in epidemiological research
- To understand the role of environment and human behavior in determining morbidity and mortality in communities

Learning Outcomes

- Students be able to apply epidemiological principles in field studies
- Should be able to clearly delineate the environment variables with reference to disease patterns
- Student should be able to discern and identify the psychological factors responsible for disease causation
- Student will be able to use community based participatory methods in epidemiological research

Syllabus:

45 Hours

Unit 1: Measures of Disease Burden

12 Hours

Anthropological and epidemiological concepts, measures of burden of disease, overview of epidemiology methods used in research studies to address disease patterns in different communities. Frequency distribution in terms of prevalence, incidence, rates and ratios of diseases.

Unit 2: Designs and methods of study

12 Hours

Study designs, surveillance method, assessment, prevention, and control of infectious and non-communicable, chronic diseases and lifestyle diseases: historical and contemporary cultural contexts.

Unit 3: Anthropology, Environment and Mental Health

12 Hours

Effects of socio-cultural, biological and other environmental determinants (water, air and food) on health; ecological and cultural model of population health; Social, psychological and behavioral issues in public health: factors influencing mental health and illness; Intervention strategies: assessing knowledge, attitudes and behaviors towards disease and treatment compliance.

Unit 4: Evidence based Decision Making in Public Health

9 Hours

Health policies, management, methods for monitoring the achievements of health care programs, and framework of evidence-based decision-making in public health

Practical:

30 Hours

Prepare a project report on topic related to epidemiology and public health by collecting primary data from the field area. It will include study designing, data collection, analyses and report writing.

Core Readings:

1. Gordis L. (2004). *Epidemiology*. Third edition. Philadelphia: Elsevier Saunders.
2. Edberg M. (2013). *Essentials of Health Behavior. Social and Behavioral Theory in Public Health*. Second Edition, USA: Jones and Bartlett Publishers.
3. Turnock B. (2016). *Essentials of Public health*. USA: Jones & Bartlett Publishers.
4. Lee, L. M. (eds.) (2010). *Principles and Practice of Public Health Surveillance*. USA: Oxford University Press.

Suggested Reading:

1. Kovner AR, McAlearney AS, Neuhauser D. (2013). *Health Services Management: Cases, Readings, and Commentary*. 10th Ed. Chicago, IL: Health Administration Press.
2. National Health and Family Welfare -5 Survey. Govt. of India. 2019-2021

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE--(DSE) Genetics of Health and Disease

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE – Genetics of Health and Disease	4	3	0	1	Class XII pass	Studied Human Population Genetics

Course Objectives

- To understand the basic tenets of genetics of health and disease
- To understand various methodologies for the identification of genetic variation.
- To understand the role of large-scale genetic investigations in determining the diverse genetic make-up of human population groups.

Learning Outcomes

Students will be able to learn:

- The historical transition and continuities of genetic health research and how genetic research contributes to health and disease.
- The classical and modern approaches in conducting genetic epidemiological studies.
- Different types of mega data projects and ethical considerations while implementing the findings of genetics research

Unit 1: Introduction

11 Hours

Introduction, scope and strategies of genetic epidemiology in 21st century. Databases in Human genetics or genetic epidemiology. Concept of heritability, Linkage, LOD score, Linkage disequilibrium and Twin studies and Family based genetic studies

Unit 2: Genetic Association Studies

11 Hours

Genotype-phenotype correlation, Genetic association studies: Candidate gene approach, Genome-wide association studies, Whole genome association study. Genetics of biomedical and behavioral traits

Unit 3: Genetic Projects**11 Hours**

Overview of HapMap Project, 1000 Genome Project, UK Biobank, Genome India Project, Human Population Structure, Ethical considerations

Unit 4: Applied Aspects**12 Hours**

Epigenomics, Epigenetic markers, Gene-environment interaction in health and disease. X-inactivation, imprinting, and epigenetic memory. Multifactorial inheritance of common traits and diseases, Behavioral genetics. Pharmacogenetics, Personalized medicine, Genetic counselling and pre-natal diagnosis, Cancer genetics

Practical:**30 Hours**

1. DNA Extraction
2. DNA Amplification: Polymerase chain reaction [PCR]
3. DNA Quantification
4. Genotyping

Core Readings

1. Vogel and Moulusky (2010). *Human Genetics*. Springer
2. Khoury M, Bedrosian S, Gwinn M, Higgins J, Ioannidis J, Little J (2010). *Human Genome Epidemiology*. Oxford University Press.

Suggested Readings

1. Gustafson JP, Tayler J, Stacey G (2008). *Genomics of Disease*. Springer
2. Timothy J.A. Chico (Eds.) (2014). *Genetics of Cardiovascular Disease* [1 ed.]. Academic Press.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

ANTHROPOLOGY : SEMESTER - VIII

DISCIPLINE SPECIFIC CORE–(DSC) Demographic Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC – 20: Demographic Anthropology	4	3	0	1	Class XII pass	NIL

Course Objectives :

To acquaint the students with the importance of demography in anthropology and give them a foundational understanding of population structure, growth and its implications.

To familiarize the students with the sources of demographic data and population policies in the country.

Learning Outcomes :

Students will be able to apply the demographical anthropological approaches to understand the bio-social determinants of demographic processes in human populations.

They will be able to discern how human population growth is affected by human behavioural and non-genetic factors.

The students will know about the rich repository of governmental demographic sources for research and in the formulation of several national policies.

Syllabus :

45 Hours

Unit 1 : Introduction to Demographic Anthropology

10 Hours

Demographic anthropology- Scope and basic concepts, Relationship between demography and anthropology, Importance of demography in anthropology, Population thought in view of its growth and decline.

Unit 2 : Theoretical Developments

12 Hours

Biological and Socio-economic population theories. Contributions of John Graunt and T. R. Malthus in demography. Theory of demographic transition.

Unit 3 : Demographic Structure

12 Hours

Population structure and sources of demographic data- Age and sex composition, demographic distribution of Indian population. Estimates of different demographic rates and ratios. Census, CRS, NSSO, SRS, NFHS-IIPS,

Unit 4 : Population Processes and National Policies

11 Hours

Fertility, Mortality, Morbidity, Marriage and Migration. Bio-social factors affecting population processes, Case Studies. National Population Policy and National Health Policy.

Practical:

30 Hours

1. Estimation of Rates and Ratios
2. Plotting of population pyramid and its significance
3. Formulation of household schedule and interview of respondents
4. Analysis of governmental demographic data and submission of project report for evaluation.

Core Readings

1. Bhende, A. and Kanitkar, T. (2019). 19th Eds. *Principles of Population Studies*. Himalaya Publishing House. Mumbai.
2. Bogue, D. J., 1969. *Principles of Demography*. Cambridge, UK
3. Howell, N. (1986). Demographic Anthropology. *Ann. Rev. Anthropology*. 15: 219-246
4. Malthus, T R .Essay on Principles of Population (Online Book)

Suggested Readings

1. Srivastava, O.S. (1996). *Demographic and Population Studies*. Vikas Publishing House, India
2. National Family Health Survey, India (<https://rchiips.org/nfhs/>)
3. Bernadi, Laura, 2007. *An Introduction to Anthropological Demography*. Germany: Max Planck Institute for Demographic Research
4. Patel, T. 1994. *Fertility Behavior: Population and Society in a Rajasthan Village*. Delhi: Oxford University Press.

Examination and Assessment : Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE--(DSE) Ergonomic Anthropology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE – Ergonomic Anthropology	4	3	0	1	Class XII pass	NIL

Course objectives:

- To provide knowledge about designing of health workplace, equipment, machine & surrounding.
- To equip the students in theoretical and applied aspect of ergonomic anthropology.

Learning outcomes:

- The student will be trained with tools and techniques of ergonomic anthropology that can help in improvement of effective workplace design.
- This course will help students to insure the safety, health and well-being of the workers.
- In this course will help the student to develop innovative idea about reducing the risk and management of occupational disease.

Syllabus

45 Hours

Unit 1 : Introduction

10 Hours

Concept and evolution of Ergonomics, Historical background, Scope of Ergonomics & Relevance in Anthropology, Evolving of Ergonomic Anthropology, Bio-mechanics concepts.

Unit 2: Ergonomics - Theories and Concepts

12 Hours

Theories of healthy standing and sitting, Posture stress, free posturing, Concept of safety, efficiency and comfort, Clearance and Reach.

Unit 3: Ergonomics principle in workplace design

12 Hours

Use of Percentiles in designing products, Average man in designing- A fallacy, Design of workplace and work environment.

Unit 4: Ergonomic Applications to reduce Occupational health hazards

11 Hours

Designing and safety: Disability ageing and inclusive design, work and health.

Practical**30 Hours**

1. Height vertex
2. Body weight
3. Sitting height vertex
4. Right anterior arm reach
5. Right anterior thumb tip reach
6. Head circumference
7. Arm scye circumference
8. Elbow to elbow breadth
9. Elbow rest height
10. Bideltoid breadth
11. Popliteal height
12. Knee height
13. Buttockpoplital length
14. Buttock knee length
15. Buttock leg length
16. Bitragion submandibular arch
17. Bitragionmenton arch

Core Readings

1. *Ergonomics in Design Methods and Technique* by MM Soares and Francis Robert, 2016 (CRC Press).
2. *Ergonomics for beginners: A quick reference glide* by Jan Dul, Bernard Weerdmeester, 2008 (CRC Press).

Suggested Readings

1. *Design and Anthropology* edited by Wendy Gunn and Jared Donovan, 2012 (Routledge).
2. *Applied Bio-mechanics concepts & connections* (2008) John Mclester; Peter St. Pierre. Wadsworth Publishing Co.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE–(DSE) Health, Illness and Culture

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE – Health, Illness and Culture	04	03	0	01	Class XII pass	NIL

Course objectives:

1. To explore the varied social and cultural dimensions of health wellbeing, illness, and healing
2. To understand the role of ritual in healing, and the politics of health, among other issues, from an ethnographic and historical perspective

Learning Outcomes:

Upon successful completion of this course, students will be able to:

1. Comprehend historical and socio-cultural influences on health, illness, and healing
2. Recognize the alternatives to biomedical understandings of health, wellbeing illness, and cure
3. Understand the dynamics of mental health and wellbeing in diverse contexts

Syllabus : **45 hrs**

Unit 1 Anthropology of Health and Illness **08 hrs**

Anthropological engagements with health and Illness: Approaches from medical anthropology; Experiential health and Spiritual health. Anthropology of Healing.

Unit 2 Disease Classification **15 hrs**

Cultural etiologies and nosologies of selected common ailments in India. Mental health; Tribal health and medicine

Unit 3 Medical Pluralism **11 hrs**

Health Sectors, medical pluralism, ethno-medicine, ethno-psychiatry and folk healing: Religion and healing: Cases studies.

Unit 4 Health Policies **11 hrs**

Right to health, Contemporary Health Policies and community health engagement.

Practical :**30 Hours**

1. To collect medical biographies and narratives associated with health, illness and their management.
2. Prepare a research design on health and health seeking behavior in cross-cultural context.
3. Case Studies of healers and their healing practices.

Core Readings

1. Hahn, Robert A. 1999. *Anthropology in Public Health: Bridging Differences in Culture and Society*. New York: Oxford University Press.
2. Helman, Cecil. 2007. *Culture, health, and illness*. London: Oxford University Press.
3. Gaur, Mokshika and Soumendra Patnaik 2011 Who is Healthy among the Korwa ? Liminality in the Experiential Health of the Displaced Korwa of Central India *Medical Anthropology Quarterly* .
4. James, A. Trostle. 2005. *Epidemiology and Culture*, Cambridge University

Suggested Reading

1. Joralemon, Donald. 2017. *Exploring medical anthropology*. London, UK: Routledge.P
2. Lenore Manderson, Elizabeth Cartwright, Anita Hardon. 2018. *Handbook of Medical Anthropology*. New York: Routledge.
3. Michael Winkelman. 2009. *Culture and Health: Applying Medical Anthropology*. USA: Jossey-Bass.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE--(DSE) Anthropology of Technology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE - Anthropology of Technology	4	3	1	0	Class XII pass	NIL

Course objectives

- To understand the role of social and cultural factors in technological innovations and usage.
- To understand the ways in which technological advancements re-constitute social and cultural realities around us.
- To introduce the studentsto digital, cyberspace and virtual media spaces in ethnographic context.

Course Learning Outcomes

The course will enable students

- To appreciate the applications of technology in everyday lives; both in the material and the virtual worlds
- To understand the human agency that controls technologies aimed for human welfare.
- To comprehend the applications and challenges of artificial intelligence in post-human era.

Syllabus :

45 hours

Unit I- Introduction

10 hours

Society, technology and culture; theoretical perspectives, definitions and inter-relationships.

Unit II- Technology in Everyday life

12 hours

Role of technology in re-constituting social institutions; kinship, marriage, family, religion, economy, polity. Use of technology in re-inventing diverse arenas of environment, health and well-being, education, urban planning, agriculture etc

Unit III Technology and Global Culture

11 hours

Exploring cyber spaces, social media platforms, virtual realities, the internet and meta-universe in ethnographic context. Technology, communication and globalization scope and challenges

Unit IV Artificial Intelligence and Intersectionality:

12 Hours

Uses and applications of Artificial intelligence, social robotics; human-machine relationships, algorithmic anthropology and digital anthropology. AI: future concerns and critique of post-human anthropology.

Tutorial**15 hours**

1. To review an ethnography/monograph which highlights the inter-relationship between society, technology and culture.
2. To prepare a research design to study the relevance of cyber spaces/social media platforms/digital cultures/ virtual realities/ the internet and meta-universe/artificial intelligence in re-constituting everyday lived realities and defining what it means to be a human.

Core Readings

1. Budka, P., & Kremser, M. (2004). 'Cyber Anthropology - anthropology of cyberculture'. In S. Khittel, B. Plankensteiner, & M. Six-Hohenbalken (Eds.), *Contemporary issues in socio-cultural anthropology: Perspectives and research activities from Austria* (pp. 213-226). LöckerVerlag, Vienna.
2. Christin, A. The ethnographer and the algorithm: beyond the black box. *Theor Soc.* **49**, 897–918 (2020). doi: <https://doi.org/10.1007/s11186-020-09411-3>
3. Maschio, T. (2021). *Digital Cultures, Lived Stories and Virtual Reality*. Routledge.
4. Postman, Neil. (1992). *Technopoly: the surrender of culture to technology*. New York: Knopf

Suggested Readings

1. Horst, H.A., & Miller, D. (Eds.). (2012). *Digital Anthropology* (1st ed.). Routledge. <https://doi.org/10.4324/9781003085201>
2. Sapignoli, M. (2021). The Mismeasure of the Human: Big data and the 'AI turn' in global governance. *Anthropology Today*, 37(1), 4–8. doi:10.1111/1467-8322.12627
3. Volti, R. (2020). *Society and Technological Change* (7th ed.). USA: Worth Publishers Inc.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.

DISCIPLINE SPECIFIC ELECTIVE–(DSE) Anthropology of Public Policy

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title and Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE - Anthropology of Public Policy	4	3	1	0	Class XII pass	NIL

Course Objectives:

The objective of the paper is to understand about the importance of anthropological knowledge in Public Policy formulation, anthropology and policy implementation and appraisal, etc

Learning Outcomes:

By studying the paper, the students will be able to:

- understand the concept and approaches of anthropology of Public Policy, engagement of anthropologists in policy research, etc.
- know the importance of traditional ecological knowledge in conserving environment
- analyze the problems of contemporary programs and policies in the country.

Syllabus:

45 hours

Unit 1 Anthropology in Public Policy

10 hours

Concepts and Approaches. Role of Anthropologists in Public Policy. Operationalization of conceptual and theoretical frameworks.

Unit 2 Public Advocacy & Change

12 hours

Anthropologists in Public Policy, Situating Anthropological Knowledge in Colonial and Post Colonial India: Power and Public Policy. Policy Advocacy and Agents of Change.

Unit 3 Development Discourse

12 hours

Development discourse, Community and Development Agencies; Way forward: Public Policy and Local Governance

Unit 4 Development and Ethics

11 hours

Ethical and Methodological Issues in Anthropology of Policy Research, Implementation and Evaluation, Challenges

Tutorial

15 hours

It will include exercise to prepare an evaluative study/ a project based on any contemporary issues relating to public policy and governance in India by employing various sources viz. books, journals, magazines, government reports, newspaper articles, etc.

Presentation of the project and group discussion

Core Readings

1. Belshaw, C. S. (Ed.). (2014). *The sorcerer's apprentice: An anthropology of public policy* (Vol. 4). Elsevier.
2. Fiske, S. J. (2006). *Anthropology in pursuit of Public Policy and practical Knowledge*. NAPA Bulletin, 26(1), 82-107.
3. Patnaik, S. M. (2016). *Whither anthropology in Public Policy: Reflections from India*. In The Routledge Companion to Contemporary Anthropology (pp. 416- 432). Routledge
4. Shore, C. (2012). *Anthropology and public policy*. The Sage Handbook of Social Anthropology, 2, 89-104.
5. Shore, C., & Wright, S. (Eds.). (2003). *Anthropology of Policy: Perspectives on Governance and Power*. USA and Canada: Routledge.

Suggested Readings

1. Van Willigen, J. (2002). *Applied Anthropology: An Introduction*. Greenwood Publishing Group.
2. Wedel, J.R. & Feldman, G. (2005), WhyAn Anthropology of Public Policy?*Anthropology Today*, 21(1),
3. Katz, S. H. 1987. Food and biocultural evolution: a model for the investigation of modern nutritional problems. In: F. E. Johnston (ed.), *Nutritional Anthropology*. New York: Alan R. Liss. Pp. 41-63.
4. Hahn, R. A., &Inhorn, M. C. (2008). *Anthropology and public health: bridging differences in culture and society*. Oxford University Press.
5. Stellmach, D., Beshar, I., Bedford, J., Du Cros, P., & Stringer, B. (2018). Anthropology in public health emergencies: what is anthropology good for?. *BMJ global health*, 3(2), e000534.

Examination and Assessment

Examination and assessment will be carried out as per the University of Delhi guidelines and notifications issued from time to time.



**Dr. B. R. Ambedkar Center for Biomedical Research
University of Delhi**

Syllabus for

**B. Sc. (Hons) Biomedical Science
UGCF-NEP
Semester VII and VIII**

Name of the Programme: B. Sc (Hons) Biomedical Science (ACBR)			
Detailed Structure of various DSC, DSE and GE courses to be followed from 2025-26			
Sem.	List of Discipline Specific Core (DSC)	List of Discipline Specific Electives (DSE)	List of Generic Electives (GEs) along with mandatory GEs (in Bold Minimum 3) to be studied if a student wishes to make it a minor in Biomedical Science
	Sem. I & II		Sem. I & II (Category I; Level 100)
I	DSC-1-Bioorganic Chemistry		GE 1: Landmark Discoveries in Science
I	DSC-2-Cell Biology		GE 2: Pandemic: Challenges and Preparedness
I	DSC-3-Human Physiology and Anatomy I		GE 3: Understanding The Human Body Systems
II	DSC-4-Biochemistry		
II	DSC-5-Principles of Genetics		
II	DSC-6-Human Physiology and Anatomy II		
	Sem. III-VI	Sem. III-VI	Sem. III-VI (Category II; Level 200)
III	DSC-7-Medical Microbiology	DSE-1-Drug Design and Discovery	GE 4: Biochemical Basis of Life
III	DSC-8-Medicinal Chemistry	DSE-2-Fundamentals of Neuroscience	GE 5: Concepts in Medicinal Chemistry
III	DSC-9-Biostatistics	DSE-3-Green Chemistry Methods in Pharmaceutical and Industrial Applications	GE 6: Environment Sustainability and Biomedical Waste Management[%]
IV	DSC-10-Immunobiology	DSE-4-Industrial Microbiology	GE 7: Genetic Basis of Diseases
IV	DSC-11-Molecular Biology	DSE-5-Intellectual Property Rights for Biologists	GE 8: Health and Body Defense System
IV	DSC-12-Pharmacology	DSE-6-Medical Biochemistry	GE 9: Practices in Biosafety[%]
V	DSC-13-Genome Organization and Function	DSE-7-Medical Laboratory Technology	GE 10: Statistical Concepts in Biology
V	DSC-14-Medical Biotechnology	DSE-8-Proteins and Enzymes	GE 11: Diseases in Everyday Life
V	DSC-15-Human Pathology	DSE-9-Research Methodology*	
VI	DSC-16-Biophysics	DSE-10-Social and Preventive Medicine	
VI	DSC-17-Human Genetics		
VI	DSC-18-Toxicology		
VII	DSC-19-Bioinformatics and Omics		

	Sem. VII-VIII	Sem. VII-VIII	Sem. VII-VIII (Category III; Level 300)
VIII	DSC-20-Developmental Biology	DSE-11-Advanced Cell Biology	GE 12: Concepts in Biotechnology
		DSE-12-Advances in Pharmaceutical Science	GE 13: Pathological Basis of Disease
		DSE-13-Protein Structure and Function: Advanced Concepts and Biomedical Applications	GE 14: Pharmacological Science
		DSE-14-Advanced Bioorganic Chemistry	GE 15: Toxic Substances and Human Health
		DSE-15-Advanced Techniques in Forensic Sciences	
		DSE-16-Immune Response to Infection and Diseases	
		DSE-17-Model Organisms in Biomedical Research	
		DSE-18-Advanced Molecular Biology and Genetic Engineering	
		DSE-19- Bridging Ancient Medicine and Practices with Modern Biomedical Research	
		DSE-9-Research Methodology*	

- # The Generic Elective Paper titled as “Understanding Genetic Basis of Diseases” has been renamed as “Genetic Basis of Diseases”. The course content for the previously approved Generic Elective paper entitled “Drug and Vaccine” has been revised and updated under the new title, “Pharmacological Science.” Consequently, the earlier approved “Drug and Vaccine” Generic Elective paper has been officially withdrawn.
- ** New GE Courses for which syllabus is included here. For rest of the GE courses, syllabus is already approved and available on the University portal.
- % The two red highlighted courses have been transferred from the Discipline-Specific Elective (DSE) pool to the Generic Elective (GE) pool, with their syllabi unchanged. These are to be considered as GE courses.
- *Research Methodology shall be offered as one of the DSE courses in the VI and VII semester. Students can opt it in either VI or VII semester. However, Students planning to pursue a 4 year UG program are advised to choose research methodology in the VI semester.

B.Sc (Hons.) Biomedical Science
Discipline Specific Core (BIOMED-DSCs)
SEMESTER- VII

DISCIPLINE SPECIFIC CORE COURSE -19 (BIOMED-DSC-19)

BIOINFORMATICS AND OMICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bioinformatics and Omics BIOMED-DSC-19	4	2	-	2	XII Passed	Basic knowledge of genetics, molecular biology

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be introduced to the field of bioinformatics and omics and their applications in biomedical research.
- Students will develop scientific and hands-on practical skills in bioinformatics that will be useful for higher studies.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will be able to work on bioinformatics tools and databases.
- Students will be able to perform pairwise and multiple sequence alignments and construct phylogenetic trees.
- Students will learn features of genomic sequences with tools to annotate them. Various next generation sequencing technologies like the ones used for variant typing will also be taught.
- Students will be able to appreciate the role of high throughput technologies along with computational tools in deciphering the differential gene expression that is important to understand the pathogenesis and mechanism of various human diseases.
- Students will also be introduced to proteomics, epigenomics, metagenomics, and metabolomics.

SYLLABUS OF BIOMED-DSC-19

Unit-I: Biological Databases and Genome Browsers

(4 hours)

Basic description and significance of bioinformatics, Introduction to various databases and their classification (primary and secondary databases) e.g. NCBI, DDBJ, EMBL, ENSEMBL, UCSC and their use in laboratories: literature, sequence, structure, medical, enzymes and metabolic pathways databases.

Unit II: Sequence Alignment and Phylogenetic Analysis (10 hours)

Introduction to sequence alignment, Nucleotide and Amino acid substitution scoring matrices, local and global pairwise sequence alignments using Dynamic Programming approach (Needleman-Wunsch and Smith-Waterman algorithms), calculating the alignment score. Pairwise alignment using word/k-tuple method (BLAST). Variables in BLAST Interpretation: BLAST score, e-value, bit score, p-value.

Multiple sequence alignment and its importance, Introduction to the basics of phylogenetic analysis. Tree-building methods: character-based methods (Maximum Parsimony) and distance-based methods (UPGMA and Neighbour joining). Construction of a phylogenetic tree and identification of homologs.

Unit III: Genomics (6 hours)

Structural and functional features of Genome sequences, Tools for the prediction of genes and regulatory elements; Gene Ontology, Next generation sequencing analysis (ILLUMINA, Oxford), Applications in SNP typing and copy number variation detection, ChIP seq

Unit IV: Transcriptomics and other Omics Technologies (10 hours)

Gene expression databases, Global profiling of gene expression, Differential gene expression, analysis using microarrays and RNA-seq- Principle, design and execution, data preprocessing (Exploration, normalization, filtering), Detection of differentially expressed genes (fold change and t-test), heatmaps, classification and prediction, Functional analysis and biological interpretation of differentially expressed genes, validation using qRT PCR, Applications of expression profiling in human diseases

Overview of other omics technologies like Proteomics, Epigenomics, Metagenomics, Metabolomics and their applications in biomedical research

Practical (60 hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Retrieval of information from databases like NCBI, ENSEMBL, UCSC, etc.
2. Pairwise Sequence alignment using BLAST
3. Multiple Sequence alignment using tools like CLUSTAL, MUSCLE, T-Coffee, etc.
4. Phylogenetic analysis using online tools like Simple Phylogeny (EMBL-EBI), Phylogeny.fr
5. Prediction of genes and genome annotation using tools like GENEID
6. Retrieval of gene expression data from GEO or SRA
7. Differential gene expression analysis using GEO2R
8. Gene Ontology using DAVID
9. Visualization of protein interactions using tools like Cytoscape, STRING, etc.

Essential readings:

- Baxevanis, A. D., Bader, G. D., & Wishart, D. S. (Eds.). (2020). Bioinformatics. John Wiley & Sons. ISBN: 9781119335955.
- Rastogi, S. C., Rastogi, P., & Mendiratta, N. (2022). Bioinformatics: Methods and Applications-Genomics, Proteomics and Drug Discovery, Fifth Edition. PHI Learning Pvt. Ltd. ISBN: 9789354437410.
- Lesk, A. M. (2017). Introduction to genomics. Oxford University Press. ISBN: 0199557489
- Ning, K. (Ed.). (2023). Methodologies of Multi-Omics Data Integration and Data Mining: Techniques and Applications (Vol. 19). Springer Nature. ISBN: 9811982104
- Mount, D. W. (2004). Bioinformatics: Sequence and Genome Analysis. Thailand: Cold Spring Harbor Laboratory Press. ISBN: 9780879697129.
- Campbell, A.M. & Heyer, L.J. (2007) Discovering Genomics, Proteomics and Bioinformatics, 2nd Edition. Benjamin Cummings. CSH Press, New York. ISBN: 8131715590
- Metzker, M. L. (2010). Sequencing technologies-the next generation. Nature Reviews Genetics, 11(1), 31-46.
- Pevsner, J. (2015). Bioinformatics and functional genomics, 2nd Edition. John Wiley & Sons. ISBN: 0471210048

Suggested readings:

- Arivaradarajan, P., & Misra, G. (2018). Omics Approaches, Technologies And Applications. Springer, Singapore. ISBN: 9811329257.
- Ghosh, Z., Mallick, B. (2008). Bioinformatics: Principles and Applications. India: Oxford University Press. ISBN: 9780195692303.
- Latest developments in the field of bioinformatics and omics technologies through research articles.

Examination scheme and mode:

Evaluation scheme and mode will be as per the guidelines notified by the University of Delhi.

B.Sc (Hons.) Biomedical Science
Discipline Specific Core (BIOMED-DSCs)
SEMESTER- VIII

DISCIPLINE SPECIFIC CORE COURSE -20 (BIOMED-DSC-20)

DEVELOPMENTAL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Developmental Biology BIOMED-DSC-20	4	2	-	2	XII passed	Basic knowledge of Biological Science

Learning Objective:

- This course provides undergraduate students with a comprehensive understanding of embryonic and post-embryonic developmental processes.
- It highlights the remarkable concept that a single fertilized egg can develop into a complex organism. Students will explore fundamental principles at the cellular and molecular levels, using model organisms like Frog, *Drosophila*, Zebra fish Chick etc.
- Additionally, the course delves into the connection between developmental biology and its implications in congenital disorders, human diseases, infertility, IVF, pre-diagnostic methods, and emerging fields like stem cell therapy.

Learning Outcomes:

Upon successful completion of the course, students will be able to:

- Comprehend the sequence of events leading to the formation of a multicellular organism from a single fertilized egg, the zygote.
- Attain fundamental knowledge regarding the cellular processes governing development, including the underlying molecular mechanisms.
- Describe the general patterns and consecutive stages of embryogenesis, elucidating how these processes contribute to the establishment of the body plan in multicellular organisms
- Explain the overarching mechanisms responsible for morphogenesis and articulate how different cells and tissues collaborate harmoniously to generate diverse tissues and organs
- Understand the evolutionary development of the human embryo.

- Appreciate the significance of cutting-edge techniques such as stem cell therapy, *in vitro* fertilization, and amniocentesis in the context of improving human well-being.
- Develop the practical skill set required to cultivate and maintain a laboratory culture of the model system.

SYLLABUS OF BIOMED-DSC-20

Total 30 hours

Unit I: Introduction to Developmental Biology. Historical evolution and Basic Concepts: **8 Hours**

Origins of Developmental biology and its historical roots: Timeline of discovery of important events in Developmental Biology. Basic concepts, Stages of development, Cell fate, determination, induction, commitment and differentiation. Concept of embryonic stem cell, Mosaic and regulative development, cell-cell lineage, cell to cell communication, Genomic equivalence.

Developmental Mechanisms of Evolutionary Change: "Unity of Type" and "Conditions of Existence", Hox Genes: Descent with Modification. Prerequisites for Evolution via Development: Developmental Correlation, Constraints, and a Fresh Evolutionary Synthesis.

Basic overview of Model Organisms with respect to development process with Human Connection: Frog, Chick, Zebrafish, *Drosophila melanogaster*, *Caenorhabditis elegans*.

Unit II: Early Embryonic Development: **8 Hours**

Gametogenesis: Saga of germ plasm, Formation of primordial germ cells, Gametogenesis :Oogenesis and Spermatogenesis with all its stages

Fertilization, Recognition of Egg and Sperm, Gamete Fusion, Fusion of the Genetic Material and Prevention of Polyspermy, Activation of Egg Metabolism, Rearrangement of the Egg Cytoplasm. Cleavage, formation of Morula, Development and implantation of Blastula and formation of placenta, extraembryonic membranes and their functions

Gastrulation: Formation of three primary germ layers, concept of induction and competence and their commitment to fate, Axis specification (Dorsoventral, anterior posterior), and Body plan patterning, Left right symmetry

Unit III: Later Embryonic Development and Organogenesis: **10 hours**

Homologous Development Pathways, Modularity, and Signaling Pathways and molecular regulation of the following Developmental Processes

Ectoderm structures: The central nervous system and the epidermis: Formation and differentiation of the Neural tube, Neural crest, and complete nervous system, Development of the Vertebrate Eye, Epidermis and the Origin of Cutaneous Structures

Mesodermal Structures and their development: Myogenesis, Osteogenesis, Formation of Limb and Heart.

Endodermal structures and their formation: Digestive system

Teratogenesis: Teratogenic agents and their effects on embryonic development

Concept of Genetic Sex determination and formation of Gonads, Infertility: Causes and underlying reasons for infertility.

UNIT: IV Developmental Biology and its Application **4 Hours**

Amniocentesis and Assisted Reproductive Technologies (ART): Ovulation Induction (OI), Artificial Insemination (AI), Donor Conception, In Vitro Fertilization (IVF), Intracytoplasmic Sperm Injection

(ICSI), Gamete Intrafallopian Transfer (GIFT), Zygote Intrafallopian Transfer (ZIFT), Preimplantation Genetic Diagnosis (PGD).

Stem Cells and Applications. Cloning Experiments: Reproductive cloning attempts.

Ethical Considerations: Addressing ethical dilemmas in reproductive sciences.

Practical

60 Hours

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs/lab visits etc.)

1. Study of whole mounts and sections of developmental stages of the embryo of man through permanent slides: Cleavage blastula, gastrula, neurula.
2. Study of whole mounts and sections of Developmental stages of bone, muscle, cartilage (photomicrographs/ slides)
3. Study of sections of developmental stages of Human heart
4. Specimen study of Human embryos at various stages of development / Visit to a medical college for specimens
5. Study of sections of human placenta (photomicrographs/ slides)
6. Video recordings and /or photomicrographs on Assisted Reproductive Technologies (ART).
7. Study of various contraceptive methods
8. Project Report on any one of the following: Development of a system/ recent development in ART/ current technologies to study Development.
9. Study of different stages of embryo using a live animal model like zebra fish/ C. elegans/chick

Essential Readings:

- Gilbert, S. F. (2016). Developmental Biology. XI Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA ISBN-13: 978-1605356044
- Balinsky B. I. and Fabian B. C. (2012). An Introduction to Embryology. V Edition, International Thompson Computer Press. ISBN-13: 978-8131517499
- Slack, J.M.W. (2012) Essential Developmental Biology. III Edition, Wiley- Blackwell. ISBN-13: 978-0470923511

Suggested Readings:

- Lewis, W. and Rosa, B. (2001) Principles of Development. II Edition, Oxford University Press. ISBN-13: 978-0198792918
- Carlson, B.M. (2007) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers. Arora, R. and Grover, A. (2018) Developmental Biology: Principles and Concepts. I Edition, R. Chand & Company

Websites and Review articles

- <https://www.hhmi.org/biointeractive/human-embryonic-development>
- <https://ocw.mit.edu/courses/biology/7-22-developmental-biology-fall-2005/index.htm>
- Burgaud, M. Bretin, B. Reignier, A. Vos, J. D. and David, L. (2023) New models to study human embryonic development, Med Sci (Paris). 2023 Feb;39(2):129-136

B.Sc (Hons.) Biomedical Science

Pool of DSEs for VII and VIII semesters

DISCIPLINE SPECIFIC ELECTIVE COURSE –11 (BIOMED-DSE-11) ADVANCED CELL BIOLOGY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the Course
		Lecture	Tutorial	Practical/ Practice		
Advanced Cell Biology BIOMED-DSE-11	4	2	0	2	XII Passed	Must have studied basic Cell Biology

Learning Objectives

- The main aim of this paper is to acquaint students with advancements in cell biology.
- Students will learn in detail about the intricate and specialized processes of transport of molecules within different compartments of cells.
- Understanding the mechanism of Cell survival, cell death and cell-renewal and the ways in which this regulation can be disrupted will help the students to understand the cause of many diseases particularly cancer.
- There have been great advancements in the techniques used for visualizing, separating and studying detailed ultra structure of cells. The course will familiarize the students with some such techniques during the practical sessions.

Learning Outcomes

- Students who successfully complete this course will acquire in depth understanding and advanced knowledge of a range of general and specialized areas in cell biology.
- They will develop insight into the complexities of intracellular transport.
- They will learn the molecular controls that govern the cellular microenvironment and cellular interactions maintaining tissue integrity.
- Students will appreciate the advancements in the techniques developed to understand the micro structure

SYLLABUS OF BIOMED-DSE-11

Unit I: Transport of Molecules across Membrane and Organelles

(12 Hours)

- A. **Nucleus:** Unidirectional nature of protein export and import through nuclear pores. Mechanism for nuclear import and export of proteins (Ran-dependent and Ran-independent pathways).

- B. **Endoplasmic Reticulum and Golgi Complex:** Five topological classes of ER membrane proteins, Topogenic sequences: N-terminal signal sequences, internal stop-transfer anchor sequences, and Internal signal anchor sequences. Export of proteins (vesicular transport and significance of KDEL sequence),
- C. **Mitochondria:** Protein transport to Outer membrane, intermembrane space, inner membrane and matrix. Role of N-terminal targeting sequences, Membrane receptors and Translocons complexes
- D. **Peroxisomes:** Transport of proteins to peroxisomal membrane and matrix. PTS1-directed import of peroxisomal matrix proteins.
- E. **Mechanism of Vesicular Transport :** Overview of the secretory and endocytic pathways of protein sorting, Molecular Mechanisms of Vesicle Budding and Fusion (v-SNAREs and t-SNAREs), Targeting GTPases and Rab Proteins, types of coated vesicles (COPII, COPI and Clathrin-coated vesicles), Role of Mannose 6-phosphate in protein sorting, Trafficking of soluble lysosomal enzymes from the trans-Golgi network and cell surface to lysosomes, Receptor-Mediated Endocytosis,

Unit II: Mechanism of Cell Death and Renewal

(6 Hours)

Senescence (Role of CDK inhibitors, p16 and p21), Apoptosis (Intrinsic and extrinsic pathway, anti and pro apoptotic proteins like, BBC3, Bcl2, SMAC and survivin), Necrosis, Autophagy, Stem cells (pluripotency, types of Stem cells and their applications).

Unit III: Tumor Cell Biology

(6 Hours)

Causes of cancer. Differences between tumor and normal cells: Genetic makeup, uncontrolled proliferation. Genetic basis of cancer: Oncogenes (Ras, Myc), Tumor Suppressor genes (Rb- LOH, p53). Inherited cancer genes (BRCA1 and 2, CDH1), altered signaling pathways controlling cell proliferation, Cancer stem cells (origin, properties and role in tumor initiation).

Unit IV: Cell-Cell Adhesion, Extracellular Matrix (ECM) and Cancer Progression (6 Hours)

Cell interaction with neighboring cells and ECM (integrins, cadherins, fibroblasts, collagen, fibronectin). Alterations leading to metastasis: release of matrix metalloproteinases (MMPs), epithelial to mesenchymal transition (EMT) and angiogenesis.

Practical

(60 hours)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To isolate organelles by subcellular fractionation and validate the separated organelles by marker enzymes
2. To study the parts and working of confocal microscope
3. Flow cytometric analysis for separating the different type of blood cells
4. Flow cytometry based cell cycle analysis
5. To study cell viability/death by using trypan blue or MTT assay
6. Flow cytometry based detection of apoptosis
7. Preparation and culturing of cancer cell lines

8. To identify and study cancerous cells using permanent slides/ photomicrographs
- 9-10. To formulate the key hypothesis, summarize the results and the conclusions of the research papers on the related topics, and discuss the state-of-the-art of the research field and the contribution to the field and possible research applications of the main findings
11. To generate a graphical abstract to convey the scientific content of a research paper

Essential Reading:

- The Cell: A Molecular Approach, by Geoffrey M Cooper, Robert E Hausman, 15 Dec 2015
- Karp, G. (2013). 7th Edition. Cell and molecular biology: Concepts and experiments. New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.
- Molecular Cell Biology Hardcover –by Harvey Lodish (Author), Arnold Berk , Chris Kaiser, Monty Krieger, Anthony Bretscher, 1 Apr 2016
- Molecular Biology of the Cell: by Bruce Alberts, Alexander Johnson, Julian Lewis. Publisher Garland Science, December 2014

Suggested Reading:

- James D. Watson (2014) 7th Edition. Molecular Biology of the Gene. Pearson, ISBN 0321762436, 9780321762436
- The Cell: A Molecular Approach, by Geoffrey M Cooper, Robert E Hausman, 15 Dec 2015
- Hardin, J. Bertoni, G. P. Kleinsmith, L.J. and Becker, W.M. (2016). 9th Edition. The world of the cell. San Francisco, USA: Benjamin Cummings Publishers, ISBN-13: 978 - 0321934925.
- Karp, G. (2013). 7th Edition. Cell and molecular biology: Concepts and experiments. New Jersey, USA: Wiley Publishers. ISBN-978-0470483374.

**DISCIPLINE SPECIFIC ELECTIVE COURSE -12 (BIOMED-DSE-12) –
ADVANCES IN PHARMACEUTICAL SCIENCE**

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Pharmaceutical Science BIOMED-DSE-12	4	2	-	2	XII Passed	Basic Knowledge of Chemistry and Biology

Learning Objectives:

- The course emphasizes the interdisciplinary nature of pharmaceutical research, integrating concepts from chemistry, biology, and biotechnology.
- Students will be introduced to the latest advancements in pharmaceutical research, including drug design principles, biotechnology-derived medications, and the use of biosensors in pharmaceutical industries.
- Knowledge of ethical considerations in clinical trials and pharmacovigilance ensures students are well-prepared to conduct responsible and ethical research.

Learning Outcomes:

Upon successfully completing this course, students will be able to:

- Understand the history and development of pharmaceutical research, including principles of drug design and the various phases of pharmacokinetics and pharmacodynamics.
- Recognize the importance of pharmacognosy and the application of herbal drugs in treating various ailments.
- Gain insights into pharmaceutical biotechnology, including the development and application of therapeutic proteins and monoclonal antibodies.
- Comprehend the principles and classification of drug formulations, including regulatory norms.
- Understand the processes and regulations involved in the approval of new drugs and the role of regulatory affairs in the pharmaceutical industry.
- Develop the foundational knowledge and skills for advanced studies and careers in pharmacology, pharmaceutical sciences, and related fields.

SYLLABUS OF BIOMED-DSE-12:

(30 hours)

Unit I: Introduction

(4 hours)

History and development of Pharmaceutical Research, Principles of drug design (QSAR-Hansch, Topliss, Lipinski, Computer aided drug design), Pharmacokinetics (ADME- Routes of drug administration, Absorption, Bioavailability, Distribution) Metabolism (biotransformation)-microsomal/P450, first pass metabolism, Excretion - kinetics of elimination), Pharmacodynamics (Enzymes-competitive/non-competitive inhibitors, Ion channels, Transporters, Receptors-agonist/antagonist, inverse agonist, partial agonist, Drug receptor interaction, Dose response relationship)

Unit II: Pharmacognosy and herbal drugs

(10 hours)

Importance of Pharmacognosy in herbal drug industry: Treatment of ailments related to- Central Nervous System (CNS)- Reserpine, Cardiovascular system (CVS)-Digoxin, GIT-Glycyrrhizin, Gymnema, Respiratory system -Codeine. Development of lead compound into effective drugs (Opium to pain killer, Cinchona bark to antimalarial, Taxus Baccata to taxol).

General methods of extraction (simple extraction with separatory funnel, industrial extraction using Soxhlet apparatus, isolation (steam distillation) and purification of phytoconstituents using column chromatography, HPLC.

Primary metabolites: General introduction and pharmaceutical applications of primary metabolites in therapy of CNS, CVS, Liver, Kidney, Intestine and Lung diseases and their pharmaceutical preparations. Carbohydrates (Acacia as emulsifying and stabilizing agent, Agar as surgical lubricant and stabilizer in preparation of suspensions, capsules etc.) Proteins and Enzymes (Gelatin as shell for capsules, Casein as therapeutic agent in dressing wounds, cosmetics) Lipids and Waxes/Oils (Castor oil as stiffening agent and laxative)

Secondary metabolites: General introduction -therapeutic application of secondary metabolites in CNS, CVS, Liver, Kidney, Intestine and Lung diseases and their pharmaceutical preparations.(Ephedrine as bronchodilator and decongestant, Morphine for pain management), Glycosides (Digitoxin in heart failure and treatment of arrhythmias) Polyphenols, Tannins, Flavonoids (Quercetin as antioxidant for treatment of heart conditions).

Nutraceuticals as health care products: General introduction and their formulations, classification and importance of nutritional supplements such as Vitamin supplements, Digestive enzymes, Probiotics, Prebiotics, Dietary fibers, Cereals, Health drinks for the treatment of ailments (as adjuvants) and lifestyle disorders.

Unit III: Pharmaceutical Biotechnology

(8 hours)

Introduction to Pharmaceutical Biotechnology, DNA sequence to therapeutic proteins, Production and Downstream processing, Interferons, Interleukins.

Monoclonal Antibodies: From structure to therapeutic applications in Cancer and Organ Transplantation.

Biologics and Biosimilars, Biosimilars as low cost treatment options in various ailments (eg. Humira for curing autoimmune diseases) and Regulatory framework for biosimilars. Personalized Medicine and applications.

Process of developing Biotechnology Derived Medications: Vaccines (Hepatitis Vaccine), oligonucleotides, Recombinant engineered protein -Insulin, Recombinant engineered hormones-Follicle Stimulating Hormone, Human Growth Hormone, Recombinant Coagulation factors and

Thrombolytic agents. Biosensors- Working and applications of biosensors in Pharmaceutical Industries for sensing enzymes, small molecules such as blood gases, glucose etc.

Unit IV : Drug Formulation, Release & Regulatory Framework (8 Hours)

(a) : Pharmaceutical formulation, drug release and dissolution

Introduction to drug formulations and their classification with suitable examples (Simple and compound powders; Monophasic and Biphasic liquids; Emulsions; Semisolid Dosage forms- Pastes, Ointments, Creams and Gels; Oral solid dosage forms- Tablets, Capsules; Aerosols). Pharmaceutical excipients. Pharmaceutical coating processes and equipment.

Drug release and dissolution: Theoretical Concepts for the Release of the Drug from drug formulations.

(b) : The New Drug Approval Process and regulatory affairs

Drugs and Cosmetics Act (1940) and Rules (1945). Pharmacy Act 1948. Investigational New Drug Applications (INDs): Approval processes and timelines involved, Preclinical testing, Clinical testing - Phase I, II, III and IV, Clinical trial protocols, Institutional Review Board / Independent Ethics committee - formation and working procedures, Informed consent process. Pharmacovigilance - Safety monitoring in clinical trials.

Practical: (60 hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Preparation of alcohol from rectified spirit by distillation.
2. Extraction of vasicine (quinazoline alkaloid) from the leaves of *Adhatoda vasica* by modified acid-base extraction and purification by column chromatography and purity check by TLC.
3. Extraction of curcuminoids (phenolics) from *Curcuma longa* using ethanol and purification by column chromatography and purity check by TLC.
4. Extraction of Eugenol oil from steam co-distillate of cloves using dichloromethane.
5. Screening of the natural products for biological activity like antidiabetic (by inhibition of alpha-amylase) or anti-microbial (Gram+/Gram- bacteria) (by MIC/Disc-diffusion method).
6. Study the effect of polarity of solvents (water/ethanol/ethyl acetate/ether/hexane) and pH (buffer/water - pH 4, 7, 8.5) of the solution on the solubility of drugs (aspirin/penicillin/sulphonamides) using UV spectroscopy.
7. Disintegration/Dissolution studies of different formulations (Capsule, tablet, syrup) of the drugs (e.g., paracetamol) using UV spectroscopy.
8. Visit to a pharmaceutical industry to understand how drug formulations are prepared.
9. Synthesis of paracetamol, preparation of paracetamol tablets by wet granulation method and virtual demonstration of formulation of film coated tablets of paracetamol.

Essential Readings:

- Roche, V.F., Zito, S.W., Lemke, T.L., & Williams, D.A. (2019). 8th Edition. *Foye's Principles of Medicinal Chemistry*. Philadelphia, PA: Lippincott Williams & Wilkins. ISBN-13: 9781496385024.
- Shah, B. (2018). *Textbook of Pharmacognosy and Phytochemistry*. New Delhi, India: CBS Publishers & Distributors. ISBN-13: 978-9386217738.

- Wildman, R.E.C., & Bruno, R.S. (2020). 3rd Edition. *Handbook of Nutraceuticals and Functional Foods*. CRC Press. ISBN-13: 978-1498703727.
- Gupta, R.C., Lall, R., & Srivastava, A. (2021). 2nd Edition. *Nutraceuticals: Efficacy, Safety and Toxicity*. Cambridge, MA: Academic Press. ISBN-13: 978-0128210383.
- Crommelin, D.J.A., Sindelar, R.D., & Meibohm, B. (2013). *Pharmaceutical Biotechnology: Fundamentals and Applications* (4th ed.). New York, NY: Springer. ISBN-13: 978-1461464860, ISBN-10: 1461464862.
- Adejare, A. (Ed.). (2020). *Remington: The Science and Practice of Pharmacy* (23rd ed.). Elsevier. ISBN-13: 978-0128200070 (hardback), ISBN-13: 978-0128223895 (eBook)
- Kokate, C.K. (2017). *Practical Pharmacognosy* (18th ed.). Nirali Prakashan. ISBN-13: 978-8185790367.
- Sreelekshmi U, Sarathchandra G, Vijayarani K, Sp P. Isolation & purification of vasicine from leaves of *Adhatoda vasica* by modified acid-base extraction method. J Pharm. Innov. 2021;10(1):171-3.
- Kulkarni SJ, Maske KN, Budre MP, Mahajan RP. Extraction and purification of curcuminoids from Turmeric (*Curcuma longa* L.). International Journal of Pharmacology and Pharmaceutical Technology. 2012;1(2):81-4.
- <https://assets.thermofisher.com/TFS-Assets/CAD/Vector-Information/pS45-pS80-Extraction-of-Eugenol-from-Cloves.pdf>

Suggestive Readings:

- Patrick, G.I. (2017). *Introduction to Medicinal Chemistry* (6th ed.). Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
- Tripathi, K.D. (2018). 8th Edition. *Essentials of Medical Pharmacology*. New Delhi, India: Jaypee Brothers Medical Publishers. ISBN-13: 978-9352704996.
- Evans, W.C. (2009). 16th Edition. *Trease and Evans' Pharmacognosy*. Edinburgh, UK: Elsevier. ISBN-13: 978-0702029349.
- Kokate, C.K., Purohit, A.P., & Gokhale, S.B. (2007). *Textbook of Pharmacognosy* (37th ed.). New Delhi, India: Nirali Prakashan. ISBN-13: 978-8190791136.
- Gupta, S.K. (2019). *Textbook of Pharmacovigilance* (2nd ed.). Jaypee Brothers Medical Publishers. ISBN-13: 978-9352707034.
- https://cdsco.gov.in/opencms/export/sites/CDSCO_WEB/Pdf-documents/acts_rules/2016DrugsandCosmeticsAct1940Rules1945.pdf

DISCIPLINE SPECIFIC ELECTIVE COURSE-13 (BIOMED-DSE-13) PROTEIN STRUCTURE AND FUNCTION: ADVANCED CONCEPTS AND BIOMEDICAL APPLICATIONS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Protein Structure and Function: Advanced Concepts and Biomedical Applications BIOMED-DSE-13	4	2	-	2	Passes Class XII	Should have studied the basics of proteins.

Learning Objectives:

The Learning Objectives of this course are as follows:

- This course is designed to deepen students' understanding the protein structure & function relationships and the remarkable protein folding processes.
- It also aims to help students understand enzyme kinetics and regulatory mechanisms, bridging the molecular intricacies of enzymology to the development of therapeutics and the underlying causes of diseases.
- The experiments have been designed for students to experience the molecular basis of protein biochemistry, connecting theoretical concepts to real-world biomedical challenges. By the end of the course, students will appreciate the fundamentals of protein biochemistry and its transformative applications in life science, industry and medicine.

Learning Outcomes:

Upon completing this course, students will:

- Understand the structural organization and key characteristics of proteins, their folding mechanisms, and the critical role of chaperons in achieving functional three-dimensional structures.
- Analyse protein misfolding and its association with various diseases.
- Comprehend enzyme function, regulation, kinetics and inhibition mechanisms, linking these concepts to developing therapeutic drugs and biomedical applications.
- Explore and appreciate the diverse applications of proteins and enzymes in pharmaceuticals, biomedicine, and industrial processes through theoretical insights and hands-on experience.

SYLLABUS OF BIOMED-DSE- 13

Unit I: Protein Structure and Functional Regulation:

10 Hours

Structure and function of proteins: membrane proteins (Aquaporin 1, ABC Transporter Protein), structural proteins (Keratin/ Collagen), DNA-binding regulatory proteins (Leucine Zipper motif/ Zn-Finger motif, with examples). Functional Allostery: limited proteolysis and ligand binding, with appropriate examples. Structural cooperativity (including oxygen saturation curves of hemoglobin and myoglobin). Post-translational modifications: phosphorylation (Protein Kinase A) and glycation. Domain swapping in proteins.

Unit II: Protein Folding:

6 Hours

Introduction to Protein Folding: Levinthal Paradox, Anfinsen's Experiment, hydrophobic collapse. Functional and evolutionary significance of intrinsically disordered proteins. Molecular chaperones (structure and functional mechanisms of Hsp90, Hsp70, & Hsp40), Chaperonin (structure of GroEL-GroES system).

Unit III: Modern Techniques for Protein Characterization:

9 Hours

Manual protein sequencing (Edman Degradation, Sanger's Method), N-terminal and C-terminal analysis; Analysis of amino acid composition, Peptide mass fingerprinting (PMF), de-novo protein sequencing. Protein purification techniques: Isoelectric focusing (IEF), 2D-Gel electrophoresis and fast protein liquid chromatography (FPLC). Methods for determining protein stability (heat or chemical-induced denaturation).

Unit IV: Pharmaceutical & Industrial Applications of Proteins:

5 Hours

Use of proteins in industry: protease, amylase and cellulase as detergents, pectinase and xylanase in fruit drinks, alkaline phosphatase and HRP in protein detection; Pharmaceutical applications: therapeutic proteins (thrombin/growth hormones, vaccines); Medical research: Abzymes, enzyme replacement therapy, diagnostic and prognostic biomarkers. Bioethics in protein research.

Practical:

60 Hours

(Wherever wet-lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs, etc.)

1. Salting out of proteins by Ammonium Sulphate Precipitation.
2. Desalting by dialysis.
3. Protein estimation by Bradford/BCA method
4. Tryptic digest of a given protein and analysis by SDS Polyacrylamide Gel Electrophoresis.
5. Protein estimation by using the molar extinction coefficient.
6. To study protein denaturation by urea and estimation of melting concentration (C_m).
7. Protein structure prediction using *in-silico* tools/approaches.
8. Project Practical: To visually score the changes in the structure of a protein due to mutations using Pymol or similar software. Examples: Mutation in Beta-globin gene in Sickle cell

anaemia and Cystic fibrosis transmembrane conductance regulator (CFTR) gene in cystic fibrosis. Similarly, more genes can be identified and analysed.

Essential Readings:

- Lehninger: Principles of Biochemistry (8th ed.). Nelson, D. L., & Cox, M. M. (2021). Macmillan. ISBN: 9781319322328.
- Biochemistry by Reginald H. Garrett, Charles M. Grisham; Ed. 6th; Cengage Learning, 2016.
- Biochemistry, by G., Stryer, L. and Tymoczko, J., Gatto, L. (2015) 8th Edition. New York, USA: W. H. Freeman and Company. ISBN-10 1464126100
- Fundamentals of Protein Structure and Function, Buxbaum Engelberg; Ed. 6th; Springer, 2015.

Suggested Readings:

- Biochemistry by Mary K. Campbell, Shawn O. Farrell; Ed. 8th; Cengage Learning, 2014.
- Proteins: Structure and Function; David Whitford; John Wiley & Sons, 2013.
- Biochemistry by Donald Voet and Judith G. Voet; Ed. 4th; John Wiley & Sons, Incorporated, 2012.
- <https://www.nobelprize.org/uploads/2024/10/advanced-chemistryprize2024.pdf>
- Proteins: Structures and Molecular Properties by Thomas E Creighton; Ed. 3rd; Freeman, 2010.

DISCIPLINE SPECIFIC ELECTIVE COURSE-14 (DSE-14)**ADVANCED BIOORGANIC CHEMISTRY****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Bioorganic Chemistry BIOMED-DSE-14	4	2	-	2	XII Passed	Basic knowledge of chemistry and biology

Learning Objectives:

The introduction of Advanced Bioorganic Chemistry course at undergraduate level to the students has been conceived to make them understand:

- Concepts of organic chemistry and its application in the field of medicinal chemistry and biology.
- Application of supramolecular chemistry and use of macromolecules in molecular diagnosis and therapeutics
- Different phases in clinical testing and new drug approval processes.

Learning Outcomes:

- After completing the course, students shall be able to understand the structure and function of different heterocyclic molecules and their use in modern day medicine, chemistry of stereoisomers and importance of asymmetric synthesis.
- Student will also learn and appreciate the polymer supported synthesis and its relevance in drug synthesis.
- They will also get insights into use of macromolecules and molecular frame work in molecular diagnosis and therapeutics.
- Student will learn rational drug design methods, various phase of clinical testing of drugs and process involved in new drug testing and approval.
- They will get grasp of industrially relevant insilico techniques useful for identification of suitable drug candidate during rational drug design.

SYLLABUS OF BIOMED-DSE-14

30 hours

Unit I: Heterocyclic Chemistry

(6 hours)

Aromaticity and Huckel rule, Active methylene groups, aldol and mixed aldol reaction, Michael addition and schiffs base reaction. Nomenclature and Reactivity of the five and six membered heterocycles, Pyrrole, Furan, thiophene, indole, oxazole, thiazole, Pyridine, Quinoline and Isoquinoline, Industrial methods for the synthesis of medicines involving heterocyclic compounds.

Unit II: Stereochemistry

(6 hours)

Optical activity, specific rotation, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers. conformation of ethane and butane, inter conversion of projection formula, optical purity. E and Z nomenclature. Prochirality (enantiomer, diastereomer) Stereochemical aspects of drug action Strategies. Enantiotopic and diastereotopic faces, (endo and exo faces). Regioselective, enantioselective, stereoselective and stereospecific reactions, Walden inversion, syn and anti addition on double bond. Asymmetric synthesis (definition and its use in drug synthesis).

Unit III: Polymer-Supported Synthesis & Supramolecular Nanostructures

(8 hours)

(a): Introduction to Polymer Supported synthesis

Concept of combinatorial and mixed combinatorial synthesis, Limitations of combinatorial synthesis. Polymer supported organic reactions: different types of resins, protecting and deprotecting group, activating group coupling group (Merrified synthesis), Phase transfer catalysis.

(b): Applications of Synthetic macromolecules and Nanomolecules

Macromolecules and molecular framework (crown ether and supra molecular probes) in molecular diagnosis and therapeutic applications of supramolecular chemistry. Synthetic artificial systems that mimic biological entities. Nanomolecules and application in nanotechnology.

Unit IV : Drug Formulation, Release & Regulatory Framework

(10 Hours)

(a) Pharma-informatics : Drug discovery pipeline, Rational drug design methods, Optimization of lead compounds, Drug target identification and validation for microbial pathogen, Selection of gene unique to the pathogen/target, screening for its presence in other microbes and human host.

Various Databases to search for new molecules, calculating drug-like properties of molecules, virtual screening of the drug like compounds with biomolecule- such as receptor/protein using online tools, Pharmacophore generation- principle and methods, prediction methods of 3D structure of protein. Drug interaction with Protein.

(b) New Drug Approval Process and regulatory affairs : New Drug Approval processes and timelines, Preclinical testing, Clinical testing - Phase I, II, III and IV, Developing clinical trial protocols, Safety monitoring in clinical trials, Introduction of Drugs and Cosmetics Act (1940 and 1945) and patent act 1970. Process of patent filing- specifications, framing of claims and various forms.

Practical:

(60 hours)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Thin Layer Chromatography (mixture of 2 compounds)/(mixture of 3 compounds)
2. Perform Claisen Schmidt reaction and report yield
3. Perform Cannizarro reaction and report yield
4. Column chromatography using Silica gel to separate mixture of 2 compounds
5. Perform Schotten Baumann reaction and report yield
6. Carry the hydrolysis of ethyl benzoate and report the melting point and yield of benzoic acid
7. Prepare Semicarbazone derivative of one the following compounds: acetone, ethyl methyl ketone, diethylketone, cyclohexanone, benzaldehyde. and and report the melting point and yield of the product.
8. Determine the antioxidant activity of any compound by DPHH scavenging assay/FRAP assay.
9. Measurement of total phenolic content of any compound by Folin Ciocateu Method.
10. Synthesis and characterization of nanoparticles.
11. Finding the active sites in a receptor/proteins (eg glucose Dehydrogenase).
12. Molecular docking of ligand with receptor/protein (Glucose dehydrogenase) using AutoDock or HEX.

Essential Readings:

- Silverman, R. B. (2020). *Organic Chemistry of Drug Design and Action* (4th ed.). Academic Press. ISBN-13: 9780123820303.
- Patrick, G. L. (2021). *An Introduction to Medicinal Chemistry* (6th ed.). Oxford University Press. ISBN-13: 978-0198749691.
- March, J. (2020). *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure* (8th ed.). Wiley. Ed. 8th
- Kalsi, P. S. (2020). *Stereochemistry: Conformation and Mechanism* (6th ed.). New Age International Publishers
- Sengupta, A., & Sarkar, C. K. (2015). *Introduction to Nano: Basics to Nanoscience and Nanotechnology*. Springer.
- Lehn, J.-M. (1995). Supramolecular chemistry. *Chemical Reviews*, 71, 199–223.
- Stromgaard, K., Krogsgaard-Larsen, P., & Madsen, U. (Eds.). (2016). *Textbook of drug design and discovery*, Fifth Edition. United States: Taylor & Francis.
- Gu, J., & Bourne, P. E. (Eds.). (2011). *Structural bioinformatics*, Second Edition. John Wiley & Sons. ISBN: 9781118210567
- Finar, I. L. (2002). *Organic Chemistry: Volume 1* (6th ed.). Pearson Education.
- Finar, I. L. (2002). *Organic Chemistry, Volume 2: Stereochemistry And The Chemistry Natural Products* (6th ed.). Pearson Education
- Ashutosh Kar (2020) *Advanced Practical Medicinal Chemistry* 3rd Edition New Age International Private Limited.
- Vogel, A. I. *Practical Organic Chemistry* (5th ed.) Longman Group Ltd., 2012.
- V.K Ahluwalia and Sunita Dhingra, *College practical chemistry*, University Press (India) Ltd.

Suggested Readings:

- Rostron, C. (2020). Drug Design and Development. United Kingdom: Oxford University Press.
- Adejare, A. (Ed.). (2020). Remington: The Science and Practice of Pharmacy (23rd ed.).
- Bajorath, J., (2013) Chemo informatics for Drug Discovery, John Wiley & Sons.
- Jhoti, H., & Leach, A. R. (Eds.). (2007). Structure-based drug discovery. Springer Netherlands.
- Gasteiger, J., & Engel, T. (Eds.). (2006). Chemo informatics: a textbook. John Wiley & Sons.
- Leach, A. R. (2001). Molecular modelling: Principles and applications. Pearson Education.
- Ager, D. J., & East, M. B. (1996). *Asymmetric Synthetic Methodology*. CRC Press.
- Mahrwald, R. (Ed.). (2011). *Enantioselective Organocatalysed Reactions II*. Springer.

DISCIPLINE SPECIFIC ELECTIVE COURSE-15 (BIOMED-DSE-15)**ADVANCED TECHNIQUES IN FORENSIC SCIENCE****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Techniques in Forensic Science BIOMED-DSE-15	4	2	0	2	XII Passed	Basic Knowledge of Biological Science

Learning Objectives:

- Present forensic science course is designed for students to explore how forensic scientist's work, the tools and techniques they use and how they reach the conclusions they present in court.
- This will engage students in using a creative, problem solving and inquiry-based approach to investigate the crime scene and criminal profiling.
- Questioned document analysis will help students understand the ways of determining the authenticity of various documents.
- The course aims to cover different aspects of forensic science including forensic toxicology wherein a brief introduction will be provided on commonly used poisons in criminal cases and their detection methods.
- The course will explain different methods of individualization of a person like fingerprinting, blood profiling and DNA profiling.
- The marks of injury and the type of death will be used to correlate the events that might have occurred during a crime scene.
- Forensic anthropology is very useful in cases particularly where the victim's body is found quite late after the occurrence of crime and in an unidentifiable state.

Learning Outcomes

Having successfully completed this course, students shall be able to understand and learn:

- The students are expected to learn the management and documentation of indoor and outdoor crime scenes. Simulation of a crime scene will familiarize them with situations during a crime scene investigation.

- Major security features in various educational documents, bank notes, cheques and other essential documents of identification.
- The identification of poisons commonly used for committing crime through biochemical tests and post mortem changes.
- The methods for individualization of human beings on the basis of their blood, fingerprint and DNA.
- The clinical features of different types of injuries and death to understand the cause of death.
- Overall the course will provide a platform to the students to take up Forensic Science course at their Master's level

SYLLABUS OF BIOMED-DSC-15

30 hours

Unit I : Crime Scene Investigation

(5 Hours)

Introduction and development of Forensic Science in India & Abroad, Pioneers in Forensic Science, 7 Principles of forensic science, Branches of forensic science. Motive of crime, *Modus operandi* and their role in criminal investigation. Methods of searching a crime scene (spiral, grid, line and quadrant search). Macro and microphotography of crime scene. Potential Evidences: Biological (blood, hair, urine, saliva, semen), physical (soil, fiber, bullet, cartridge, weapon), chemical (ink, dye, paint, explosive, drugs/alcohol) and psychological evidences (interview, interrogation, polygraph test reports). Introduction to Bhartiya Nyaya Samhita for the offences against a person.

Unit II : Forensic Investigation of Physical Evidence

(8 Hours)

(a): Examination of Questioned Documents

Preliminary examination of questioned documents: Handwriting, Forgeries, Age of Document & Alterations. Introduction to various security features in important documents (like water marks, intaglio and embossed printing, microprinting, holograms etc). Examination of documents like currency notes, stamp papers, mark sheets, Passports/Visas etc. Methods of examining questioned documents (imaging with visible, UV and IR light, electrostatic detection device, Raman spectroscopy)

(b): Types of Injuries and Death

Classification of injuries into Blunt-end (abrasions, contusions and lacerations) and Sharp-end (incision, stab, fracture). Different types of deaths (natural, accidental, suicidal and homicidal), manner of death (strangulation, drowning and drug overdose), modes of death (coma, syncope and asphyxiation) and their diagnosis. Medico-legal aspects of different types of injuries and deaths.

Unit III: Criminal Identification

(8 Hours)

Introduction to Criminalistics, Means of criminal identification by:

- Fingerprinting: Fingerprint as forensic evidence (Dactylography, Dermatoglyphic, and Dactyloscopy), Fundamental principles and classification of fingerprinting (latent, patent and plastic fingerprints). Unique features of fingerprints (minutiae). Physical and chemical methods of developing fingerprints.
- Preliminary Blood Examination: Various parameters of blood as forensic evidence (blood identification, blood grouping, blood typing, and analyzing patterns of blood spatter/splashes).

- DNA Profiling: Principle, methodology and applications of DNA profiling in criminal identification. Inheritance disputes, Paternity and infidelity testing. Lineage markers, DNA databanks and their utility in various criminal investigations.

Unit IV: Forensic Analysis of Biological Evidence

(9 Hours)

(a) : Forensic Toxicology

Importance, Role of a toxicologist, Difference between intoxicant (carbon monoxide, alcohol) and poison (arsenic, cyanide). Classification of poisons (metallic, gaseous, volatile, non-volatile, alkaloids, pesticides, animal based and vegetable based).

(b): Forensic Anthropology

Analysis of skeletal remains. Personal identification (age, sex, stature) by bones like skull, vertebral column and pelvic. Taphonomy (fossilization) to determine the time of death.

Practical

(60 Hours)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Drawing and documentation of an artificially created indoor/outdoor crime scene by using drawing templates and taking field notes such as area of crime, victim's condition, all the evidences marked/acquired etc.
2. Micro and macrophotography of an artificially created indoor/outdoor crime scene and marking/labelling potential evidences such as fingerprints, murder weapon, traces of blood/hair/fiber and footprints etc.
3. Examination of important documents (currency notes, stamp papers, mark sheets, Passports/Visas) and their security features (like water marks, optically variable ink, micro-printing, intaglio printing) by oblique/UV light and digital microscopy.
4. Qualitative tests for detection of intoxicant alcohol by potassium dichromate or ceric ammonium nitrate and poison (chloroform) by aniline/pyridine based and/or arsenic by Marsh test using arsenic trioxide).
5. Determine the pattern and total ridge count (TRC) in individual fingerprints.
6. Preliminary blood analysis: detection by luminol/phenolphthalein and blood group analysis by kits.
7. RFLP based DNA profiling using a kit (includes steps like cutting of given DNA samples by restriction enzymes, separation of fragments on gel electrophoresis and comparison of bands for finding the correct match).
8. Mini / Microsatellite based DNA profiling; theoretical or kit based. (Students will be introduced to both southern hybridization-based method and also PCR based method).
9. Depiction of different types of injuries and death (as covered in the theory) through various pictures and videos.
10. Estimation of age and sex of victim's body by analyzing various features of the skull (like mandible, orbits, sagittal suture etc) and pelvis (like ischiopubic ramus bridge, subpubic angle, pubic symphysis etc).
11. Use of long bones for estimation of stature of the victim's decomposed body (using length of tibia, femur and humerus for correlation with height).

- 12 – 15. Case study presentations by students based on different modes of death (like strangulation, drowning, accident, blunt end injury, sharp incision, fire, firearm etc) and analysis of postmortem parameters.

Essential Readings:

- Archana Mahakalkar (2023). *Introduction to Basics of Forensic Anthropology (A Short-Focused Book)*. Walnut Publication. ISBN-13: 978-9359110851
- Mary H. Dudley (2021) 1st Edition. *Forensic medicolegal injury and death investigation*. Florida, USA: CRC Press. ISBN-13: 978-1032097688
- Richard, S. (2019). 4th Edition. *Forensic science: From the crime scene to the crime lab*. London, UK: Pearson Education, Inc. ISBN 13: 978-0-13-480372-2
- James, S.H. Nordby, J.J. and Bell, S. (2015). 4th Edition. *Forensic science: An introduction to scientific and investigative techniques*. Florida, USA: CRC Press. ISBN-13: 978-1439853832

Suggested Readings:

- Bardale, R. (2024). 4th Edition. *Principles of forensic medicine and toxicology*. New Delhi: Jaypee Brothers Medical Publishers. ISBN-13: 978-9350254936.
- Pankaj Shrivastava *et al.* (Ed). (2023) *Textbook of Forensic Science*. Springer Singapore. ISBN: 978-981-99-1376-3

DISCIPLINE SPECIFIC ELECTIVE COURSE -16 (BIOMED-DSE-16)**IMMUNE RESPONSE TO INFECTION AND DISEASES****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immune Response to Infection and Diseases BIOMED-DSE-16	2	2	-	2	XII Passed	Basic knowledge of Immunology and Microbiology

Learning Objectives

The students will learn:

- Molecular aspects of infections caused by various pathogenic microorganism followed by induction of host mediated immune responses.
- Defense evasive mechanisms adopted by the pathogen and their correlation with disease appearance and manifestation.
- Mechanisms associated with the generation of a huge diversity of T cell receptors and immunoglobulins from limited number of genes.
- Responses of the body during transplantation, cancer, hypersensitive reactions and autoimmune disorders.

Learning Outcomes:

Having successfully completed this course, students shall be able to learn:

- Mechanisms behind the infection and elimination of pathogens by various components of the immune system.
- Diversity of T cell receptors and antibody repertoire arisen by the different combinations of genes that can lead to detection of an enormous diversity of antigenic entities.
- Immune responses of the host during grafting and transplantation of tissues and suppression of the immune system in order to accept the graft.
- Most importantly, students will have an understanding about the different types of allergic reactions, onset of cancer from an immunological perspective, autoimmune disorders and their mechanisms.

SYLLABUS OF BIOMED-DSE-16:

(30 hours)

Unit I: Overview of the Immune System:

(4 Hours)

Components of the immune system: Innate immunity, adaptive immunity, humoral immunity and cell mediated immunity. Entry of bacteria and viruses through respiratory tract and gastrointestinal tract into the host, their establishment and infection. Factors influencing the pathogen load, role of complement and innate immune responses in early immune responses, adaptive immunity and its collaboration with innate immunity to counter pathogenic microorganisms. Lymphoid organs and their significance in immune responses.

Unit II: Mechanisms of Diversity of T cell repertoire and B cell repertoire–T Cell Receptor: Organization and Expression (6 Hours)

An introduction to cell mediated immunity, structure of TCR, germ-line organization of TCR gene segments, mechanism of TCR DNA rearrangements, assembly of rearranged TCR genes
B - Cell Receptor: Organization and Expression- An introduction to humoral immune response and role of innate immunity in the activation of humoral immune response, generation of antibody diversity, association of heavy and light chains. Class switching among constant region genes, expression of immunoglobulin gene, synthesis, assembly, and secretion of immunoglobulins as antibodies.

Unit III: Immune Response to Infectious Organisms (6 Hours)

Viral infections: Viral detection and neutralization by humoral immunity, cell mediated antiviral mechanisms, viral evasion of host defense mechanisms; with influenza virus as an example.
Bacterial infections: Immune responses to bacteria such as; *Salmonella typhi* and *Mycobacterium tuberculosis*, that causes typhoid and tuberculosis, respectively.
Parasitic diseases: Host responses to *Plasmodium* infection.

Unit IV: Immune Dysregulation & Clinical Immunology (14 Hours)

(a) Transplantation immunology

Concepts of MHC and role of HLA in tissue typing, Immunological basis of graft acceptance and rejection: Role of cell mediated responses, mechanisms involved in graft rejection. Clinical manifestations of graft rejection, general immunosuppressive therapy with cyclosporin A

(b) Hypersensitive Reactions:

Concepts of allergy, allergen and atopy. Type I-IV hypersensitive reactions and their molecular mechanisms with two examples each.

(c) Autoimmunity:

Organ specific autoimmune diseases (Myasthenia gravis), systemic autoimmune diseases (systemic lupus erythematosus and rheumatoid arthritis), mechanisms for induction of autoimmunity: Release of sequestered antigens and molecular mimicry.

(d) Cancer and the Immune System:

Immune responses to tumors: role of NK cells and macrophages, immune surveillance theory. Tumor evasion of the immune system: immunologic enhancement of tumor growth, modulation of tumor antigens, mechanism of immune evasion by tumors. Cancer immunotherapy

Practical (60 hrs)

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To perform test for RA
2. Demonstration of immunoprecipitation
3. Analysis of antigen and antibody using immunoelectrophoresis
4. Perform quantitative precipitin assay
5. Demonstration of immunohistochemistry using kits
6. Identification and morphological characterization of various types of lymphocytes, macrophages, dendritic cells, neutrophils, basophils and mast cells using appropriate staining methods (Leishman staining, Giemsa staining etc.)
7. To perform Hemagglutination Reactions:
 - a. Rh Typing,
 - b. Coomb's test,
8. A visit to any regional vaccine/immunology institute to demonstrate the process of antisera production.

Essential Readings:

- Dorothy Wood, Joanne Willey, Kathleen Sandman (2022). 12th Edition. Prescott's microbiology. New York, USA: McGraw-Hill Education. ISBN-10: 1-264-77733-7 / 1264777337
- Punt, J. Stranford, S. Jones, P. and Owen, J. (2019). 8th Edition. *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN- 13: 978-1464189784
- Delves, P.J. Martin, S.J. Burton, D.R. and Roitt, I. M. (2017). 13th Edition. *Roitt's Essential Immunology*. New Jersey, USA: Wiley-Blackwell Science. ISBN: 13: 978- 1118415771.
- Cappuccino, J.G. and Sherman, N. (2013). 10th Edition. Microbiology: A laboratory manual. California, USA: Benjamin Cumming. ISBN-13: 978-0321840226.

Suggestive Readings:

- Willey, J. Sherwood, L and Woolverton, C.J. (2016). 10th Edition. *Prescott's Microbiology*. New York, USA: McGraw-Hill Education. ISBN-13: 978-1259281594.
- Tille, P. (2013). 13th Edition. Bailey & Scott's diagnostic microbiology. Missouri, USA: Mosby Publishers. ISBN-13: 978-0323083300.
- Madigan, M.T., Martinko, J.M., Stahl, D.A. and Clark, D.P. (2010). 13th Edition. Brock biology of microorganisms. California, USA: Benjamin Cumming. ISBN-13: 978-0321649638.
- Kindt T. J., Osborne B. A. , Goldsby R. A. (2007). 6th Edition *Kuby Immunology*. New York, USA: W.H. Freeman and Company. ISBN-13: 978-1429202114 ISBN-10: 1429202114.
- Tortora, G.J., Funke, B.R. and Case C.L. (2006). 9th Edition. Microbiology: An introduction. California, USA: Benjamin Cummings. ISBN-13: 978-0536292117.
- Hay, F.C. and Westwood, O.M.R. (2002). 4th Edition. *Practical Immunology*. New Jersey, USA: Blackwell Science. ISBN: 9780865429611.
- Pelczar, M.J (2001). 5th Edition. Microbiology. New York, USA: McGraw Hill International. ISBN-13: 9780074623206.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC ELECTIVE COURSE-17 (BIOMED-DSE-17)**MODEL ORGANISMS IN BIOMEDICAL RESEARCH**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Model Organisms in Biomedical Research BIOMED-DSE-17	4	2	0	2	XII Passed	Basic knowledge of Biological Science

Learning Objectives:

This course aims to give the students an introduction to different model organisms, fundamental discoveries made through these organisms, what they are used for, the techniques to modify their genome, and how the students may use these organisms employing modern technological approaches for research and understanding of biology.

Learning Outcomes:

After the completion of this course, students shall learn and appreciate:

1. The need to study model organisms ranging from unicellular to multicellular and complex higher order animals and their use in deciphering the mysteries of life.
2. Selection criteria of a model organism for any specific condition
3. Ethical issues related to studies on model organisms

SYLLABUS OF BIOMED -DSE- 17:**(30 hours)****Unit I: Introduction****(3 hours)**

Introduction to model organisms; need to study model organisms; criteria to choose appropriate model organisms for biomedical research; Ethical issues in using model organisms.

Unit II: Unicellular model organisms**(7 hours)**

Escherichia coli: Life cycle, Advantages and disadvantages as a model, It's use in understanding of the fundamental concepts of molecular biology such as replication, gene expression and protein synthesis through *E. coli*, Utilization in discovery of fundamental metabolic pathways and understanding of antibiotic resistance mechanisms.

Saccharomyces cerevisiae (Baker's yeast): Life cycle, Mating types and their inheritance, Culture conditions, Advantages and disadvantages as a model, Use of yeast in the discovery of cell cycle regulatory genes-*cdc* mutants, Yeast two hybrid systems for protein-protein interactions. Commonly used yeast assays, Overview of the Yeast Genome Deletion Collection.

Unit III: Invertebrate model organisms

(8 hours)

Caenorhabditis elegans (Nematode worm)

Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in programmed cell death (role of proteases- *ced* genes), Cell-fate mapping, lineage studies, Discovery of RNAi. Nobel prizes won by *C. elegans*. Use in study of ageing process. Genetic screening

Drosophila melanogaster (Fruit fly)

Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of fundamental discoveries in genetics using fruit fly- TLR genes, development regulators, Nobel prizes won by *Drosophila*, Insights into forms of cancer and neurodegenerative diseases using *Drosophila*. The Gene disruption project, transgenic flies.

Unit IV: Vertebrate and Alternative Model Organisms in Biomedical Research (12 hours)

(a): Vertebrates model organisms

Danio rerio (Zebrafish): Life cycle, Maintenance, Advantages and disadvantages as a model, Overview of historical discovery of genetic control of early embryonic development, Zebrafish as a model for neurodevelopmental disorders and ecotoxicological studies, Introduction to tools for standard mutagenesis and Genetic screening.

Mus musculus (Mouse) and *Rattus norvegicus* (Rat)

Mouse vs rat w.r.t. physical features, age, size, weight, gestation period, weaning time and maintenance in animal house. Advantages and disadvantages of inbred and outbred species. “Premier” model organism for studying complex physiological processes and complex disorders such as infectious diseases (malaria) and non-infectious diseases (RA, diabetes, CVD, neurodegenerative disorders). Generation and application of knockout and transgenic mice as disease models. Applications in immunization, drug development and toxicology. Overview of the Knockout database.

Overview of other vertebrates model organisms commonly used in biomedical research- rabbit and guinea pig

(b): Introduction to other model organisms

Dictyostelium discoideum (Social amoeba) as a model for induced multicellularity and differentiation.

Daphnia (Water flea), ciliate and fish as models for ecotoxicological studies.

Practical

(60 hours)

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. To induce artificial competence in *E.coli* and compare it with organisms having natural competence.
2. To explore Saccharomyces genome database (SGD)
3. To explore the Wormbase database to retrieve information for *ced9* for understanding *C. elegans* as a model organism
4. To investigate Flybase and retrieve information of any homologous gene for a Cancer to evaluate fruit fly as a suitable model organism.
5. To study SCN2A gene involved in neurodegenerative disorders through the MGI database (Mouse Genome Informatics).

6. To study genes involved in neurodevelopment using the Zebrafish Information Network.
7. To observe different mutants of Yeast
8. To observe different mutants of *Drosophila*
9. To observe different mutants of *C. elegans*
10. To select a suitable model organism for any given disease and design experiments to investigate the given hypothesis like deciphering the mechanism of a particular protein in the pathogenesis of a disease or progress of a disease, etc.

Essential Readings:

- Walz K et al. (2019), 1st edition, Cellular and Animal Models in Human Genomics Research. Elsevier, ISBN: 9780128165737
- Lodish H et al. (2021), 9th edition, Molecular Cell Biology. W H Freeman & Co., ISBN: 1319208525
- Experiments with *Drosophila* for Biology Courses: An e-resource book for laboratory experiments at under- and post-graduate levels and for research projects in Biology courses. Editor-in-Chief: S. C. Lakhota, Co-Editor: H. A. Ranganath. Indian Academy of Sciences, Bengaluru. March 2021, ISBN: 978-81-950664-2-1
- Tang, B., Wang, Y., Zhu, J., & Zhao, W. (2015). Web resources for model organism studies. *Genomics, proteomics & bioinformatics*, 13(1), 64–68. <https://doi.org/10.1016/j.gpb.2015.01.003>
- Westerfield, M. (2000). The zebrafish book. A guide for the laboratory use of zebrafish (*Danio rerio*). 4th ed., Univ. of Oregon Press, Eugene.

Suggested Readings:

- Hedrich, H., (2012) 2nd edition. The Laboratory Mouse, Elsevier, ISBN: 9780123820082.
- Wilson-Sanders, S.E. (2011), Invertebrate models for biomedical research, testing, and education). *ILAR J*, 52(2):126-52. doi: 10.1093/ilar.52.2.126.
- Yancheva et al. (2015), Fish in Ecotoxicological Studies, *Ecologia Balkanica*, Vol 7 (1), pp149
- Vilas-Boas, J.A., et al. (2020), Ciliates in ecotoxicological studies: A minireview, *Acta Limnol. Bras*, <https://doi.org/10.1590/S2179-975X6719>, Compendium of CCSEA
- Guide for the Care and Use of Laboratory Animals Paperback by National Research Council, National Academic Press; 8th edition (2010), ISBN-10: 0309154006, ISBN-13: 978-0309154000
- Eisenmann, D. M., Wnt signaling (June 25, 2005), *Worm Book*, ed. The *C. elegans* Research Community, WormBook, doi/10.1895/wormbook.1.7.1, <http://www.wormbook.org>.
- Handbook on Laboratory Animals by PV Desai and P Saravanan, Jaypee Brothers Medical Publishers (P) Ltd., 2nd edition (2015), ISBN 9789351529521
- Handbook of laboratory animal science: Essential principles and practices Hau, Jann; Schapiro, Steven Jay. 3rd edition (2011), CRC Press, ISBN:978-1-4200-8455-9

DISCIPLINE SPECIFIC ELECTIVE COURSE-18 (BIOMED-DSE-18)
ADVANCED MOLECULAR BIOLOGY AND GENETIC ENGINEERING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Advanced Molecular Biology and Genetic Engineering BIOMED-DSE-18	4	2	-	2	XII Passed	Basic knowledge of Biological Science

Learning Objective:

- The course aims to teach an in-depth understanding of how those basic principles are applied in developing advanced techniques, enabling students to analyze the genomes and proteomes of any organism.
- The students would gain perspective on the transition of applications of molecular techniques performed in prokaryotes to the complex eukaryotes.
- As the course progresses, students will gain proficiency in gene editing tools such as CRISPR-Cas9 in creating transgenic organisms and in genetic engineering; they will learn the importance of molecular interactions, including protein-protein protein-DNA interactions.
- Finally, students will be primed to the significance of responsible molecular biology research practices and understand the ethical, regulatory and social aspects of RDT and genetic engineering.

Learning Outcomes:

- Based on this learning, they will appreciate how the recombinant DNA technology, which provides the ability to isolate, manipulate and express genes derived from any cell type, is helpful in creating therapeutic genes and recombinant proteins in human medicines.
- In-depth understanding of transcription, translation, and post-transcriptional modification process.
- Understanding the applications of these molecular processes and comprehending the next-generation techniques used in genome sequencing and analysis.
- Understand and apply molecular techniques in producing transgenic organisms and recombinant proteins as therapeutics.
- Students would appreciate the recent advances in Molecular Biology, Genetic Engineering and advanced high throughput sequencing methods that are leading to whole genome

sequencing of diverse organisms, and creating recombinant proteins in human medicine.

SYLLABUS OF BIOMED -DSE-18

30 hours

Unit-I: Basic Understanding of Molecular Biology

(3 Hours)

Structure of DNA and its forms (duplex, triplex, quadruplex); Structure and versatility of RNA; Structure of Proteins; Formation of nucleosome, chromatin and genome structure; Replication, Mutation and Repair of DNA. Mechanisms of Transcription, RNA-splicing and Translation. The Genetic Code, Transcriptional Regulation in Prokaryotes and Eukaryotes, Regulatory RNAs.

Unit II: Genome Dynamics- Recombination and Transposable Elements (9 Hours)

Homologous Recombination in DNA –Strand invasion, Holiday Junction model and Double strand break and repair and various enzymes involved; Homologous recombination in eukaryotes; genetic consequences of recombination.

Site-Specific Recombination in DNA- Role of enzymes in Site Specific recombination - Tyrosine recombinases, gamma integrase, Hin recombinase

Transposition- Prokaryotic transposable elements- IS elements, Composite transposons, Tn-3 elements; Eukaryotic transposable elements- Ac-Ds system in maize and P elements in Drosophila; Uses of transposons; Eukaryotic Viruses.

Unit-III: Enzymes and Vectors used in recombinant DNA Technology (8 Hours)

Restriction Modification system; Introduction to rDNA technology: Molecular gene cloning by Gibson Assembly; Restriction and modification enzymes used in rDNA technology. Reverse transcriptase for cDNA synthesis

Prokaryotic and Eukaryotic Vectors for cloning & expression with one example each: Expression and purification of recombinant proteins using a therapeutic gene of interest as an example; Importance of fusion proteins. Importance of genome organization of λ bacteriophage for understanding cloning vectors. Yeast vectors and expression system.

Unit-IV: Applications of rDNA Technology in Genetic Engineering

(10 Hours)

- a. Construction of cDNA library: Preparation and cloning of cDNA, Applications of cDNA library. A comparative analysis of Northern hybridization & Microarray methods for studying transcriptomes; Phage Display and Immunoprecipitation for protein-protein interactions; South-Western hybridization and DNase-foot printing for DNA-Protein interaction
- b. Basic concepts of transgenic organisms: Role of reporter genes, CRISPR-CAS; Functional analysis of cloned genes in transgenics; Production of transgenic plants, animals and microbes with one example of each; Applications of transgenic animals.
- c. Production of recombinant proteins for their application in human medicine: Three generations of recombinant hormones as therapeutics with one example of each; Recombinant enzymes - Streptokinase synthesis and application in myocardial infarction.
- d. Vaccines: DNA vaccines and Reverse Vaccinology

- e. Ethical and legal concerns in transgenics and recombinant therapeutics: Ethical issues in genetic engineering, patenting genes, cloning, genetic testing & screening; The legal & socio-economic impact of Biotechnology; Biosafety regulatory framework for the production of genetically modified organisms (GMOs) & their release in the environment. Cartagena Protocol on biosafety.

Practical

60 hours

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Gene-specific Primer Designing for PCR-based cloning.
2. Based on the provided restriction map of a plasmid vector, selection of REs for restriction digestion experiment.
3. Double Restriction Digestion of a recombinant plasmid and analysis using agarose gel electrophoresis.
4. RNA isolation and gel electrophoresis.
5. Checking the methylation status of provided genomic DNA using isochizomers such as DpnI and DpnII.
6. Bacterial transformation with a yeast vector that serves as a shuttle vector.
7. To perform a zymogram to assay the activity of an enzyme using Native Gel Electrophoresis.
8. Application of PCR technique in Forensics
9. Mandatory Project on **anyone** of the following topics (group of 5 to 10 students):
 - 9a. PCR-based cloning of a prokaryotic gene and over-expression of the recombinant protein on SDS PAGE.
 - 9b. Construct the design of an experiment/flow chart of techniques and methods learnt in this paper (and previous papers, too) to find a solution in Gene Therapy/production of a recombinant protein/in forensic, etc.

Essential Readings:

- Karp, G. (2010). Cell and Molecular Biology: Concepts and Experiments. (VI Edition); John Wiley & Sons. Inc.
- Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. (2009). The World of the Cell.(VII Edition). San Francisco: Pearson Benjamin Cummings Publishing.
- Peter J. Russell. (2009). Genetics- A Molecular Approach. (III Edition). San Francisco, United States of America: Benjamin Cummings.
- Watson, J. D. Baker T. A. Bell, S. P. Gann, A. Levine, M. and Losick, R. (2013). 7th Edition. *Molecular Biology of the Gene*. New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-0-321-76243-6.
- De Robertis, E.D.P. and De Robertis, E.M.F. (2006). Cell and Molecular Biology. (VIII Edition). Philadelphia: Lippincott Williams and Wilkins.
- Malacinski, George M.; Freifelder, David (1998). Essentials of Molecular Biology. (III Edition) Jones & Bartlett Pub.

- Brown, T. A. (2016). 7th Edition. Gene cloning and DNA analysis: An introduction. New York, USA: John Wiley and Sons, ISBN- 978-1-119-07256-0.
- Primrose, S. B. and Twyman, R. B. (2006). 7th Edition. Principles of gene manipulation and genomics. Oxford, UK: Blackwell Scientific Publishers. ISBN: 978-1405135443.
- Bernard, R. G. Jack, J. P. and Cheryl, I. P. (2022). 6th Edition. Molecular biotechnology: Principles and applications of recombinant DNA. USA: ASM press, ISBN- 978168367368.

Suggested Readings:

- Kornberg, A. (2005). 2nd Edition. *DNA replication*. California, USA: University Science Books, ISBN-13: 978-1891389443.
- Cox, M. M. Doudna J. A. and Donnell, M. O. (2012). 1st Edition. *Molecular biology: Principles and practice*. London, UK: W H Freeman & Co Publishers, ISBN-13: 978-0-716-7998-8.
- Green, M. R. and Sambrook, J. (2012). 4th Edition. *Molecular cloning: A laboratory manual*, New York, USA: Cold Spring Harbor Laboratory Press, ISBN-13: 978-1936113422.
- Winnaeker E. L. (1987). From Genes to Clones: Introduction to Gene Technology. Publisher VCH. ISBN - 0895734206, 9780895734204.
- D. M. Glower and B. D. Hames (1995). DNA cloning: A practical approach by IRL PRESS, Oxford. ISBN: 9780199634767.

**DISCIPLINE SPECIFIC ELECTIVE COURSE –19 (BIOMED-DSE-19) BRIDGING
ANCIENT MEDICINE AND PRACTICES WITH MODERN BIOMEDICAL RESEARCH**

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Bridging Ancient Medicine and Practices with Modern Biomedical Research BIOMED-DSE-19	4	2	-	2	XII Passed	Basic Knowledge of Biological Sciences

Learning Objectives

The Learning Objectives of this course are as follows:

- Students will be introduced to the field of ancient medicine including Ayurveda, Naturopathy and Yoga.
- Students will develop scientific and hands-on practical skills in investigating ancient medicine applications in modern biomedical research that will be useful for higher studies and research.

Learning Outcomes:

The Learning Outcomes of this course are as follows:

- Students will be introduced to the concept, scope and relevance of various ancient medical practices and the role of ancient medicine applications in modern biomedical research.
- Students will gain insights into the clinical applications of nutraceuticals, Yoga and basis of ethnopharmacological practices for drug development.
- Students will be able to appreciate the genomic context of ayurvedic classification.
- Students will learn to perform group project work to analyze the health benefits of Ancient traditional medicine

SYLLABUS OF BIOMED-DSE-19

(30 hours)

Unit I (a): Introduction to Ancient Medicine Knowledge

(4 hours)

Introduction and historical account of ancient medical practices including Ayurveda, Naturopathy and Yoga. Concept of Five elements (Pancha mahabhuta), Pancha kosha, Yoga sutras and Nature cure. Contribution of Charaka and Sushruta. Ayurvedic Pharmacopoeia of India, Traditional knowledge digital library, ICMR Research programmes on traditional medicine, WHO traditional medicine strategy.

Unit I (b): Ayurgenomics

(6 hours)

Tridosha theory of Ayurveda (Vata; Pitta; Kapha), Concept of Prakriti and Vikruti, Prakriti types (Vata; Pitta; Kapha; Vata/Pitta; Pitta/Kapha; Vata/Kapha; and Vata/Pitta/Kapha), Scientific explanation for Prakriti: Ayurgenomics (Integration of the principles of Ayurveda with the genomics), P4 medicine (four Ps are predictive, preventive, personalized, and participatory)

Case studies on expression levels of genes involved in immunity, cell division, blood coagulation, etc with respect to different Prakriti types, Studies on the Genetic Basis of Prakriti (high-altitude adaptation, rheumatoid arthritis, human leukocyte antigen), Studies on Physiology, Disease and Prakriti (Triglyceride, VLDL and LDL levels, Diabetes, Parkinson's disease), Epigenetics in Ayurveda.

Unit II: Health Benefits of Yoga

(6 hours)

Yoga Practices including postures (overview of asanas), breathing techniques (pranayama), meditation (dhyana/dharana), and relaxation for health promotion and therapeutics: Immune modulation (treating infectious diseases), headache, migraine, obesity, hyperthyroidism, diabetes, PCOD, hypertension (Savasana), anxiety and depression (Hatha Yoga), arthritis and cancer. Learning outcomes of experimental studies related to yoga in Mental Health, Stress, Cardiovascular Disease, Musco-skeletal disorders, Neurological Disorders, etc.

Unit III: Ethnopharmacology: Traditional medicine in modern drug discovery

(7 hours)

Introduction, scope and relevance. Quantitative and Comparative Methods in Ethnopharmacology (Materia medica and cultural consensus, Pharmacological research), Biodiversity, Conservation and Ethnopharmacology. Stages of ethnopharmacological research in drug discovery (ethnobotanical surveying and fieldwork/Screening and evaluation of traditional medicine, the pharmacological assessment of activity with diverse targets in the laboratory, and the transfer of results back to indigenous communities). Understanding the basis of ethnopharmacological practices for the development of early medicines using the examples of morphine, aspirin and digitalis. Recent drug discovery projects with ethnopharmacological association (Artemisinin for malaria, Prostratin as antiviral). Challenges in Ethnopharmacology (Biopiracy)

Unit IV: Nutraceuticals

(7 hours)

Introduction, scope and relevance. Difference Between Nutraceuticals, functional foods and Pharmaceuticals, Main categories of Nutraceuticals (Herbals, Nutrients and Dietary supplements), Ayurvedic Classification and Nutraceuticals- Classification of food according to the doshas (Vata, Pitta, and Kapha), Studying specific bioactive compounds in foods and herbs that target doshic imbalances (Ashwagandha for stress (Vata imbalance), Turmeric for inflammation (Pitta imbalance), Ginger for digestion and metabolism (Kapha imbalance). Research evidence based applications of nutraceuticals with examples related to neural (*Bacopa monnieri*, *Curcuma longa*), cardiovascular (flavanoid rich grapes, tea polyphenols), Diabetes (*Psyllium*, *Momordica charantia*) and renal disorders (*Tribulus terrestris*, Stevia). Nutraceuticals for health promotion, immune-boosting and protection. Adverse effects of Nutraceuticals.

Practical:

60 hours

Group project work to analyze the health benefits of Ancient traditional medicine

- Identification of Problem/Hypothesis through literature review (2 weeks)
- Questionnaire preparation (3 weeks)
- Survey after due ethical clearance/Data collection from published data or scientific literature (4 weeks)

- Data Analysis (4 weeks)
- Compilation and Presentation of results (2 weeks)

Essential Readings:

- Sebastian, T. (2024). Cell line studies in Ayurveda: Bridging ancient wisdom and modern science. *International Journal of Biological and Pharmaceutical Sciences Archive*, 7(1), 158-161. (DOI: 10.53771/ijbpsa.2024.7.1.0030)
- Mohan, S, Abdollahi, S, & Pathak, Y (Eds.). (2023). *Applications of Functional Foods and Nutraceuticals for Chronic Diseases: Volume I*. CRC Press. e-book ISBN: 9781003220053
- Heinrich, M, Jäger, AK (Eds.) (2015) *Ethnopharmacology*. Wiley. ISBN: 978-1-118-93074-8.
- Wiart, C (2007). *Ethnopharmacology of Medicinal Plants: Asia and the Pacific*. Netherlands: Humana Press. e-book ISBN: 9780429125263.
- Cosola C, Sabatino A, Di Bari I, *et al.* (2018) Nutrients, Nutraceuticals, and Xenobiotics Affecting Renal Health. *Nutrients*. (DOI: 10(7):808. (<https://doi.org/10.3390/nu10070808>))
- Huang Z, Chavda VP, Bezbaruah R, *et al.* (2022) An Ayurgenomics: A new approach in personalized and preventive medicine Development for Personalized Care. *Front Pharmacol*. 13:866827. (DOI: 10.36348/SIJB.2019.v02i10.001)
- Mukerji, M, & Prasher, B (2011). Ayurgenomics: A new approach in personalized and preventive medicine. *Sci Cult*, 77(1-2), 10-7.
- Khalsa, S B, Cohen, L, McCall, T, *et al.* (2016). *Principles and Practice of Yoga in Health Care*. United Kingdom: Jessica Kingsley Publishers. ISBN: 9781909141209.
- Basu-Ray I, Metri K, Khanra D, *et al.* (2022). A narrative review on yoga: a potential intervention for augmenting immunomodulation and mental health in COVID-19. *BMC Complement Med Ther.*, 22(1):191. doi: 10.1186/s12906-022-03666-2. PMID: 35850685; PMCID: PMC9289356.
- Bunn, M. (2010). *Ancient Wisdom for Modern Health: Rediscover the Simple, Timeless Secrets of Health and Happiness*. Australia: Enlightened Health Publishing.

Suggested Readings:

- Chakrabarti, D. (2024). *History of Ancient India (11 Volume Series)*. Sage Publications. New Delhi. ISBN: 9789353887009.
- PHOSP-COVID Collaborative Group (2022). Clinical characteristics with inflammation profiling of long COVID and association with 1-year recovery following hospitalisation in the UK: a prospective observational study. *The Lancet. Respiratory medicine*, 10(8), 761–775. (DOI: 10.1016/S2213-2600(22)00127-8)
- Wal P, Aziz N, Dash B *et al.* (2023) Neuro-nutraceuticals: Insights of experimental evidences and molecular mechanism in neurodegenerative disorders. *Futur J Pharm Sci*. 9, 31. (DOI: 10.1186/s43094-023-00480-6)
- Gupta R C, Doss R B, Garg R C, *et al.* (2021). Nutraceuticals for diabetes and glucose balance. In *Nutraceuticals* (pp. 83-100). Academic Press. ISBN: 9780128210383. (DOI: 10.1016/B978-0-12-821038-3.00006-9)
- Sosnowska B, Penson P, Banach M (2017) The role of nutraceuticals in the prevention of cardiovascular disease. *Cardiovasc Diagn Ther.* (Suppl 1):S21-S31. (DOI: 10.21037/cdt.2017.03.20)

- Ghani U, Naeem M, Rafeeq H, *et al.* (2019). A novel approach towards nutraceuticals and biomedical applications. *Sch. Int. J. Biochem*, 2, 245-252. (DOI: 10.36348/SIJB.2019.v02i10.001)
- Kim C H, Heinrich M, Yen H R, *et al.* (2023). Insights in ethnopharmacology: 2022. *Frontiers in Pharmacology*, 14. (DOI:[10.3389/fphar.2023.1264063](https://doi.org/10.3389/fphar.2023.1264063))
- Wallace R K (2020) Ayurgenomics and Modern Medicine. *Medicina (Kaunas)*. 56(12):661. (DOI:[10.3390/medicina56120661](https://doi.org/10.3390/medicina56120661))
- McCall, T (2007). *Yoga as Medicine: The Yogic Prescription for Health and Healing*. United Kingdom: Random House Publishing Group.
- Pandomatti, S. C., Tyagi, I., Shrivastava, K. K., Mahajan, S., Patel, J., & Shinde, M. A. (2024). A Literature Review of the Integration of Ancient Indian Mythology in Clinical Medicine: A Holistic Approach to Health and Healing. *Cureus*, 16(7), e63779. (DOI: 10.7759/cureus.63779)
- Latest developments in associated fields through research articles. (https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=ayurveda+%2B+ayurgenomics+%2B+naturopathy+%2B+yoga+%2B+ethnopharmacology+%2B+nutraceuticals&btnG=)

B.Sc (Hons.) Biomedical Science
Pool of Generic Elective Papers

GENERIC ELECTIVE COURSE -05 (BIOMED-GE-05)

CONCEPTS IN MEDICINAL CHEMISTRY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Concepts in Medicinal Chemistry BIOMED-GE-05	4	3	-	1	XII Passed	Basic knowledge of Chemistry and Biology

Learning Objectives:

The introduction to Concepts of Medicinal Chemistry course at undergraduate level to students has been conceived to make them understand:

- Concepts of chemical science interlinked to other science disciplines such as chemistry, biology, biochemistry, pharmacology etc.
- Application of the area in revealing new drug design and targets through studying the drug-receptor interactions and lead discovery.
- Various drug targets in the body and drug development strategies.

Learning Outcomes:

- After completing the course, students shall be able to understand the structure and function of biomolecules, chemistry of stereoisomers and its importance in process of drug designing. Further, they will be able to explore various kinds of drug targets including protein, enzymes, nucleic acids etc.
- They will also appreciate the process of drug-receptor interactions; identify association between chemical structure and its physicochemical properties.
- After the completion of the course, the learners will demonstrate a strong foundation via problem solving, critical thinking and analytical reasoning in the fundamentals of medicinal chemistry, physicochemical principles of drug action and measurement of drug effects, comprehend the physicochemical basis for the rational drug design, analogue synthesis, and mechanism of action of drugs.
- The students will be able to design and carry out small molecule (low molecular drug-relevant compounds) synthesis. They will understand the natural product isolation along with identification of their phytochemical constituents. They will also learn to identify biomolecules.

SYLLABUS OF BIOMED-GE-05

(45 hours)

Unit I: Introduction and Stereoisomerism

(16 Hours)

Importance of water as solvent, Partition coefficient, Drug dissolution, Acid-base properties, Henderson Hasselbach equation, Surface activity, Bio-availability, Hammett equation. Physicochemical Interactions-bonding and non-bonding interactions, Rational drug design and Introduction to SAR, Concept of prodrugs and Stereochemical aspects of drug action.

Optical isomerism: Optical activity, enantiomerism, D and L designation, racemic modification, R and S sequence rules, diastereoisomers, (2L), Geometrical isomerism: Definition, nomenclature– E and Z isomerism, Walden inversion, Conformational isomers: conformation of ethane and butane, Specific rotation, optical purity.

Unit II: Biomolecules

(8 Hours)

Amino Acids: Structure and classification of amino acids, ionization & titration curves and formation of peptide bond, cis and trans conformation and planarity. Ramachandran Plots (ϕ , ψ and ω), Secondary structure of proteins (α -helical, β -pleated sheet). Nucleotides: structure and numbering, Tautomerism in nucleic acid bases, pH and properties; Sugars and conformation of sugar phosphate backbone. Monosaccharides- cyclization of aldoses and ketoses, concept of mutarotation, anomers, epimers.

Unit III : Principles of Drug Action: Receptor Interactions & Target Classification

(a): Drug-Receptor Interaction

(8 Hours)

Kinetic analysis of ligand receptor interactions using Scatchard plot, Double reciprocal plot, Hill plot, Forces involved, Affinity, Efficacy and potency, Relationship between dose and effect (graded and quantal response). Concept of Enzyme inhibition and Michaelis equation. Drug distribution and Zero & First order kinetics, half life, Microsomes and drug metabolism-Phase I and Phase II enzyme

(b): Drug Target Classification

(8 Hours)

Drug Target Classification: Proteins as target: a) Classification of receptors and their functions and their activation/inhibition (such as Agonist, antagonists and inverse agonist) , Desensitization and sensitization of receptors. b) Enzymes as targets: Enzyme inhibitors (competitive, non-competitive, suicide inhibitors) Nucleic acids as drug targets: Classes of drugs that interact with DNA: DNA intercalators (amracrine) and DNA alkylators (amine: mechlorethamine, nitrosoureas: carmustine).

Unit IV: New Drug Approval Process and regulatory affairs

(5 Hours)

Investigational New Drug Applications (INDs): Approval processes and timelines involved, Preclinical testing, Clinical testing - Phase I, II, III and IV, Developing clinical trial protocols, Institutional Review Board / Independent Ethics committee - formation and working procedures, Informed consent process and procedures. Pharmacovigilance - Safety monitoring in clinical trials, Introduction of Drugs and Cosmetics Act (1940 and 1945) and patent act 1970. Process of drug patent filing- specifications, framing of claims and various forms.

Practical:**(30 hours)**

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Recrystallization of an organic compound (e.g., benzoic acid) and determination of its melting point.
2. Preparation of Hippuric acid/s-benzyl thiuronium salt/ Benzoquinone, recrystallization and characterization.
3. Phytochemical qualitative examination of *Curcuma Longa* constituents by solvent extraction (Tannins, Saponins, Flavanoids, Alkaloids, Polyphenols)
4. Conduct qualitative tests for amino acids/proteins: Ninhydrin, Xanthoproteic, Million's, Lead Acetate, Biuret test.
5. Prepare the titration curve of acetic acid/glycine.
6. Measure absorption spectrum of protein and DNA and calculate the purity of protein
7. Measure protein concentration using absorption spectrum (BSA)
8. Extraction of caffeine from tea leaves.
9. Study absorption property of caffeine using absorption spectroscopy.

Essential Readings:

- Patrick G.I. (2017). 6 th Edition. Introduction to medicinal chemistry. Oxford, UK: Oxford University Press. ISBN-13: 978-0198749691.
- Silverman, R.B. and Holladay, M.W. (2014). 3 rd Edition. The organic chemistry of drug design and drug action. San Diego, USA: Elsevier, Academic Press. ISBN-13: 9780123820303.
- Nelson, D. L. and Michael M. Cox (2021) 8th Edition. Lehninger Principles of Biochemistry. New Jersey, USA: Prentice Hall Publishers.
- Nasipuri, D. (2020), Stereochemistry of Organic Compounds: Principles and Applications, 4 th Edition, New Age International.
- Plummer, D. (2017) An Introduction to Practical Biochemistry, 3rd edition. McGraw-Hill College.

Suggested Readings:

- Wermuth, C. G., Aldous, D., Raboisson, P., & Rognan, D. (2015). *The Practice of Medicinal Chemistry* (4th ed.). Elsevier, Academic Press.
- King, F. D. (2003). *Principles and Practice of Medicinal Chemistry* (2nd ed.). The Royal Society of Chemistry
- Nogrady, T., & Weaver, D. F. (2005). *Medicinal Chemistry: A Molecular and Biochemical Approach* (3rd ed.). Oxford University Press

GENERIC ELECTIVE COURSE -14 (BIOMED-GE-14) PHARMACOLOGICAL SCIENCE

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Pharmacological Science BIOMED-GE-14	4	3	-	1	XII Passed	Basic knowledge of human physiology

Learning Objectives:

- This course focuses on the study of drugs and their application in treating various diseases. Students will gain knowledge about different drug formulations and their methods of administration within the body.
- The course covers the fundamental mechanisms through which drugs influence or modify physiological processes to achieve therapeutic effects.
- Additionally, students will develop an understanding of selecting and utilizing drugs to manage microbial infections and address diseases resulting from hormonal imbalances.

Learning Outcomes:

- Students will be introduced to the naming and formulation of drugs, the routes of drug administration, and the factors influencing the choice of one route over another in specific patient conditions.
- The course will cover fundamental concepts of drug absorption, transport, excretion, and the effects of metabolism on drug activity. Topics will include the quantification of drug half-life, bioavailability, and elimination, along with the factors that influence these processes. Students will also explore the primary macromolecular targets of drugs in the body, such as receptors and enzymes and gain insight into measuring drug response, efficacy, potency, and the variables affecting drug action.
- Additionally, students will learn about the mechanisms of action, side-effects and contraindications of various drug classes.
- The course will also address the selection and use of antimicrobial drugs, the challenges associated with their indiscriminate or inadequate use, and the therapeutic applications of hormones and hormone antagonists.

SYLLABUS OF BIOMED-GE-14

Unit I: Introduction to pharmacology

(10 hours)

Nomenclature of drugs (Generic, IUPAC and Proprietary name); Drug formulations- Powders, Liquids, Emulsions, Semisolid, Solid dosage forms and Aerosols; Routes of drug administration, their advantages and disadvantages, drug adverse effects.

Unit II: Pharmacokinetics and pharmacodynamics

(12 hours)

Pharmacokinetics: Drug absorption, distribution, metabolism, and excretion, bio-availability, Therapeutic window, Kinetics of elimination, biological half-life of drug.

Pharmacodynamics: Various macromolecular targets of drugs (membrane receptor, transporters, enzymes, channels etc.). Dose response curve, Therapeutic Index, Affinity, Efficacy, Potency, Agonist and Antagonist.

Unit III: Mechanism of action of different classes of drugs

(15 hours)

Mechanism of action, main side-effects and contraindications of the following drugs-

1. Antipyretics and Analgesics (Paracetamol and Ibuprofen)
2. Anti-inflammatory drugs (Aspirin, Celecoxib)
3. Sedatives (Diazepam)
4. Cholinergics (Bethanechol)
5. Adrenergics (Isoprenaline)
6. Oral hypoglycemic agent (Tolbutamide)

Unit IV : Pharmacotherapy: Antimicrobials and Hormonal Agents

(8 Hours)

(a): Anti-microbial therapy

General aspects of anti-microbial therapy, Antibacterial drugs (Ciprofloxacin), Antifungal drugs (Amphotericin B).

(b): Hormones as drugs

Brief introduction; Insulin and Insulin Analogues, Hormone Replacement Therapy (HRT), Estrogen and Progestins.

Practical:**(30 Hours)**

(Wherever wet lab experiments are not possible, the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Handling and housing of laboratory animals.
2. Demonstration of different routes of drug administration using rat/mice.
3. Fixing of organ bath and kymograph
4. To record CRC of acetylcholine using guinea pig ileum/ rat intestine (virtually)
5. Study of competitive antagonism using acetylcholine and atropine.
6. Determination of dose ratio.
7. Study the effect of an analgesic by Tail-flick test.
8. Study of effect of an anti-anxiety drug using Plus Maze test.

Essential Readings:

- Tripathi, K.D. (2018). 8th Edition. *Essentials of Medical Pharmacology*. Jaypee Brothers, India, ISBN-13: 9352704996-978.
- Kulkarni, S.K. (2014). 4th Edition, Reprint. *Handbook of Experimental Pharmacology*, Vallabh Prakashan, India, ISBN-13: 978-8185731766.

Suggestive Readings:

- Katzung, B. G., (2021) Basic and Clinical Pharmacology, 15th Edition, McGraw-Hill Education, ISBN: 978-1260452310.
- Ritter, J.M., Flower, R., Henderson, G., *et al.* (2019). 9th Edition (International). *Rang and Dale's Pharmacology*. Relx India Pvt. Ltd, ISBN-13: 978-0702074479.

UNIVERSITY OF DELHI



DEPARTMENT OF BOTANY

Bachelor of Science in Botany & Life Sciences

OR

Bachelor of Botany (Honours with Research/Academic Project/Entrepreneurship)

OR

Bachelor of Botany (Honours with Research in Major in Botany)

OR

**Bachelor of Science (Hons.) in Botany with Dissertation/ Academic Projects/
Entrepreneurship**

Under UGCF-2022 based on NEP-2020

(Effective from Academic Year 2022-23)

Courses offered in B.Sc (Honours) BOTANY Semester VII and VIII with the course contents

Department of Botany
SEMESTER –VII
(Under UGCF-2022 based on NEP-2020)

S. No.	Contents	Page Numbers
1	B. Sc (Honours) BOTANY- (DSCs) DSC-19: Genomics, Proteomics and Bioinformatics	3
2	Pool of Discipline Specific Electives (DSEs) BOT-DSE-08: Research methodology [#] BOT-DSE-09-Biodiversity Informatics ¹ BOT-DSE-10-Plant Tissue Culture BOT-DSE-11-Reproductive Ecology ² BOT-DSE-12-Environmental Biotechnology & Management	6
4.	*Pool of Generic Elective Courses (GEs) BOT-GE-09: Intelligent Systems in Plants BOT-GE-10: Informatics and Statistics for Biology and Allied Sciences BOT-GE-13: Plant Biotechnology BOT-GE-18: Genetic Engineering technologies and Applications BOT-GE-20: Genomics, Proteomics and Metabolomics	NA
5	Dissertation on Major/Minor/Academic Project	As per University guidelines

^{1,2} Courses are already offered as Generic Elective

* The syllabi of the mentioned GE courses have already been approved.

Research Methodology shall be offered in Semester VI and VII as per the guidelines of University of Delhi. Students planning to pursue a 4 year UG program are advised to choose research methodology in the VI semester.

DISCIPLINE SPECIFIC CORE COURSE (DSC-19): Genomics, Proteomics and Bioinformatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Genomics, Proteomics and Bioinformatics DSC-19	4	2	0	2	Semester VI	Nil

Learning Objectives:

- Introduce students to fundamental and emerging concepts in genomics, proteomics, and bioinformatics.
- Familiarize students with analytical tools and real-world applications of omics technologies across agriculture, health, and environmental sectors.
- Explore interdisciplinary fields such as metagenomics, epigenomics, and single-cell genomics and their significance in global problem-solving.
- Develop basic computational skills to utilize bioinformatics databases and tools for data interpretation in genomics and proteomics.

Learning Outcomes:

By the end of the course, students will be able to:

- Explain the principles and applications of genomics in agriculture, human health, and environmental science.
- Understand the concepts of epigenetics and demonstrate familiarity with tools used to study epigenetic modifications.
- Describe metagenomics and single-cell genomics, and their relevance in microbiome analysis and environmental monitoring.
- Understand core techniques and tools in proteomics, including post-MS data analysis, and their translational value.
- Demonstrate knowledge of bioinformatics concepts, databases, and software tools for sequence, structure, and functional analysis of biological data.

Theory: **30 hours**

Unit 1: Genomics and Epigenetics **10 hours**

Genomic concepts: genomes, genes, and non-coding regions, Structure of complexity of eukaryotic genome, Applications in agriculture, health, and the environment, CRISPR-Cas9: A beginner-friendly introduction to genome editing, Genomics ethics: privacy, data sharing, and equity. Epigenomics. DNA methylation and histone modifications, Overview of Bisulfite sequencing and ChIP-Seq, Role of epigenetics in stress adaptation in plants.

Unit 2: Metagenomics and Single-Cell Genomics **5 hours**

Metagenomics: concept and applications, Human Microbiome Project (HMP), Environmental metagenomics: Role in pollution control and ecosystem management. Single-cell genomics: its concept and importance.

Unit 3: Proteomics **7 hours**

Overview of Proteomics, Complexity of protein structure (primary, secondary and tertiary), Post translational modifications (phosphorylation, glycosylation), Proteome analysis by 2-D gel electrophoresis, Edman sequencing (Methodology and limitations in protein sequencing) and MALDI-ToF (Matrix-Assisted Laser Desorption/Ionization – Time of Flight), nLC-MS/MS (nano-Liquid Chromatography coupled with Tandem Mass Spectrometry), X-ray crystallography.

Unit 4. Bioinformatics **8 hours**

Introduction to bioinformatics: definition and scope, Nucleotide and Protein databases (GenBank, UniProt, PDB), metabolic pathway database (KEGG), Search engines for databases (Entrez and PubMed), File format (FASTA), BLAST, Concept of sequence alignment, molecular phylogeny

PRACTICALS: **60 hours**

1. Virtual Exploration of Plant Genomes

1a. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).

1b. Search for a gene of interest (e.g., drought resistance or photosynthesis-related genes).

1c. Record details such as gene location, sequence, function, and related pathways.

1d. Compare homologous genes between two plant species using BLAST.

2. Study of GenBank and UniProt for the retrieval of nucleic acid and amino acid sequences

3. Sequence homology and gene annotation through BLAST tool

4. Illumina sequencing through photograph

5. Explore single nucleotide polymorphisms (SNPs) in plants and their role in trait variation.
6. Predict the structure of protein from its amino acid sequence. (Phyre 2/ Modweb/ CPH model/ Swiss Model).
7. Analysis of protein (s) on 2-D Gels, X-ray crystallography and protein microarray through photographs.
8. *In silico* analysis for PTM, Localization, and functions using the above-mentioned software.
9. Basic handling of data, transcriptome assembly, batch blast, batch primer design, setting up a local blast, basic of genome assembly, and isolation of microsatellites using MISA.

Suggested Readings (Books and Articles):

- Brown, T.A. (2017). *Genomes 4*. Garland Science. *A student-friendly introduction to genomics with clear explanations and examples.*
- Dale, J.W., & Park, S.F. (2010). *Molecular Genetics of Bacteria*. Wiley-Blackwell. *Covers foundational concepts in bacterial genomics and applications.*
- Allis, C.D., Caparros, M.-L., Jenuwein, T., & Reinberg, D. (2015). *Epigenetics*. Cold Spring Harbor Laboratory Press. *(Focus on the introductory sections for basics of DNA methylation and histone modifications.)*
- Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Wiley-Blackwell. *(Chapters on metagenomics provide a straightforward introduction with practical applications.)*
- Handelsman, J. (2004). *Metagenomics: Application in Microbial Ecology*. ASM Press. *(Focuses on simple and engaging content about microbial diversity studies.)*
- Doudna, J.A., & Sternberg, S.H. (2017). *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*. Houghton Mifflin Harcourt. *(Written for a general audience, this book explains CRISPR in simple terms.)*
- Regev, A. et al. (2017). "The Human Cell Atlas." *eLife*. *(Overview of single-cell genomics and its goals in mapping human cells.)*
- Varshney, R.K., Roorkiwal, M., & Sorrells, M.E. (2017). *Genomic Selection for Crop Improvement*. Springer. *(Readable sections on GWAS and genomic applications in crop breeding.)*
- Sandel, M.J. (2009). *The Case Against Perfection: Ethics in the Age of Genetic Engineering*. Harvard University Press. *(Simplifies the ethical dilemmas posed by genomics and genome editing.)*

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-08): revised RESEARCH METHODOLOGY to be followed from 2025-26 academic year

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
RESEARCH METHODOLOGY DSE-08	4	2	0	2	Semester V	Nil

Learning Objectives:

- To introduce fundamental principles of research, including types, designs, and approaches used in biological sciences.
- To provide hands-on experience in data collection, analysis, interpretation, and scientific communication.
- To develop critical skills for framing research questions, hypotheses, and experimental designs.
- To equip students with tools for conducting literature reviews using digital and print resources.
- To train students in scientific writing, referencing, plagiarism checking, and intellectual property rights.
- To encourage ethical practices and promote problem-solving through scientific investigation aimed at societal benefit.

Learning Outcomes:

After successful completion of the course, students will be able to:

- Describe the key concepts, types, and methodologies of research in biological sciences.
- Formulate research questions and hypotheses, and design appropriate experimental or survey-based studies.
- Conduct comprehensive literature reviews, identify research gaps, and synthesize existing knowledge.
- Collect, analyze, and interpret qualitative and quantitative data using appropriate statistical or software tools.
- Write scientific reports, proposals, reviews, and thesis documents using correct referencing and citation styles.
- Demonstrate ethical research conduct, understand plagiarism, and appreciate the basics of intellectual property rights.

Theory: **30 hours**

Unit 1: Basic Concepts of Research **4 hours**

Objectives, Research Methods vs Methodology, Types of Research-Quantitative vs Qualitative, Analytical vs Descriptive, Basic vs Applied, Field Research, Search engines, Literature-review and its consolidation

Unit 2: Research Design, Data Collection and Analysis **12 hours**

Conceptualization a research problem, Developing a research model, Validation of the proposed model with standard procedures and attributes, Experimental design, and implementation, Observation and Data acquisition, Methods of data collection, Data quality check, Processing and Analysis Strategies; Data presentation (Tables and Figures), Interpretation

Unit 3: Ethical Issues **04 hours**

Intellectual Property Rights, Copy Right, Plagiarism, Commercialization and Royalty

Unit 4: Report Writing **10 hours**

Technical Research writing (Dissertation/ Reports/Research/Review papers), Citations, Acknowledgements, Research Grants/ Fellowships, Bibliography

PRACTICALS: **60 hours**

1. Search engines, Literature survey, identification of gap areas
2. Presentation of collated literature
3. Experimental layout, execution, observation
4. Data analysis, using softwares, tables and figures
5. Writing a report/research paper/dissertation/summary
6. Preparation of bibliography in different formats as per journal's requirements
7. Usage of software tools for checking plagiarism

Suggested Readings:

1. Coley, S.M. and Scheinberg, C.A. (1990). "Proposal writing". Stage Publications.
2. Stapleton, P., Yondeowei, A., Mukanyange, J., Houten, H. (1995). Scientific writing for agricultural research scientists – a training reference manual. West Africa Rice Development Association, Hong Kong.
3. Wadhera, B.L. (2002). Law Relating to Patents, Trade Marks, Copyright Designs and Geographical Indications, Universal Law publishing.
4. Dawson, C. (2002). Practical research methods. UBS Publishers, New Delhi.
5. Anthony, M, Graziano, A.M. and Raulin, M.L. (2009). Research Methods: A Process of Inquiry, Allyn and Bacon.
6. Kothari, C.R. (2014). Research Methodology: Methods and Techniques, 2nd edition, New Age International (P) Ltd.,

7. Walliman, N. (2011). Research Methods- The Basics. Taylor and Francis, London, New York, USA.
8. Cresswell, J.W. (2014). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches (4th edition). SAGE Publications Inc.
9. Rao, G.N. (2018). Biostatistics & Research Methodology. Pharmamed Press.
10. Gary J. Burkholder, G.J., Cox, K.A., Crawford, L.M. Hitchcock, J.H. (2019). Research Design and Methods: An Applied Guide for the Scholar-Practitioner. SAGE Publications, Inc.
11. Mukherjee, S.P. (2019). A Guide to Research Methodology: An Overview of Research Problems, Tasks and Methods. CRC Press
12. Flick, U. (2020). Introducing Research Methodology: Thinking Your Way Through Your Research Project. SAGE Publications Ltd.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE- 09): Biodiversity Informatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Biodiversity Informatics DSE-09	4	2	0	2	Semester VI	Nil

Learning Objectives:

To introduce students to an integrated area of study where concepts learnt under different courses in previous semesters are to be utilised. The field of Biodiversity informatics integrates information on systematics, ecosystems to curate, analyse and develop an information management system to provide sound scientific bases for policy decisions.

Learning Outcomes:

- Assess knowledge on basic principles of Ecology, Conservation, Restoration, Biodiversity, Genetics, Molecular biology.
- Introduce applications of Remote Sensing and Geographical Information System as well as Informatics.
- Provide an opportunity to learn principles of Data Capture systems, basic elements of digitisation of Biological data, some key elements of Information Science along with creation/curation of Biological Databases (collection, storage & retrieval)
- Emphasise the importance of field collection, maintenance of herbaria & specimen collections.
- Introduce relevant National and International Biodiversity Laws.

Theory :

30 hours

Unit 1. Understanding Biodiversity and Informatics

05 hours

Introduction to Global & National movements for conservation, institutions (including National Biodiversity Authority of India, NBPGR and others) and other non-Governmental organisations (NGO s) and networks involved in biodiversity informatics. Ecapiulating Basic principles of Ecology & Biodiversity - Geological Time scale and evolution of life forms, Five major

extinctions, Ecosystems & Ecosystems diversity: biomes, mangroves, coral reefs, wetlands and terrestrial diversity. Biodiversity Hotspots & factors of endemism. Levels of Biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of Biodiversity (latitudinal, insular).

Unit 2. Measuring/Estimating Biodiversity

08 Hours

- i. Magnitude of biodiversity (Global and Indian data). Introduction to Diversity Indices (Simpson, Shannon) and estimation of Species diversity: richness and evenness, loss of species.
- ii. Introduction to Metagenomics, use of ancient DNA (aDNA) for estimation of biodiversity loss.
- iii. Estimating Threats to natural Biodiversity: Habitat loss and fragmentation Disturbance and pollution; Introduction of exotic species; Human intervention and Biodiversity loss; Consequences of monotypic agricultural practice
- iv. Global Environmental changes, land and water use changes ; Impacts of Climate Change on Biological systems.

Unit 3. Informatics Resources and Methods

11 hours

- i. National & International efforts in Conservation, databases GBIF, IUCN categorized- endangered, threatened, vulnerable species.
- ii. Red data book and related documentation.
- iii. Categories of Biodiversity informatics databases and tools based on target life cycle step : data planning and collection, data quality and fitness, data description, data preservation and publication, data discovery and integration, computational modeling and analysis.(few databases example can be chosen to explain the steps - BRAHMS, Genbank, Catalog of Life, DataOne, GBIF, BioCollections)
- iv. Remote Sensing/Geographical Information Systems and its applications.
- v. Data capture – citizen science, uploading information on portals (e.g. www.indiabiodiversityportal.org).
- vi. Key parameters for conservation (populations reproductive ecology)
- vii. Essential management practices in in-situ and ex-situ Biodiversity Management :
 - a. Management of - Biosphere reserves, National Parks, Sanctuaries, Sacred groves etc.
 - b. Management of Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks etc.

Unit 4. Applications of Biodiversity Informatics

06 Hours

- i. Modeling Ecosystems & Predictions, conservation plans for species/taxa/ecosystem.

- ii. Definitions and concepts of system, sub-system, variables and parameters, systems analysis, modeling and simulation (Lotka-Volterra model).
- iii. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International. (This is important for IPR perspective, gives the student and faculty options for assignments/ assessments, case studies)
- iv. Legal issues in Biodiversity Management & Conservation; Rules for exchange of genetic materials; Case studies -National & International.
- v. Designing & implementing ecological restorations.

PRACTICALS:

60 hours

1. Measurement of species diversity (calculation of Diversity Indices - from data collected on plant species in different areas of the campus.
2. Use of molecular markers for estimating biodiversity (DNA Barcoding).
(Simple case studies and wherever possible experiments can be performed to teach the concept).
3. Blast analyses of selected DNA sequences from the International Gene Banks.
4. Introduction to simulations based on various environmental models.
5. Applications of RS/GIS techniques for species distribution models.
6. Experiential Learning Module: Visit to Biodiversity Parks, study the management and species diversity, based on that prepare a proposal for enhancement/ creation of local Biodiversity Park/Community outreach activities and other attributes.

Suggested Readings:

- Groom MJ, Meffe GK, Carroll CR (2006) Principles of Conservation Biology, 3rd edition, Sinauer Associates.
- Tandon U, Parasaran M, Luthra S (2018) Biodiversity : Law, Policy and Governance, Routledge, India
- Wilson, Edward O., 1993, Diversity of Life. Harvard University Press, Cambridge, MA.
- Wheeler CP, Bell JR, Cook PA (2011) Practical field Ecology: A Project guide, Wiley-Blackwell
- IUCN RED DATA BOOK - <https://portals.iucn.org/library/node/16746>
- <http://biodiversity-informatics-training.org/bi-curriculum/>
- <https://www.tdwg.org/standards/>
- https://methodsblog.com/2015/05/26/beta_diversity/

Additional Resources:

- Saha, G.K. and Mazumdar, S. (2017). Wildlife Biology: An Indian Perspective. PHI learning Pvt. Ltd. ISBN: 8120353137, 978-812035313
- Sinclair, A.R.E., Fryxell, J.M. and Caughley, G. (2006). Wildlife Ecology, Conservation and Management. Wiley-Blackwell, Oxford, UK.
- Singh, S.K. (2005). Text Book of Wildlife Management. IBDC, Lucknow.
- Banerjee, K. (2002). Biodiversity Conservation in Managed and Protected Areas. Agrobios, India.
- Sharma, B.D. (1999). Indian Wildlife Resources Ecology and Development. Daya Publishing House, Delhi.
- www.indiabiodiversityportal.org
- www.johnkyrk.com/evolution.swf
- Magurran, A.E. 2013. Measuring Biological Diversity, John Wiley.
- Primack, R.B. (1998). Essentials of Conservation Biology. Sinauer Associates, Inc. Sunderland, MA.
- Rachel Carson (1962) A Silent Spring, Houghton Mifflin Company .

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE - 10: Plant Tissue Culture

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Plant Tissue Culture DSE-10	4	2	0	2	Class XII pass	Nil

Learning Objectives:

- To impart foundational knowledge of plant tissue culture techniques and their theoretical principles.
- To familiarize students with the historical development and key contributors in plant tissue culture.
- To provide hands-on understanding of media preparation, explant selection, and aseptic techniques.
- To expose learners to advanced applications such as micropropagation, protoplast fusion, and somatic embryogenesis.
- To develop entrepreneurial and research skills for applying tissue culture in agriculture, biotechnology, and industry.

Learning Outcomes:

After successful completion of the course, students will be able to:

- Explain the historical background and basic principles of plant tissue culture, and define key terminology.
- Identify various types of tissue culture media, their components, and their physiological relevance.
- Demonstrate knowledge of sterile techniques, explant preparation, and culture initiation.
- Apply tissue culture methods such as micropropagation, protoplast culture, anther culture, and embryo rescue in crop improvement.

- Evaluate advanced applications like artificial seeds, secondary metabolite production, cryopreservation, and germplasm conservation for commercial and biodiversity goals.

Theory: **30 hours**

Unit 1: Introduction **2 hours**

Historical perspective, Important contributions of Haberlandt, White, Reinert & Steward, Murashige, Skoog, Cocking, Guha & Maheshwari, Morrel & Martin.

Terminologies: Cell culture, organ culture, explant, callus, totipotency, plasticity, regeneration, soma clonal variation.

Unit 2: Techniques of Plant Tissue Culture **6 hours**

Types and composition of Media: Role of nutrients, vitamins, hormones, and supplements in nutrient medium. Composition of Murashige and Skoog's and White's medium. Impact of gelling agents and pH on the nutrient medium.

Collection of plant material, aseptic culture techniques: surface sterilization of tissues (maintenance of aseptic conditions by use of autoclave and laminar flow chamber), filter sterilization, inoculation.

Unit 3: Protoplast culture and Micropropagation **10 hours**

Protoplast isolation (mechanical and enzymatic), culture, purification (viability test) and fusion (spontaneous, induced), selection of fused protoplasts, applications of protoplast culture; Micropropagation: Selection of plant material and suitable explant, methodology, plant regeneration pathways-somatic embryogenesis, organogenesis, difference between somatic and zygotic embryos.

Unit 4: Applications of Plant Tissue Culture **12 hours**

Anther culture, Production of haploids, triploids and cybrids, artificial seeds (production & advantages), embryo rescue, virus elimination, bioreactors for secondary metabolite production; Cryopreservation; Germplasm conservation, Novel sources of variation.

Practicals: **60 hours**

1. To study the equipment used in tissue culture: autoclave and laminar air flow chamber.
2. Preparation of Murashige & Skoog's (MS) medium.
3. Demonstration of sterilization and inoculation methods using leaf and nodal explants of tobacco, carrot, *Datura*, *Brassica*, etc. **(any two)**.
4. Study of anther, embryo and endosperm culture (demonstration/photographs).
5. Study of micropropagation, somatic embryogenesis & artificial seeds (demonstration/photographs).
6. Isolation of protoplasts (demonstration/photographs)

7. Visit to a plant tissue culture facility/ Industry and submission of report.

Suggested Readings:

- Bhojwani, S.S. (1990). Plant Tissue Culture: Applications and Limitations {Elsevier}
- Bhojwani, S.S, Bhatnagar, S.P. (2015). The Embryology of Angiosperms, 6th edition. New Delhi, Delhi: Vikas Publication House Pvt. Ltd.
- Bhojwani, S. S. and Dantu, P. K. (2013). Plant Tissue Culture: An Introductory Text Springer
- Bhojwani, S. S. and Razdan, M. K. (1996). Plant Tissue Culture: Theory and Practice, Revised Edition, Elsevier
- Newmann, Karl-Hermann (2020). Plant Cell and Tissue Culture: A Tool in Biotechnology, 2nd Edition Springer

Additional Resources:

- Park, Sunghun (2021). Plant Tissue Culture: Techniques and Experiments, 4th Edition Elsevier
- Razdan, M. K. (2019). Introduction to Plant Tissue Culture, 3rd Edition CBS / Oxford & IBH
- Smith, R. H. (2013). Plant Tissue Culture: Techniques and Experiments, 3rd Edition {Elsevier}
- Stewart, C. Neal (2016). Plant Biotechnology and Genetics, 2nd Edition Wiley-Blackwell
- Trigiano, R. N. (2011). Plant Tissue Culture, Development, and Biotechnology CRC Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-11): Reproductive Ecology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reproductive Ecology DSE-11	4	2	0	2	Class XII pass with Biology/ Biotechnology	Nil

Learning Objectives :

- To acquaint students about the diversity in floral architecture, floral rewards so that they can correlate the concepts with breeding mechanisms.
- To help them appreciate the adaptive significance of various traits associated with pollination, seed dispersal and seedling recruitment.
- To sensitize students towards challenges faced by flowering plants on account of climate change and other anthropogenic activities.
- To build on the concepts of inbreeding and outbreeding depression, seed ecology and resource allocation.

Learning Outcomes:

After completing this course students will:

- Become familiar with interesting concepts involved in understanding of reproductive ecology such as floral rewards, plant-pollinator interactions and pollinator guilds.
- Have an understanding of intricacies and complexities involved in the reproductive success.
- Will have background knowledge and an opportunity to utilize this knowledge to undertake interdisciplinary research in conservation biology and other allied fields such as plant breeding.

Theory:**30 hours****Unit 1: Floral Ecology****10 hours**

Floral architecture (transitions between symmetrical and asymmetrical flowers,) role of pollination systems (any two examples), Phenology, Sexual systems, (monoecy, dioecy, hermaphroditism, gynodioecious, androdioecious etc.) cryptic sexuality- resource allocation and reproductive allocation, evolution from solitary flowering to inflorescence, floral attractants, and rewards (pollen, nectar, scent, colour)..

Unit 2: Pollination Ecology**8 hours**

Pollination syndromes, (transitions from generalized and specialized pollination system, including mutualistic and non-mutualistic interactions with two examples each), pollinator guilds (concept with two examples); ambophily, pollen banks, pollen mediated gene flow, mating systems, Factors affecting pollen-pistil interactions (abiotic, biotic, and anthropogenic);, inbreeding and outbreeding depression; resource allocation.

Unit 3: Seed Ecology**4 hours**

Dispersal mechanisms (primary and secondary with two examples), viability, dormancy, germination; seedling recruitment; natural seed banks and species survival, seed shadow, seed mediated gene flow .

Unit 4: Reproductive Ecology- Challenges and Contemporary Issues 8 hours

Impact of climate change on sexual reproduction, global pollinator crisis and pollination failure; crop yield reduction, habitat fragmentation and altitudinal shifts; impact of invasive species on native plants and pollinators, Effect of pollution on reproductive biology of plants

PRACTICALS:**60 hours**

1. To study diversity in floral architecture (type of soil, temperature, humidity etc. to be mentioned).
2. To carry out histochemical tests in pollen (proteins, lipids, starch).
3. To study the structure of nectary of any flower available in the campus (through section, whole mount).
4. To analyse nectar volume and composition (using refractometer/chromatography)
5. To study through temporary preparations - types of stigma (dry and wet) and style (hollow and solid).
6. To calculate pollen to ovule ratio and predict the mating system using established literature.
7. Study of species survival (ovule to seed ratio).
8. Effect of antibiotics on pollen germination.

Essential Readings:

- Tandon, R., Shivanna, K.R., Koul, M. (Eds) 2020. Reproductive Ecology of Flowering Plants: Patterns and Processes. Springer LINK
- Shivanna, K.R., Tandon, R. 2014. Reproductive Ecology of Flowering Plants: A Manual. Springer LINK
- Lovett-Doust, J., Lovett-Doust, L. 1988. Plant Reproductive Ecology: Patterns and Strategies: Oxford University Press, USA.
- Rustagi, A., Chaudhry, B. (Eds) 2022. Plant Reproductive Ecology-Recent Advances. Intech Open, London, U.K
- Mangla, Y., Khanduri, P., Gupta, C.K. 2022. Reproductive Biology of Angiosperms: Concepts and Laboratory Methods. Cambridge University Press.

Suggested Readings:

- Spencer C.H. Barrett & Christopher G. Eckert (1990) Current issues in plant reproductive ecology. Israel Journal of Botany 39:1-2, 5-12.
- Nicolson, S.W., Wright, G.A. 2017. Plant–pollinator interactions and threats to pollination: perspectives from the flower to the landscape. Functional ecology 31:22-25
- Hicks, L. 2020. Flowers colors are changing in response to climate change; Pigment changes can make plants less attractive to pollinators. Science News.

**DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-12): Environmental
Biotechnology & Management**

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical/ Practice		
Environmental Biotechnology & Management DSE-12	4	2	0	2	Class XII pass	Nil

Learning Objectives:

The course aims to build awareness of:

- various global and regional environmental concerns due to natural causes and/or human activities.
- different types of pollution and their impacts on the environment.
- existing and emerging technologies that are important in the area of environmental biotechnology to fulfill Sustainable Development Goals.

Learning Outcomes:

After completion of course the student will be able to:

- demonstrate awareness about emerging concerns such as climate change, waste management; biodegradation of xenobiotic compounds; bioremediation, etc.
- relate applications of biotechnology for alleviating the environmental concerns
- appreciate the scientific, ethical and/or social issues
- understand the national and international legislations, policies and role of public participation in Environmental Protection

Theory :

30 hours

Unit 1: Environment

5 hours

Basic concepts and issues, global environmental problems - ozone layer depletion, UV-B, greenhouse effect and acid rain due to anthropogenic activities, their impact and biotechnological approaches for management. Fate of pollutants in the environment, Bioconcentration, Biomagnification.

Unit 2: Microbiology of waste water treatment**7 hours**

Aerobic process - activated sludge, oxidation ponds, trickling filter. Anaerobic process - anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactors. Treatment schemes for waste waters of dairy and sugar industries.

Unit 3: Content: Xenobiotic compounds and their Biotreatment**12 hours**

Organic (Bio degradation of petroleum products and pesticides) and inorganic (heavy metals, phosphates, nitrates). Bioremediation of xenobiotics in environment - ecological consideration, Bioaccumulation and Biosorption of heavy metals, Biopesticides, bioreactors, bioleaching, biomining, biosensors, Bioindicators and Bioprospecting

Unit 4: Legislations, Policies for Environmental Protection and Pollution Management**6 hours**

Stockholm Conference (1972) and its declaration, WCED (1983) and Montreal Protocol - 1987, Kyoto Protocol- 1997. Environmental ethics, Water Pollution (Prevention and Control) Act- 1974, Air Pollution (Prevention and Control) Act-1981, National Environmental Policy - 2006, Central and State Pollution Control Boards: Constitution and power.

PRACTICALS:**60 hours**

1. Study the working and uses of trickling filters and activated sludge in treating waste water through photographs.
2. Study of biomagnification and bioconcentration and its impact on environment through photographs.
3. Study of different xenobiotic compounds (including pesticides (DDT), PAHs, heavy metals (Cr (VI) and Hg), and their effects on Environment.
4. Study of airborne microbes using settle plate method from various sites (classroom, terrace and garden).
5. Prepare compost pits using fruit peels, leaves noting the changes as well as temperature over time for biodegradation.
6. Estimate Cr(VI) concentration in water sample (through diphenylcarbazide using spectrophotometric method).
7. Detect nutrient pollution that causes eutrophication by performing colorimetric estimation of nitrate (using salicylic acid method) and phosphate (molybdenum blue method)
8. A visit to any institute/ industry/ field site to understand the uses of microbes in environmental management and a report to be submitted for the same.

Suggested Readings:

1. De, A. K. (2022). Environmental Chemistry, 10th Edition, New Delhi. New Age International Pvt. Limited

2. Dennis, A., Seal, K.J., Gaylarde, C.C. (2004). Introduction to Biodeterioration, Cambridge University Press
3. Rahman, Z. Thomas, L., (2025) Industrial and Environmental Microbiology. ISBN: 9781032644769. CRC Press
4. Ahmed, N., Qureshi, F.M., Khan, O.Y. (2006). Industrial and Environmental Biotechnology, Horizon Press
5. Rochelle, P.A. (2001). Environmental Molecular Biology, Horizon Press.
6. Jadhav, H.V., Bhosale, V.M. (2015). Environmental Protection and Laws, Himalaya publishing House Pvt Ltd.
7. Trivedi, P. C. (2006). Biodiversity Assessment and Conservation, Agrobios Publ.
8. Rana, S.V.S. (2015). Environmental Biotechnology, Rastogi Publications, India.

Department of Botany

SEMESTER –VIII

(Under UGCF-2022 based on NEP-2020)

S. No.	Contents	Page Numbers
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3	*Pool of Generic Elective Courses (GEs) BOT-GE-09: Intelligent Systems in Plants BOT-GE-10: Informatics and Statistics for Biology and Allied Sciences BOT-GE-13: Plant Biotechnology BOT-GE-18: Genetic Engineering technologies and Applications BOT-GE-20: Genomics, Proteomics and Metabolomics	NA
4	Dissertation on Major/Minor/Academic Project	As per DU guidelines

** The syllabi of the mentioned GE courses have already been approved.*

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

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

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

Learning Objectives:

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

Learning Outcomes:

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

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

Theory:

30 hours

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

7 hours

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

Case studies on plants from algae to angiosperms

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

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

10 hours

Water stress; High light stress; Temperature stress; Hypersensitive reaction; Pathogenesis Related (PR) proteins; Reactive oxygen species (ROS) –Production and scavenging mechanisms; Systemic acquired resistance; Mediation of insect and disease resistance by jasmonates. Photosynthesis: a case study, Lighting the way: Compelling open questions in photosynthesis research, Perspectives on improving photosynthesis to increase crop yield, Air plant genomes shed light on photosynthesis innovation , Alternative electron pathways of photosynthesis power green algal CO₂ capture.

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

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

Unit 3: Genetic and molecular circuitry

05 hours

- a. Molecular motors (Kinesin, dyneins, myosins) and Regulatory RNAs (Attenuators, Riboswitches, siRNAs, miRNAs, lncRNAs, eRNAs), relevant case studies for each.
- b. RNA biology in Plants - Beyond transcription: compelling open questions in plant RNA biology
- c. Small RNA-mediated DNA methylation during plant reproduction.
- d. Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops.

Unit 4: Emerging areas in plant biology and Applied Botany:

8 hours

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

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

PRACTICALS:

60 hours

1. Grow a model organism (of choice) in the college (in vitro cultures / garden / greenhouse etc.)
2. Design and conduct an experiment on the model organism (e.g., Antibiotic sensitivity assay in *E.coli*, oxygen evolution in aquatic plants besides *Hydrilla*)
3. Calculate mitotic index and duration of stages in mitosis in temporary preparation of normal and colchicine treated root tips.
4. Adaptations in plants; study cuticle, stomata, aerenchyma development in plants (micrographs/ temporary sections from available material).
5. ROS scavenging experiment (in case not included in Stress Physiology)
6. Study of embryo mutants, homeotic mutants in floral development (ABCDE model) in *Arabidopsis*.
7. Tools for In silico analysis - KEGG, STRING, Cytoscape,
8. Case studies in integrative approaches to understanding plants :

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

- a. Environmental physiology
- b. Gene regulation circuitry
- c. Stress and adaptation
- d. Plant cell biology
- e. Plant growth and development
- f. Photosynthesis and carbohydrate metabolism
- g. Nutrient uptake, transport and metabolism
- h. Effective resource utilisation (water; assimilates; nutrients)
- i. Root – rhizosphere biology
- j. Reproduction, seed and fruit biology
- k. Defence and protection
- l. Building genomic circuits

SUGGESTED READINGS (Books):

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

SUGGESTED READINGS (Selected Papers):

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

- Ancestral traits and specializations. *American Journal of Botany*, 111(1), e16264. DOI: 10.1002/ajb2.16264.
- Bowman, J.L. (2022). The origin of a land flora. *Nature Plants*, 8(12), pp.1352–1369. doi:<https://doi.org/10.1038/s41477-022-01283-y>.
 - Eckardt et al. (2024) Lighting the way: Compelling open questions in photosynthesis research. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3914–3943, <https://doi.org/10.1093/plcell/koae203>
 - Croce et al. (2024) Perspectives on improving photosynthesis to increase crop yield. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3944–3973, <https://doi.org/10.1093/plcell/koae132>.
 - Willoughby, A.C. (2024) Air plant genomes shed light on photosynthesis innovation. *The Plant Cell*, Volume 36, Issue 10, October , Pages 3897–3898, <https://doi.org/10.1093/plcell/koae213>.
 - Gilles Peltier et al. (2024) Alternative electron pathways of photosynthesis power green algal CO₂ capture. *The Plant Cell*, Volume 36, Issue 10, October, Pages 4132–4142, <https://doi.org/10.1093/plcell/koae143>.
 - Manavella et al. (2-23) Beyond transcription: compelling open questions in plant RNA biology. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1626–1653, <https://doi.org/10.1093/plcell/koac346>.
 - Hiu Tung Chow, Rebecca A Mosher (2023) Small RNA-mediated DNA methylation during plant reproduction. *The Plant Cell*, Volume 35, Issue 6, June 2023, Pages 1787–1800, <https://doi.org/10.1093/plcell/koad010>.
 - Nakayama et al. (2022) Molecular mechanisms underlying leaf development, morphological diversification, and beyond. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2534–254. <https://doi.org/10.1093/plcell/koac118>.
 - Elizabeth A Kellogg. (2022) Genetic control of branching patterns in grass inflorescences. *The Plant Cell*, Volume 34, Issue 7, July 2022, Pages 2518–2533, <https://doi.org/10.1093/plcell/koac080>.
 - D Blaine Marchant, Virginia Walbot (2022) Anther development—The long road to making pollen. *The Plant Cell*, Volume 34, Issue 12, December 2022, Pages 4677–4695, <https://doi.org/10.1093/plcell/koac287>
 - Rudall, P. J. (2021) Evolution and patterning of the ovule in seed plants. *Biological Reviews*, 96(3), 2021, 943-960. doi: 10.1111/brv.12684.
 - Finley, B. K., Mau, R. L., Hayer, M., Stone, B. W., Morrissey, E. M., Koch, B. J., ... & Hungate, B. A. (2022) Soil minerals affect taxon-specific bacterial growth. *The ISME journal*, 16(5), 1318-1326.
 - Franklin, K. A., Sommers, P. N., Aslan, C. E., López, B. R., Bronstein, J. L., Bustamante, E., ... & Marazzi, B. (2016) Plant biotic interactions in the Sonoran Desert: current knowledge and future research perspectives. *International Journal of Plant Sciences*, Volume 177, Issue 3, 2016. Pages 217-234, <https://www.journals.uchicago.edu/doi/pdf/10.1086/684261>.
 - Qamar U. Zaman (2024) Genome-editing: Engineering plants using diverse CRISPR-associated proteins and deregulation of genome-edited crops. *Trends in Biotechnology*, Volume 42, Issue 5; P560-574 May 2024.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-13): Plant Stress Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Plant Stress Biology DSE-13	4	2	0	2	Semester VII	Nil

Learning Objectives:

This course explores the physiological, biochemical, and molecular mechanisms by which plants respond to environmental stresses. It covers abiotic and biotic stress factors, their impact on plant growth and development, and adaptive mechanisms to mitigate stress effects. The course also introduces strategies for improving stress tolerance in crops. The following are the specific objectives of this course:

- Identify key abiotic and biotic stress factors affecting plants and explain the associated physiological, biochemical, and molecular responses.
- Examine plant signaling pathways and adaptive strategies such as avoidance, acclimation, and resistance under stress conditions.
- Gain hands-on experience in plant identification, vegetation assessment, and classification techniques, with emphasis on ecological and agricultural relevance.
- Apply principles from plant physiology, molecular biology, and biochemistry to analyze plant-environment interactions and stress resilience.
- Critically assess transgenic and biotechnological approaches to enhance plant tolerance to climate stress and improve crop productivity.

Learning Outcomes:

At the end of this course students will be able to:

- Identify different types of plant stresses and their effects on plant physiology.
- Understand the molecular and biochemical responses of plants to stress.
- Analyze plant adaptation and tolerance mechanisms under stress conditions.
- Explore strategies to enhance plant resilience against environmental challenges.
- Apply knowledge of plant stress biology in agricultural and environmental contexts.

Theory :**30 hours****Unit 1: Introduction to Plant Stress Biology, Abiotic and Biotic Stresses 15 hours**

Types (abiotic and biotic), Perception, Acclimation vs Adaptation, Phenotypic plasticity.

- Drought stress- Physiological and Biochemical responses, Resistance or Tolerance mechanisms
- Salinity- Osmotic and Cytotoxic effects, Ion homeostasis, Salt-tolerant mechanisms: Developmental and Physiological protective mechanisms-exclusion vs tolerance, Osmoprotectants, Ion transporters, Compatible solutes- glycine betaine, proline
- Temperature - Cold and heat stress (in brief)
- Stress caused by Pathogens, Herbivores, Parasitic plants, Susceptibility and Resistance, PR proteins, Pattern-triggered immunity and Effector triggered immunity (in brief).

Unit 2: Stress Sensing and Signaling Mechanisms**7 hours**

Hormonal regulation (Abscisic acid, Jasmonic acid, Salicylic acid), Reactive Oxygen Species and Nitrous Oxide, Salt Overly Sensitive pathway, Late embryogenesis abundant proteins (LEA), Calcium signaling and binding proteins.

Unit 3: Stress Tolerance Mechanisms**6 hours**

Antioxidant enzymes (Superoxide dismutase, Catalase, Peroxidase), Osmolytes, Secondary metabolites (Alkaloids, Phenolics and Terpenoids), Chaperones (Heat Shock Proteins).

Unit 4: Crop Improvement Strategies**2 hours**

Traditional plant breeding (Mutation breeding, Protected cultivation) and Biotechnological approaches (brief account of stress tolerant genetically engineered plants).

PRACTICALS:**60 hours**

1. To study the effect of salt stress on seed germination percentage.
2. To study the effect of salt stress on plant shoot and root length.
3. To study the effect of stress (any one) on chlorophyll content.
4. To determine electrolyte leakage in stressed plants.
5. To determine SOD or peroxidase enzyme activity in control and stress plants.

Experiments through demonstration (through photographs)

6. To study the plant responses under environmental stress (Stomatal closure, Leaf curling, Root alteration, Stunted plant growth, Wilting).
7. To demonstrate the effect of stress on total protein through 2-D gel electrophoresis profile.
8. To study the effect of stress on plant cell wall and membrane.

9. To study the effect of biotic stress on plants through photographs (necrosis, rotting, nematode attack, SAR).

Suggested Readings:

1. Taiz, L., Zeiger, E., Moller, I. M., Murphy, A. (2018). Plant Physiology and Development, 6th edition. New York, NY: Oxford University Press, Sinauer Associates.
2. Bhatla, S.C., Lal, M.A. (2018). Plant Physiology, Development and Metabolism. Singapore: Springer Nature, Singapore Pvt. Ltd.
3. Giri, B., & Sharma, M. P. (Eds.) (2021). Plant Stress Biology: Strategies and Trends. Springer Nature.
4. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). Biochemistry and molecular biology of plants. John Wiley & sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-14): Immunological Concepts and Applications in Plant Science

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Immunological Concepts and Applications in Plant Science DSE-14	4	2	0	2	Semester VII	Nil

Learning Objectives:

- Comprehend innate and induced plant immune responses. Recognize major plant pathogens—fungi, bacteria, viruses, and nematodes—and study their interactions with host defense systems.
- Examine the molecular and physiological basis of plant-microbe interactions and the dynamic strategies used by both.
- Utilize immunological tools and diagnostics for plant disease management, including detection and characterization of plant pathogens.
- Apply knowledge of plant immunology to develop eco-friendly, sustainable control strategies using beneficial microbes and natural compounds.
- Understand and apply plant immune principles for breeding disease-resistant crops and enhancing plant health.
- Design and conduct laboratory experiments to investigate plant immune responses and assess disease control strategies.

Learning Outcomes:

At the end of this course students will be able to:

- Describe the fundamental principles of plant immunity, including innate and induced defense mechanisms.
- Analyze interactions between plants and pathogens at the molecular and cellular levels.
- Apply immunological methods for diagnosing and managing plant diseases effectively.
- Identify major types of plant pathogens—fungi, bacteria, viruses, and nematodes—and their disease strategies.

- Explain the concept of ISR and its role in enhancing plant defense against diverse pathogens.
- Outline key signaling pathways involved in plant defense, such as MAPK cascades and calcium signaling.
- Integrate knowledge of plant immunity to design eco-friendly and sustainable disease control measures.
- Evaluate the use of plant immunity in breeding disease-resistant crops and applying beneficial microbes or natural products.

Unit 1: (i) Introduction to Immunological Concepts:

10 hours

Basic concepts of immunology, Innate and Acquired (Adaptive) immunity, Human Immune system, Humoral (antibody-mediated) and cellular (cell-mediated) Immunity, Concepts of antigen, epitope, hapten, valence, antibodies (immunoglobulins)- structure, types (IgG, IgM, IgA, IgD, and IgE) and functions, antigen-antibody reaction, antisera and vaccines. Immune system in plants, Comparison between the plant and animal immune system.

(ii) Plant Immunity:

Plant pathogens and pests (viruses, bacteria, fungi, insects, mites and nematodes), Plant-pathogen interactions; Compatible interactions (parasite virulence and host plant susceptibility), Incompatible interactions (parasite avirulence and host plant resistance), non-host and host - resistance, Horizontal and vertical resistance, concept of host range, coevolution of plant defence and pathogen attack mechanisms: the Zigzag Model.

Unit 2: Components of Plant Immunity:

10 hours

(i) Innate Immunity/ Resistance

- **Non-specific or Basal Resistance: Passive (Constitutive defenses)** including pre-existing mechanical defences (cuticle, waxes, lignified cell wall, bark, trichomes, thorns); pre-existing biochemical defences (alkaloids, phenolic compounds, terpenoids, nutrient deprivation, phytoanticipins); **Active (Inducible Defences):** Pathogen-associated molecular patterns (PAMPs), pattern-recognition receptors (PRRs), PAMP-triggered Immunity (PTI). Popular Models of PTI in plants- Flagellin-induced Resistance, Elongation Factor (Ef-tu)-induced Basal Resistance.
- **Pathogen Race-specific resistance:** Molecular Models of specific Host-pathogen Recognition, gene-for-gene or receptor-ligand model (Flor's Model), Pathogen effectors, Intracellular nucleotide-binding leucine-rich repeat receptors (NLRs), Plant Resistance (R) genes, Avirulence (Avr) proteins/ Effectors, Effector-triggered susceptibility (ETS), Effector-triggered immunity (ETI), Hypersensitive response.

(ii) Acquired Resistance : Systemic Acquired Resistance (SAR), Induced Systemic Resistance (ISR)

Unit 3: Signal Transduction Pathways activated during Plant resistance: 5 hours

- Phytohormone signaling: salicylic acid, jasmonic acid, ethylene
- Calcium signaling: Calmodulin (CaM), Calcineurin B-like proteins (CBLs) in *Arabidopsis*
- Mitogen-activated protein kinase (MAPK) Cascades
- The Oxidative burst (ROS)
- Major transcription factor families in plant immunity (WRKY, NAC, MYB, bZIP)

Unit 4: Applications of immunology in Plant Science: 5 hours

Development of disease-resistant crops, enhanced nutrient uptake, engineering enhanced resistance in crops via gene editing (e.g., CRISPR-Cas9), developing novel biopesticides/ biocontrol agents based on induced systemic resistance (ISR), genetic engineering strategies for broad-spectrum resistance by Pseudo-Response Regulator (PRR) and chimeric PRR transgenes. RNAi based antiviral resistance (siRNA).

PRACTICALS 60 hours

1. To study the structure of antibody (diagrammatic and crystal structure) digitally.
2. Study of diseased plants and identification of its causal pathogen based on visually observed symptoms (Viral, bacterial, Fungal - one disease each)
3. Analysis and interpretation of digitally represented zig-zag model
4. Analysis and Interpretation of Western blots
5. Understanding the concept of immunoprecipitation by performing immunodiffusion.
6. To study the antigen-antibody reaction by ABO blood group system and Rh factor
7. Study and applications of immunological techniques: ELISA, Immunodiffusion, Radioimmunoassay.

Suggested Readings:

- Dhia Bouktila and Yosra Habachi (2021) *An Introduction to Plant Immunity*: Bentham Science Publishers, Sharjah, UAE.
- Iakovidis, M., Chung, E. H., Saile, S. C., Sauberzweig, E., & El Kasmi, F. (2023). *The emerging frontier of plant immunity's core hubs. The FEBS journal*, 290(13), 3311–3335. <https://doi.org/10.1111/febs.16549>
- Prescott, L.M., Harley J.P., Klein D. A. (2005). *Microbiology*, 6th edition: McGraw Hill, New Delhi.

Additional Reading:

Agrios, G.S. (2005) Plant Pathology 5th Edition: Elsewhere Academic Press, Amsterdam.

**DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-15): Advances in Genetics,
Genomics and Plant Breeding**

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Genetics, Genomics and Plant Breeding DSE-15	4	2	0	2	Semester VII	Nil

Learning Objectives : This course aims to equip students with advanced knowledge and practical skills in genetics, genomics, and plant breeding to address key challenges in crop improvement.

- Develop a foundational understanding of inheritance, gene interactions, chromosomal behavior, and the application of genomics in identifying gene functions in plants.
- Acquire hands-on knowledge of breeding methods such as hybridization, mutation breeding, marker-assisted and genomic selection for crop improvement.
- Learn to formulate and execute plant breeding programs targeting agricultural challenges like yield enhancement, disease resistance, and abiotic stress tolerance.
- Understand how genetic traits interact with environmental factors to affect plant performance and adapt breeding strategies accordingly.
- Recognize the importance of plant genetic diversity and apply it effectively in breeding programs for sustainable crop development.

Learning Outcomes :

Upon successful completion of the course, students will be able to:

- Understand the core principles of genetics, including inheritance, gene interactions, and chromosomal behaviour.
- Apply genomics to identify genes and analyze their functions in plants.
- Gain hands-on expertise in modern breeding techniques such as hybridization, mutation breeding, marker-assisted selection, and genomic selection.
- Design and implement plant breeding programs aimed at yield enhancement, disease resistance, and abiotic stress tolerance.
- Analyze genotype-environment interactions to optimize plant performance through targeted breeding strategies.

- Appreciate the significance of conserving plant genetic diversity and apply it for sustainable crop improvement.

Theory :

30 Hours

Unit 1: Chromatin Organization and Fine Structure of Gene and Molecular Cytogenetics

06 Hours

Chromatin structure and packaging of DNA: architecture of chromosome in eukaryotes, karyotypes and ideogram. Fine structure of gene (Phage rII locus), cis-trans complementation test. Genome analysis in crops; Utilization of aneuploids (addition, deletion, substitution and nullisomic lines) in gene localization. Evolutionary significance of chromosomal aberrations in crop improvement, molecular cytogenetical tools for identification and structural analysis of genomes, introgression studies and ploidy detection.

Unit 2: Applied Genetics

04 Hours

Applications of molecular cytogenetics: Alien gene transfer studies, gene mapping of agronomic traits and crop improvement in wheat, rice, tomato and cotton. Application of transposons in mutagenesis, genome mapping and evolution. Pedigree analysis and introduction to genetic counselling in humans; ethical, legal and social issues related to genetic analysis.

Unit 3: Current Trends in Genomics, Epigenomics and Metagenomics, Genome Editing Techniques

10 Hours

Gene discovery and deciphering gene function for improvement of crops. Applications of genomics in agriculture, health and environment. Epigenomics: DNA methylation, histone modifications and chromatin remodelling; Epialleles: inheritance and role in genetic regulation. Basic tools for studying epigenomics: Overview of Bisulfite sequencing and ChIP-Seq. Applications in crop improvement and disease management. Introduction to metagenomics; the human microbiome: microbes and health. Environmental metagenomics: role in pollution control and ecosystem management. Introduction to genome editing, CRISPR-Cas9; applications of genome editing in agriculture and medicine. Ethical concerns: Designer babies, GMOs, and genome editing regulations.

Unit 4: Genetic Systems and Breeding Methods and Molecular Breeding

10 Hours

Gene pools (primary, secondary and tertiary), systems of mating, breeding methods for sexually, asexually/clonally propagated crops; self-incompatibility, male sterility and apomixis. Heterosis: types, genetic and molecular basis; Inbreeding. Molecular DNA markers and mapping populations, construction of high-density maps, QTL mapping, Association mapping. Integration of genetic maps with physical maps/chromosomes. Gene tagging, Marker Assisted Selection (MAS), Bulk Segregation Analysis (BSA), Genomic selection and Genome Wide Association Studies (GWAS). Introduction to the statistical tools. Breeding for biotic and abiotic stresses, and

quality traits. Variety development and release of new varieties, Plant breeders and Farmers' rights.

PRACTICALS:

60 hours

1. Preparation of karyotype and ideogram from mitotic metaphase spread and analysis of degree of asymmetry.
2. Study of molecular cytogenetics: identification of progenitor genomes in allopolyploids crops using GISH (wheat, rice, tomato and cotton).
3. Mapping of ribosomal DNA gene using FISH.
4. Localization of Gene introgression using Fiber-FISH/ND-FISH.
5. Pedigree construction and analysis based on inheritance of monogenic traits in humans.
6. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
7. Search for transcription factors linked to abiotic stress (e.g., drought, salinity). Note down their family (e.g., MYB, WRKY), function, and expression pattern.
8. Study of DNA methylation in plants using methylation sensitive enzymes.
9. Exploration of Single Nucleotide Polymorphisms (SNPs) in plants and their role in trait variation using Bioinformatics databases and tools.
10. Demonstration of basic method of selfing, emasculation, hybridization and crossing techniques in field/potted plants.
11. Comparison of characteristic features of released and notified varieties, hybrid and parental lines.
12. Comparison of quality parameters in improved varieties of cereals, pulses and oilseeds.
13. Genetics/Genomics/Plant breeding in News/Societal issues: presentation on a news article. Articles should have been published within last 2 years.

Suggested reading:

- Phundhan Singh (2014). Plant Breeding: Molecular and New Approaches. Kalyani Publishers
- Phundhan Singh (2015). Essentials of Plant Breeding. Kalyani Publishers
- B.D. Singh (2022). Plant Breeding: Principles and Methods, 12th Edition. MedTech Science Press.
- Arthur M. Lesk (2017). Introduction to Genomics, 3rd Edition. OUP Oxford.
- Hartl, D.L., Jones, E.W. (2009). Genetics: Analysis of Genes and Genomes, 7th Edition. Jones & Bartlett Publishers.
- Peter S Harper (2010). Practical Genetic Counselling, 7th Edition. CRC Press.
- Russell, P. J. (2013). iGenetics: A Molecular Approach: Pearson New International Edition. Pearson Higher Ed.
- Griffith et al. (2015). Introduction to Genetic Analysis. W H Freeman & Co.
- Klug, W.S., & Cummings, M.R. (2003). Concepts of Genetics, 7th Edition. Prentice-Hall.
- Pierce, B.A. (2016). Genetics – A conceptual approach, 7th Edition. W H Freeman & Co.
- Snustad D.P. & Simmons, M.J. (2015). Principles of Genetics. John Wiley & sons.
- Hartl, D.L., Jones, E.W. (2009). Genetics Analysis of Genes & Genomes. Jones & Barlett Pub.
- Phillip Meneely (2020). Genetic Analysis: Gene, Genomes, and Networks in Eukaryotes. Oxford University Press.

DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE-16): Genomics, Proteomics and Bioinformatics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Genomics, Proteomics and Bioinformatics DSE-16	4	2	0	2	Semester VII	Nil

Learning Objectives:

- Introduce students to fundamental and emerging concepts in genomics, proteomics, and bioinformatics.
- Familiarize students with analytical tools and real-world applications of omics technologies across agriculture, health, and environmental sectors.
- Explore interdisciplinary fields such as metagenomics, epigenomics, and single-cell genomics and their significance in global problem-solving.
- Develop basic computational skills to utilize bioinformatics databases and tools for data interpretation in genomics and proteomics.

Learning Outcomes:

By the end of the course, students will be able to:

- Explain the principles and applications of genomics in agriculture, human health, and environmental science.
- Understand the concepts of epigenetics and demonstrate familiarity with tools used to study epigenetic modifications.
- Describe metagenomics and single-cell genomics, and their relevance in microbiome analysis and environmental monitoring.
- Understand core techniques and tools in proteomics, including post-MS data analysis, and their translational value.

- Demonstrate knowledge of bioinformatics concepts, databases, and software tools for sequence, structure, and functional analysis of biological data.

Theory :

30 Hours

Unit 1: Genomics and Epigenetics

10 Hours

Genomic concepts: genomes, genes, and non-coding regions, Structure of complexity of eukaryotic genome, Applications in agriculture, health, and the environment, CRISPR-Cas9: A beginner-friendly introduction to genome editing, Genomics ethics: privacy, data sharing, and equity. Epigenomics. DNA methylation and histone modifications, Overview of Bisulfite sequencing and ChIP-Seq, Role of epigenetics in stress adaptation in plants.

Unit 2: Metagenomics and Single-Cell Genomics

5 Hours

Metagenomics: concept and applications, Human Microbiome Project (HMP), Environmental metagenomics: Role in pollution control and ecosystem management. Single-cell genomics: its concept and importance.

Unit 3: Proteomics

7 hours

Overview of Proteomics, Complexity of protein structure (primary, secondary and tertiary), Post translational modifications (phosphorylation, glycosylation), Proteome analysis by 2-D gel electrophoresis, Edman sequencing (Methodology and limitations in protein sequencing) and MALDI-ToF (Matrix-Assisted Laser Desorption/Ionization – Time of Flight), nLC-MS/MS (nano-Liquid Chromatography coupled with Tandem Mass Spectrometry), X-ray crystallography.

Unit 4. Bioinformatics

8 hours

Introduction to bioinformatics: definition and scope, Nucleotide and Protein databases (GenBank, UniProt, PDB), metabolic pathway database (KEGG), Search engines for databases (Entrez and PubMed), File format (FASTA), BLAST, Concept of sequence alignment, molecular phylogeny

PRACTICALS :

60 Hours

1. Virtual Exploration of Plant Genomes:

- 1a. Access a plant-specific genome database (e.g., *Oryza sativa* in Gramene or *Arabidopsis thaliana* in TAIR).
- 1b. Search for a gene of interest (e.g., drought resistance or photosynthesis-related genes).
- 1c. Record details such as gene location, sequence, function, and related pathways.

- 1d. Compare homologous genes between two plant species using BLAST.
2. Study of GenBank and UniProt for the retrieval of nucleic acid and amino acid sequences
3. Sequence homology and gene annotation through BLAST tool.
4. Illumina sequencing through photographs.
5. Explore single nucleotide polymorphisms (SNPs) in plants and their role in trait variation.
6. Predict the structure of protein from its amino acid sequence. (Phyre 2/ Modweb/ CPH model/ Swiss Model).
7. Analysis of protein (s) on 2-D Gels, X-ray crystallography and protein microarray through photographs.
8. *In silico* analysis for PTM, Localization, and functions using the above-mentioned software.
9. Basic handling of data, transcriptome assembly, batch blast, batch primer design, setting up a local blast, basic of genome assembly, and isolation of microsatellites using MISA.

Suggested Readings (Books and Articles):

- Brown, T.A. (2017). *Genomes 4*. Garland Science. *A student-friendly introduction to genomics with clear explanations and examples.*
- Dale, J.W., & Park, S.F. (2010). *Molecular Genetics of Bacteria*. Wiley-Blackwell. *Covers foundational concepts in bacterial genomics and applications.*
- Allis, C.D., Caparros, M.-L., Jenuwein, T., & Reinberg, D. (2015). *Epigenetics*. Cold Spring Harbor Laboratory Press. *(Focus on the introductory sections for basics of DNA methylation and histone modifications.)*
- Pevsner, J. (2015). *Bioinformatics and Functional Genomics*. Wiley-Blackwell. *(Chapters on metagenomics provide a straightforward introduction with practical applications.)*
- Handelsman, J. (2004). *Metagenomics: Application in Microbial Ecology*. ASM Press. *(Focuses on simple and engaging content about microbial diversity studies.)*
- Doudna, J.A., & Sternberg, S.H. (2017). *A Crack in Creation: Gene Editing and the Unthinkable Power to Control Evolution*. Houghton Mifflin Harcourt. *(Written for a general audience, this book explains CRISPR in simple terms.)*
- Regev, A. et al. (2017). "The Human Cell Atlas." *eLife*. *(Overview of single-cell genomics and its goals in mapping human cells.)*
- Varshney, R.K., Roorkiwal, M., & Sorrells, M.E. (2017). *Genomic Selection for Crop Improvement*. Springer. *(Readable sections on GWAS and genomic applications in crop breeding.)*
- Sandel, M.J. (2009). *The Case Against Perfection: Ethics in the Age of Genetic Engineering*. Harvard University Press. *(Simplifies the ethical dilemmas posed by genomics and genome editing.)*

Based on Undergraduate Curriculum Framework-2022

UNIVERSITY OF DELHI
UNDERGRADUATE PROGRAMMES OF STUDY
STRUCTURE, COURSES & SYLLABI OF
SEMESTER –VII AND SEMESTER –VIII
B.Sc. (Hons.) ZOOLOGY

(4th Year of UG as per UGCF-2022 existing)



Department of Zoology
University of Delhi
Delhi-110007

SEMESTER – VII**List of DSC Papers for VII Semester**

Course Title	Nature of the Course	Total Credits	Components		
			Lectures	Tutorial	Practical
Animal Models and Experimentation	DSC- 19	4	2	0	2

List of DSE Papers for VII Semester

Course Title	Nature of the Course	Total Credits	Components		
			Lectures	Tutorial	Practical
Research Methodology for Zoology#	DSE-17	4	3	0	1
Advanced Bio-techniques and Bioinstrumentation*	DSE- 18	4	3	0	1
Ichthyology	DSE- 19	4	3	0	1
Applied Entomology	DSE- 20	4	3	0	1

Research Methodology shall be offered in Semester VI and VII as per the guidelines of University of Delhi. Students planning to pursue a 4 year UG program are advised to choose research methodology in the VI semester.

*Mandatory DSE to be offered in Semester-VII

SEMESTER – VIII**List of DSC Papers for VIII Semester**

Course Title	Nature of the Course	Total Credits	Components		
			Lectures	Tutorial	Practical
Comparative Physiology of Vertebrates	DSC- 20	4	2	0	2

List of DSE Papers for VIII Semester

Course Title	Nature of the Course	Total Credits	Components			Page No.
			Lectures	Tutorial	Practical	
Evolutionary Immunobiology of Animals*	DSE- 21	4	3	0	1	35
Faunal Conservation and Restoration	DSE- 22	4	3	0	1	38
Reproductive Endocrinology	DSE- 23	4	3	0	1	41

***Mandatory DSE to be offered in Semester-VIII**

List of GE Papers for VII Semester

Course Title	Nature of the Course	Total Credits	Components		
			Lectures	Tutorial	Practical
Principles of Developmental Biology	Zoo-GE-17	4	2	0	2
Biology of Animal Cells	Zoo-GE-18	4	2	0	2
Immunology: Understanding the body's defense mechanisms	Zoo-GE-19	4	2	0	2
Concepts of Human Metabolism	Zoo-GE-20	4	2	0	2

List of GE Papers for VIII semester

Course Title	Nature of the Course	Total Credits	Components		
			Lectures	Tutorial	Practical
Neurobiology	Zoo-GE-21	4	2	0	2
Classical and Molecular Cytogenetics	Zoo- GE- 22	4	2	0	2
Concepts of Evolutionary Ecology	Zoo-GE-23	4	2	0	2

STRUCTURE FOR SEMESTER –VII

SEMESTER	DISCIPLINE SPECIFIC CORE COURSE (DSC)	DISCIPLINE SPECIFIC ELECTIVE COURSE (DSEs)
VII	ZOO-DSC-19: Animal Models and Experimentation	Zoo -DSE-18: Advanced Biotechniques and Bioinstrumentation*
		Zoo -DSE-19: Ichthyology
		Zoo-DSE-20: Applied Entomology
		Zoo-DSE-17: Research Methodology for Zoology#

*Mandatory DSE to be offered in Semester-VII

Research Methodology shall be offered in Semester VI and VII as per the guidelines of University of Delhi. Students planning to pursue a 4-year UG program are advised to choose research methodology in the VI semester.

SEMESTER	GENERIC ELECTIVE COURSEs (GEs)
VII	Zoo- GE- 17: Principles of Developmental Biology
	Zoo- GE- 18: Biology of Animal Cells
	Zoo- GE- 19: Immunology: Understanding the body's defence mechanisms
	Zoo- GE- 20: Concepts of Human Metabolism

DISCIPLINE SPECIFIC CORE COURSE -19**Animal Models and Experimentation****Zoo-DSC-19****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical Practice		
Animal Models and Experimentation Zoo-DSC-19	04	02	0	02	As per the Program Eligibility	Basic understanding of Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To acquire an in-depth knowledge of the importance and applications of animal models in scientific research.
- To understand theoretical concepts, ethical principles and legal frameworks governing animal experimentation to assist in comprehending the quick response to pandemics in the form of vaccines.
- To gain theoretical and practical knowledge of experimental techniques using animal models.
- To develop skills to design experiments involving animal models for studies related to diseases, drug testing, and toxicity assessments/ Biomedical research.
- To explore alternatives to animal experimentation and their role in modern research.

Learning Outcomes

By studying this course, students will be able to:

- Have a better understanding of the concepts of the selection criteria, types, and applications of animal models in research.
- Demonstrate competence in handling, restraining, and administering treatments to animals in a humane and ethical manner.
- Analyze and interpret data generated from animal experiments.

- Critically evaluate the ethical considerations in using animals for research and propose alternatives when feasible.
- Design small-scale experiments using appropriate animal models to investigate scientific hypotheses.

SYLLABUS OF DSC-19

THEORY 30 hrs

UNIT 1: Introduction to Animal Models 6 hrs

Definition and Importance, Historical perspective and significance in biomedical research. Types of Animal Models: Inbred, outbred, transgenic, and knockout models. Criteria for Selecting an Animal Model: Relevance to human biology. Ethical considerations.

UNIT 2: Experimental Design and Techniques 10 hrs

Design of Experiments (DoE): Importance of hypothesis-driven research. Sample size estimation and randomization. Tissue collection and processing. Gene Editing in Animal Models: CRISPR-Cas9 and its applications. Creating knockout and knock-in models.

UNIT 3: Application of Animal Models 8 hrs

Disease Models: Oncology - Induced tumour models. Neurological disorders: Alzheimer's and Parkinson's models. Metabolic disorders: Diabetes and obesity models. Infectious diseases: Models for tuberculosis, malaria, and viral infections. Drug Discovery and Toxicology: Role of animal models in preclinical trials. Acute and chronic toxicity studies. Use of animals in stem cell research.

UNIT 4: Ethical and Regulatory Aspects of Animal Experimentation 6 hrs

Ethics in Animal Experimentation: Importance of humane treatment of animals. Principles of the 3Rs: Replacement, Reduction, and Refinement. Regulatory Frameworks: CPCSEA (India) and International Guidelines. Role of Institutional Animal Ethics Committees (IAECs). Good Laboratory Practices (GLP) for animal studies. Alternatives to Animal Testing: *In-vitro* models, organoids, and computational models. Advantages and limitations of alternatives.

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Selection and Handling of Animal Models: Basic handling and restraint techniques for mice, rats, and zebrafish. Observation of behavior and physiological parameters.
2. Techniques in Experimental Research: Induction of disease models, Behavioral testing: Maze and anxiety tests. Sample collection: Blood and tissue collection techniques.
3. Histology and Imaging: Preparation of tissues for histological studies. Basic imaging techniques (e.g., fluorescent microscopy).

4. Ethical Simulations: Case studies on ethical dilemmas. Mock IAEC proposal writing and review.
5. Presentation of Findings - Preparation of Scientific Posters - Oral Presentation Skills for sharing Research Outcomes
6. Project on any topic/ Project report on visit to any research institute/laboratory to for understanding some ongoing research studies using any animal model.

Essential/Recommended readings

1. Guide for the Care and Use of Laboratory Animals – National Research Council 8th Edition, 2011 9 Publisher: National Academies Press; ISBN: 978-0-309-15400-0.
2. Laboratory Animal Medicine 2nd Edition, 2002 Publisher: Academic Press; ISBN: 978-0-12-263951-7– James G. Fox, Bennett J. Cohen, Franklin M. Loew.
3. Principles of Laboratory Animal Science, Revised Edition, 2001, Publisher: Elsevier ISBN: 978-0-444-50612-2– L.F.M. van Zutphen, V. Baumans, A.C. Beynen.
4. Handbook of Laboratory Animal Management and Welfare, 4th Edition, 2013, Publisher: Wiley-Blackwell; ISBN: 978-0-470-65567-1– Sarah Wolfensohn, Maggie Lloyd.
5. Ethics of Animal Research: Exploring the Controversy, 2012, Publisher: MIT Press; ISBN: 978-0-262-01734-6– Jeremy R. Garrett.

Suggested Readings

1. Experimental Design and Data Analysis for Biologists 2002, Publisher: Cambridge University Press; ISBN: 978-0-521-00976-8– Gerry P. Quinn, Michael J. Keough.
2. Animal Models in Biomedical Research, 2010, Publisher: Humana Press; ISBN: 978-1-60761-670-2 – Timothy G. Geary, Aaron Maule (Editors).
3. Alternatives to Animal Testing: New Ways in the Biomedical Sciences, 2008, Publisher: Wiley-VCH; ISBN: 978-3-527-32090-2 – Christoph A. Reinhardt. Laboratory Manual for Animal Research, 1997, Publisher: Oxford University Press; ISBN: 978-0-19-511908-4– Tom L. Beauchamp (*A practical resource for students learning techniques in animal research and experimentation*).
4. CPCSEA Guidelines for Laboratory Animal Facility, 2003 – Committee for the Purpose of Control and Supervision of Experiments on Animals (India).
5. Zebrafish: Methods and Protocols. 2012, Publisher: Humana Press; ISBN: 978-1-61779-597-8 – Allan V. Kalueff, Adam C. Gould.
6. Behavioral Research and Animal Welfare, 2019 Publisher: Springer; ISBN: 978-3-030-13966-1 – Edward Narayan.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -18**Advanced Biotechniques and Bioinstrumentation****Zoo-DSE-18****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Biotechniques and Bioinstrumentation Zoo-DSE-18	04	03	0	01	As per the Program Eligibility	Basic understanding of Zoology

Learning Objectives

The learning objectives of this course are as follows:

- To understand advanced techniques used for research, diagnostics, and industrial applications Biotechnology.
- To learn the principles, applications, and limitations of bioinstrumentation methods.
- To gain hands-on experience in the operation and maintenance of advanced instruments.
- To develop critical thinking to select and apply suitable techniques for solving specific biological problems.
- To learn to interpret experimental data and troubleshoot issues in instrumentation.

Learning Outcomes

By studying this course, students will be able to

- Have a better understanding of the diverse cellular processes and cellular interactions.
- To explain the principles and working mechanisms of advanced instruments in biotechnology.
- To demonstrate proficiency in operating instruments like spectrophotometers, chromatographs, and PCR machines.
- To design experiments using advanced techniques like chromatography, electrophoresis, and mass spectrophotometry.
- To analyze experimental data generated by advanced bioinstrumentation.
- To apply biotechnological tools to solve problems in diagnostics, genomics, proteomics, and drug discovery.

Syllabus of DSE-18**THEORY 45 hrs****UNIT- 1: Spectroscopic Techniques 10 hrs**

Principles and Applications: UV-Visible spectroscopy, Fluorescence spectroscopy, Circular Dichroism (CD). Advanced Techniques: Infrared (IR) spectroscopy, Atomic Absorption Spectroscopy (AAS), and Nuclear Magnetic Resonance (NMR).

Applications: Structure determination, protein folding studies, and biomolecular interactions.

UNIT-2: Chromatography and Electrophoresis 10 hrs

Chromatography: Principles and applications of HPLC, Gas Chromatography (GC), and Ion Exchange Chromatography.

Electrophoresis: Polyacrylamide Gel Electrophoresis (PAGE), Agarose Gel Electrophoresis, 2D Gel Electrophoresis. Applications in genomics and proteomics.

UNIT-3: Molecular Biology Techniques 9 hrs

Polymerase Chain Reaction (PCR): qPCR, RT-PCR, and digital PCR.

DNA Sequencing: Sanger sequencing and Next-Generation Sequencing (NGS).

UNIT 4: Imaging and Analytical Tools 16 hrs

Microscopy: Principles and applications of Confocal Microscopy, Electron Microscopy (SEM, TEM). Mass Spectrometry (MS): Principles, instrumentation, and applications in proteomics and metabolomics. Principles, components, and applications of Biosensors in diagnostics.

PRACTICALS 30 hrs

(Laboratory periods: 15 classes of 2 hours each)

1. Chromatography Techniques: Separation of biomolecules using Chromatography.
2. Electrophoresis Techniques: SDS-PAGE for protein separation.
3. Amplification of DNA. Gel documentation and analysis of PCR products.
4. Imaging Techniques: Demonstration of SEM/TEM.
5. Biosensors: Demonstration of glucose biosensors and ELISA techniques.

Project related to topics covered in Theory/ project report based on visit to labs/institutions/industry.

Essential/Recommended readings

1. Principles and Techniques of Biochemistry and Molecular Biology by Keith Wilson and John Walker, 7th Edition (2010), Cambridge University Press.
2. Biophysical Chemistry: Principles and Techniques by Upadhyay, Upadhyay, and Nath, Revised Edition (2020), Himalaya Publishing.
3. Introduction to Spectroscopy by Donald L. Pavia et al., 5th Edition (2015), Cengage Learning.
4. Bioinstrumentation by John G. Webster, 1st Edition (2004), Wiley-Interscience.

Suggestive readings

1. Fundamentals of Analytical Chemistry by Douglas A. Skoog et al., 9th Edition (2013), Cengage Learning.
2. Molecular Biology of the Gene by James D. Watson et al., 7th Edition (2013), Pearson.
3. Chromatography: Principles and Instrumentation by B.K. Sharma, Revised Edition (2007), Goel Publishing House.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -19**Ichthyology****Zoo-DSE-19****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Ichthyology Zoo-DSE-19	4	3	0	1	As per the Program Eligibility	Basic understanding of Zoology

Learning Objectives

The Learning Objectives of this course are as follows:

- To increase student familiarity with evolutionary history and taxonomic diversity of fishes.
- To improve understanding of the basic physiological and behavioural adaptations of fishes.
- To enhance students' skills in studying locally available fish species.
- To expose students to some of the issues surrounding the conservation of fish biodiversity in the environment.

The Learning Outcomes

The learning Outcomes of this course are as follows:

After studying this course, students can:

- Keep track of types of fishes and their morphology.
- Get detailed knowledge about the physiology of fishes.
- Attain knowledge of various feeding habits, adaptations, parental care, and reproduction of fishes.
- Attain advanced knowledge about the fishes which would be helpful for designing experiments for research.

Syllabus- DSE-19:

THEORY **45 hrs****Unit 1: Introduction to Fishes** **16 hrs**

Introduction and types of fishes, Classification, General Characters, Fish Origin: The diversification and relationships of jawless and jawed fishes, Fish morphology and anatomy: Scales, Teeth, Muscles, Swim-bladder, Gills, Fins, Skull, Weberian ossicles, Lateral-line system.

Unit 2: Fish Physiology **15 hrs**

Gas exchange, Internal transport and Homeostasis- Aquatic and Aerial respiration, Cardiovascular physiology, Hematology, Lymphoid organs, osmoionic regulation, Acid-base balance, nitrogen excretion and metabolism, Sensory systems—photoreception, chemoreception, mechanoreception, electroreception.

Unit 3: Reproduction and Development **8 hrs**

Oviparity and ovoviviparity, Prolific breeders, Fecundity, Induced breeding, Fish larval stages, Parental care in fishes.

Unit 4: Food and Feeding habits of Fishes and their Adaptations **6 hrs**

Fish foods and feeding habits, Adaptations in hill stream and deep-sea fishes, Types of migration in fishes, Abiotic factors and their influence on fish.

PRACTICALS: **30 hrs****(Laboratory periods: 15 classes of 2 hours each)**

1. Identification of local fishes by physical key methods.
2. Study of different types of fish scales.
3. Study of chromatophores of fishes under microscope.
4. Analysis of water quality parameters viz. temperature, pH, dissolved oxygen.
5. Fish Morphometric measurements: Standard length, Total length, Fork length, Dorsal fin height, Pectoral fin length, Ventral fin length, Anal fin height.
6. Study of anatomy of digestive systems among different types of fishes.
7. Gonado-somatic index.
8. Study of Weberian ossicles and otoliths.
9. Visit to local fish market/farm and report preparation.

Essential/Recommended Readings:

1. Biology of Fishes, Bone, Q. and Moore, R., Taylor and Francis Group, CRC Press, U.K.
2. The Physiology of Fishes, Evans, D. H. and Claiborne, J. D., Taylor and Francis Group, CRC Press, UK
3. The Senses of Fish Adaptations for the Reception of Natural Stimuli, von der Emde, R., Mogdans, J. and Kapoor, B. G., Narosa Publishing House, New Delhi, INDIA
4. Ichthyology, Lagler, K.F., Bardach, J.E. and Miller, R.R. John Wiley and Sons Inc., New York, USA
5. A textbook of fish biology and fisheries, Khanna S.S. and Singh H.R. Narendra publishing house, Delhi

Suggested readings:

1. Ichthyology, Karl F. Lagler, John E. Bardach, Robert R. Miller, Dora R. May Passino, Wiley, New York, USA
2. Ichthyology Handbook, Kapoor, B. G., Khanna, B. Springer Science & Business Media, 2004

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -20**Applied Entomology****Zoo-DSE-20****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisites of the course (if any)
		Lectures	Tutorial	Practical / Practice		
Applied Entomology Zoo-DSE-20	4	3	0	1	As per the Program Eligibility	Basic understanding of Insect Biology and Animal World.

Learning Objectives:

The learning objectives of this course are as follows:

- To impart in-depth knowledge about various aspects of the insect world.
- To gain theoretical and practical knowledge of experimental techniques using insects as research models.
- To understand the immense role of insects as ecosystem providers.
- To gain theoretical and practical knowledge of insects as pests and their economic impact.
- To explore pest management measures which are effective, economical and eco-friendly.

Course Learning Outcome:

Upon completion of the course, students will be able to:

- Learn about the fascinating world of insects from a holistic perspective.
- Learn about the biology of insects.
- Understand the difference between various types of beneficial and destructive insects.
- Gain knowledge about important insect pests of crops, fruits, vegetables, stored grains, and of medical importance.

- Analyze the advantages and limitations of the various pest management measures and then design/ customize more effective measures by targeting the lacunae in the existing methods of pest management and by integrating the various aspects of Integrated Pest Management (IPM).

SYLLABUS OF DSE-20

THEORY

45 hrs

Unit 1: Exploring the Fascinating World of Insects.

10 hrs

Overview of the economic importance of insects: Beneficial insects (Honey bees, Silkworm, Lac insect, ecosystem service providers: flesh flies, dung beetles, termites); Insect pests of agricultural crops, stored grains, medical and household; Insects as forensic agents: role of insects/arthropods in criminal investigation by predicting time and cause of death.

Unit 2: Co-evolution of insects and plants

5 hrs

Insect-plant relationships, Mechanisms of insect resistance in plants, Tri-trophic interactions (Plant-insect pest-natural enemies).

Unit 3: Bionomics of Insect Pests

18 hrs

Agricultural Crops and Stored grains: Pest, Economic threshold (ET), Economic injury level (EIL), classification of pests; Identification, seasonal history, nature of damage, life history and control of pests of rice: *Leptocorisaacuta*; pulses: *Helicoverpaarmigera*; Sugarcane: *Scirpophaganivella*; Cotton: *Eariasvitella*; Vegetables: *Raphidopalpafoveicollis*; Fruits: *Papiliodemoleus*, Stored grains: *Sitophilus oryzae*, *Corcyra cephalonica*, *Callosobruchuschinensis*. Medical pests: Mosquitoes, lice, fleas, house fly, cockroach, and termites

Unit 4: Pest Management Methods

12 hrs

Physical, Cultural, Chemical, Biological, Microbial, Genetic (SIT, F₁ sterility, etc.), Biotechnological, and Bio-rational methods (using pheromones, JH mimics, MH agonists, etc.) in pest management. Integrated Pest Management (IPM) and Integrated Vector Management (IVM).

PRACTICALS :

30 hrs

(Laboratory periods: 15 classes of 2 hours each)

1. Study of morphology, growth and development of insect pests

- (a) Rearing of a hemimetabolous [(e.g. Red cotton bug, *Dysdercuskeonigii*)/ holometabolous (e.g. pulse beetle, *Callosobruchuschinensis*)] insect pest in the laboratory. Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.

- (b) Study of life history stages of insect pests of medical and household importance – mosquitoes (*Anopheles*, *Culex*, *Aedes*), lice, sand fly, flea, house fly, cockroach (*any four*). Submission of life cycle stages and details on its biology, economic importance, and appropriate pest management method.

2. Insect Toxicology:

- (a) Estimation of LD₅₀ and LC₅₀ of insecticides using mosquito larvae/ given data.
(b) Pesticide residue analysis of contaminated soil/vegetable/water samples using TLC.

Project work/ Field visits

1. Field survey of beneficial insects and insect pests. Submission of geo-tagged photographs captured in different locations, with details of field observations.
2. Visit to the labs and/or fields. Submission of a field report.

Essential/recommended readings:

1. Atwal, A.S. (1993) Agricultural Pests of India and South East Asia. Kalyani Publishers, New Delhi.
2. Dennis, S. Hill (2005). Agricultural Insect Pests of the Tropics and Their Management, Cambridge University press.
3. Metcalf, C. L., Flint, W.P. and R.L. Metcalf (1962). Destructive and Useful Insects: their habits and control, 4th Ed. Mc Graw-Hill.
4. Pedigo, L. P. (2002). Entomology & Pest Management, Prentice Hall, New Jersey, USA.
5. Service, M. (2012). Medical Entomology for students, Cambridge University Press, UK.

Suggested Readings:

1. S. Pradhan (1998) (Reprint 2023). Insect Pest of Crops. National Book Trust, New Delhi.
2. Schoonhoven, L. M., van Loon, J.A., & Dicke, M. Insect Plant Biology (2005). Oxford University Press, USA.
3. Jolivet, P. (1998). Interrelationship between insects and Plants, CRC Press, USA.
4. Norris, Caswell-Chen and Kogan, M. (2002). Concepts of IPM, Prentice-Hall, USA.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -17**Principles of Developmental Biology****Zoo-GE -17****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Principles of Developmental Biology Zoo-GE-17	4	2	0	2	As per the program eligibility	Nil	Zoology

Learning Objectives**The learning objectives of this course are to:**

- Identify the basic principles of developmental biology
- Understand the mechanisms associated with the development of organ system of the human body
- Acquaint the students with the fascinating transformation of a single cell (fertilised egg) into a fully developed, complex organism.
- Explain the basic principles and concepts underlying morphogenesis.
- Be able to investigate the effects of environmental factors on embryonic development.

Learning Outcomes

By studying this course, students will be able to:

- Understand the process and significance of formation of haploid germ cells
- Interpret the events that lead to formation of a multicellular organism from a single fertilized egg, the zygote.
- Understand the general patterns and sequential developmental stages during embryogenesis; and understand how the developmental processes lead to establishment of the body plan of multicellular organisms.
- Gain knowledge of the general mechanisms involved in morphogenesis and to explain how different cells and tissues interact in a coordinated way to form various tissues and organs.
- Become aware of the effects of pollutants/chemicals on abnormal embryonic development.

SYLLABUS

THEORY **30 Hrs**

UNIT- 1: Introduction and Historical perspectives **2 hrs**

Definition and scope of developmental biology; Importance of embryology in medicine and biology.

UNIT- 2: Gametogenesis, Fertilisation and Morphogenetic movements **18 hrs**

Spermatogenesis and oogenesis; Types of eggs, Egg membranes; Fertilization (External and Internal), Blocks to polyspermy; Planes and patterns of cleavage; Types of Blastula. Gastrulation: Process of Gastrulation in frog and chick. Fate of the three germ layers: ectoderm, mesoderm, and endoderm.

UNIT- 3: Metamorphosis **2 hrs**

Metamorphosis of Amphibian larvae to Adult.

UNIT- 4: Placentation and Teratology **8 hrs**

Types of placenta (shape and structure), Functions of Placenta, Amniocentesis. Teratology: Teratogenesis, Teratogenic agents and their effects on embryonic development.

PRACTICALS **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. Study of whole mounts and sections of developmental stages of frog through permanent slides: Cleavage stages, blastula, gastrula, neurula (Neural plate, Neural fold and Neural tube stages), tail-bud stage, tadpole (external and internal gill stages)
2. Study of whole mounts of developmental stages of chick through permanent slides (Hamburger and Hamilton Stages): primitive streak stage, head process stage, head fold stage, 4-somite stage, 13-somite stage, 16-somite stage, 37-somite stage
3. Types of placenta with the help of photomicrographs/ slides.

PROJECT WORK

Project report on *Drosophila* or any insect culture/Visit to Poultry Farm/IVF Centre.

Essential/recommended readings

1. 1.Slack, J.M.W. (2013) Essential Developmental Biology. III Edition, Wiley-Blackwell.
2. 2.Gilbert, S. F. (2010). Developmental Biology. IX Edition, Sinauer Associates, Inc. Publishers, Sunderland, Massachusetts, USA
3. 3.Balinsky, B. I. and Fabian B. C. (2006). An Introduction to Embryology. VIII Edition, International Thompson Computer Press.
4. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Suggested readings

1. Baweja, V. and Misra, M. (2021). *E-book on Practical Manual of Developmental Biology*.
2. Arora, R. and Grover, A. (2018). *Developmental Biology: Principles and Concepts*. 1st Edition, R. Chand & Company.
3. Carlson, B.M. (2007.) Foundations of Embryology. VI Edition, Tata McGraw-Hill Publishers.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -18**Biology of Animal Cells****Zoo-GE -18****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Biology of Animal Cells Zoo-GE-18	4	2	0	2	As per the Program Eligibility	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Explore the diversity of the cells ranging from unicellular to multicellular organisms
- Explore the different models of the plasma membrane and various modes of transport across them
- Understand the fundamental structure of cell and its various functions.
- Examine the structural details of the cell organelles in relation to their role in the organism.
- Investigate the process of cell division and its relevance in the continuation of the species
- Analyse the various practical techniques to study the cell and its function.

Learning Outcomes

By studying this course, students will be able to:

- Explain the fundamental and functional principles of different types of cells
- Describe the structure and various models of plasma membrane and its role in transport of materials across cells
- Analyze the organizational details of key cell organelles involved in diverse cellular processes.

- Appreciate the characteristics of cellular growth, division, survival and death to regulate these important processes.
- Comprehend the process of cell division and its role in cellular cycle.
- Gain insights into the defects in functioning and regulation of cell organelles leading to diseases.
- Apply practical skills to understand the different cell division methods..

SYLLABUS

THEORY (30 Hrs)

UNIT 1: Types of Cells, Plasma Membrane and Endo-membrane System 13 hrs

Virus, Viroids, Mycoplasma, Prokaryotic and Eukaryotic cells. Different structures and models of plasma membrane, Transport across membranes: active and passive transport, facilitated transport; Cell-cell junctions: Tight junctions, adherens junctions, gap junctions. Endo-membrane system: Structure and Functions: Endoplasmic Reticulum, Vesicular transport from ER to Golgi apparatus; Protein sorting and transport from Golgi apparatus; Golgi apparatus, Vesicular transport: Coated Vesicles; Lysosomes; Peroxisomes.

UNIT 2: Mitochondria 4 hrs

Endo-symbiotic hypothesis; Respiratory chain, Chemi-osmotic hypothesis.

UNIT 3: Cytoskeleton 4 hrs

Microtubules, Microfilaments and Intermediate filaments.

UNIT 4: Nucleus and Cell division 9 hrs

Structure of Nucleus: Nuclear envelope, Nuclear pore complex, Transport of molecules across nuclear membrane, Chromatin: euchromatin, heterochromatin and packaging, nucleosome, nucleolus. Cell division: Mitosis, meiosis and regulation of cell cycle.

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Principles of Microscopy: Compound microscope: Phase contrast microscope; Electron microscope; Differential Interference Contrast (DIC) Microscope.
2. Principle and types of cell fixation and staining; Cell fractionation.
3. Study of prokaryotic cells by Gram staining and eukaryotic cells (cheek cells) by staining with hematoxylin/methylene blue.
4. Study the effect of hypotonic, isotonic, and hypertonic solutions on cell permeability.
5. Preparation of a temporary slide of squashed and stained onion root tip to study various stages of mitosis.
6. Study of various stages of meiosis through permanent slides.

7. Preparation of stained mount to show the presence of Barr body in human female WBCs /cheek cells.

Essential/recommended readings:

1. Cooper, G.M., Hausman, R.E. (2019). The Cell: A Molecular Approach. VIII Edition, ASM Press and Sinauer Associates.
2. Becker, Kleinsmith, and Hardin (2018). The World of the Cell, IX Edition, Benjamin Cummings Publishing, San Francisco.
3. Karp, G. (2015). Cell and Molecular Biology: Concepts and Experiments, VIII Edition, John Wiley & Sons Inc.

Suggested readings:

1. Renu Gupta, Seema Makhija and Ravi Toteja (2018). Cell Biology Practical Manual, Prestige Publishers, New Delhi
2. V. K Sharma (1991). Techniques in Microscopy and Cell Biology, Tata McGraw-Hill Publishing Company Limited, New Delhi.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -19**Immunology: Understanding the body's defense Systems****Zoo-GE -19****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Immunology: Understanding the body's defense System Zoo-GE-19	4	2	0	2	As per the Program Eligibility	Biology in Class 12th	Zoology

Learning Objectives**The learning objectives of this course are to:**

- Describe the general difference between the innate and the adaptive immune system.
- Broadly describe how the innate and the adaptive immune systems mature in the body, how they interact with each other, and how they function in protecting the host from infections.
- Impart an in-depth knowledge on how our immune system fights with infection and foreign substances that can harm our body.
- Acquire knowledge of the immunogenicity of biomolecules.

Learning Outcomes

By studying this course, students will be able to:

- Have an in-depth understanding of the innate and the adaptive immune system.
- Gain experimental skills and techniques frequently used in research in immunology.
- Develop essential skills in experimental design, techniques and execution, which are relevant to immunology.
- Comprehend and analyze the different cellular and humoral components of the immune system.

- Appreciate the contribution of various components of immune system in health and disease including basis of vaccination, autoimmunity, immunodeficiency and hypersensitivity

SYLLABUS

THEORY 30 Hrs

UNIT- 1: Basics of Immunology 5 hrs

History and scope of immunology; Types of immunity: innate and adaptive, Humoral and cell-mediated immunity, Active and Passive immunity; Cells and organs of the immune system, overview of Haematopoiesis.

UNIT- 2: Antigens and Antibodies 7 hrs

Antigenicity, immunogenicity; Structure and types of antibodies; Antigen-antibody interactions (agglutination, precipitation); Monoclonal antibodies production and their therapeutic applications.

UNIT- 3: Immune Response, Mechanisms and Immunological Disorders 11 hrs

Major Histocompatibility Complex (MHC I & II); Exogenous and endogenous antigen processing; overview of Cytokines and complement system. Immunological Disorders: Hypersensitivity reactions (Gell and Coomb's classification); Autoimmunity and autoimmune diseases (e.g., rheumatoid arthritis, thyroiditis); Immunodeficiency (e.g., SCID, AIDS).

UNIT- 4: Applied Immunology 7 hrs

Vaccines and immunization programs; Principles of immunodiagnostics (ELISA, RIA, Western blot); Basics of Immunotherapy; Transplantation

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Study of lymphoid cells and organs in rat/mouse*.
2. Identification of different blood cells using Leishman's/Giemsa/Crystal violet stained blood smear.
3. Blood group determination by ABO kit.
4. Cell counting and viability test (trypan blue dye exclusion test) from splenocytes from rat/mouse/any other species.
5. To understand the antigen and antibody interactions by:

6. Ouchterlony's double immune-diffusion method to study immune-precipitation and interpretation of patterns of identity, non-identity and partial identity.
7. Demonstration of ELISA.
8. FACS

PROJECT WORK

Project on any topic/ Project report on visit to any research institute/laboratory to study the immunological techniques.

Essential/recommended readings

1. Owen, Punt, Stranford, Patricia Jones, Judy Owen (2018). Kuby Immunology (8th ed.). New York, WH: Freeman, ISBN: 978-1319114670
2. Kenneth Murphy, Casey Weaver (2016), Janeway's Immunobiology (9th ed.). Garland Science, ISBN: 978-0815345053
3. Kindt, T. J., Goldsby, R.A., Osborne, B. A. and Kuby, J. (2006) Immunology, VI; Edition, W.H. Freeman and Company.
4. Abul Abbas, Andrew Lichtman, Shiv Pillai (2017). Cellular and Molecular Immunology; Elsevier
5. David, M., Jonathan, B., David, R. B. and Ivan, R. (2006) Immunology, VII Edition, Mosby, Elsevier Publication.

Suggested Readings

1. Peter Parham (2020) The immune System. (5th ed.). Garland Science, ISBN: 978-1285776902
2. Ivan Roitt, Ivan Roitt, and R. M. Hay (2016) Immunology (9th Edition) Blackwell Science.
3. Singh, I. K. and Sharma, P. [Eds.] (2022) An Interplay of Cellular and Molecular Components of Immunology. Taylor & Francis group, CRC Press.
4. Singh, I. K. and Sharma, P. [Eds.] (2022) Essentials of Immunology, Laboratory Manual; Prestige Publishers.
5. Kaur, H., Toteja, R., and Makhija, S. (2021) Textbook of Immunology, I.K International Publishing House and Wiley India Ltd.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -20**Concepts of Human Metabolism****Zoo-GE -20****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Concepts of Human Metabolism Zoo-GE-20	4	2	0	2	As per the Program Eligibility	Biology in Class 12 th	Zoology

Learning Objectives**The learning objectives of this course are to:**

- Understand the concepts of various metabolic pathways.
- Obtain knowledge of the tissue metabolism and its regulation.
- Become conversant with the idea of enzyme specificity in metabolic pathways.
- Learn how the body adjusts to variations in the demand for energy.

Learning Outcomes

By studying this course, students will be able to:

- Comprehend the fundamental concepts of metabolism.
- Better appreciate the importance and functions of carbohydrates, lipids, proteins in human metabolism.
- Comprehend the concept and mechanism of enzyme action and its regulation.
- Appreciate the importance of high energy compounds, electron transport chain, synthesis of ATP under aerobic and anaerobic conditions.

SYLLABUS

THEORY **30 Hrs****UNIT 1: Overview of Metabolism** **4 hrs**

Concept of metabolism: anabolism and catabolism, general introduction of metabolic pathways; Regulation of metabolism (enzymatic and hormonal), compartmentalization of metabolism, Overview of digestion and absorption of carbohydrates, lipids and proteins.

UNIT 2: Metabolism of Carbohydrates **12 hrs**

Glycolysis, Citric acid cycle, Gluconeogenesis, Hexose Monophosphate pathway, Glycogen metabolism.

UNIT 3: Metabolism of Lipids and Proteins **9 hrs**

Lipids: Beta oxidation of fatty acids, Metabolism of Ketone bodies, Metabolism during starvation. Proteins: Concept of Ureotelism, Uricotelism and Ammonotelism, Transamination, Deamination, Nitrogen metabolism, Ketogenic and glucogenic amino acids.

UNIT 4: Electron transport System and ATP synthesis **5 hrs**

Biological Redox systems; Overview of mitochondrial respiratory chain: electron carriers, sites of ATP production, ATP synthesis vis Oxidative phosphorylation; Chemiosmotic THEORY, shuttle systems.

PRACTICALS **60 hrs**

(Laboratory periods: 15 classes of 4 hours each)

1. To qualitatively identify the functional groups of carbohydrates.
2. Estimation of total protein in given solutions by Lowry's method.
3. Separation of amino acids and lipids by chromatography.
4. Study the action of salivary amylase under optimum conditions.
5. To study biological oxidation using goat liver.

Essential/recommended readings

1. Stryer, L., Berg, J., Tymoczko, J., Gatto, G. (2019). Biochemistry (9th ed.). New York, WH: Freeman.
2. Nelson, D.L., Cox, M.M. (2017). Lehninger: Principles of Biochemistry (7th ed.), New York, WH: Freeman Company.

Suggested Readings

1. Voet, D., Voet. J. G. (2013). Biochemistry (4th ed.), New Jersey, John Wiley & Sons Asia Pvt. Ltd.
2. Murray, R.K., Bender, D.A., Botham, K.M., Kennelly, P.J., Rodwell, V.W. and Well, P.A. (2009). Harper's Illustrated Biochemistry. XXVIII Edition, International Edition, The McGraw- Hill Companies Inc.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

SEMESTER –VIII

SEMESTER	DISCIPLINE SPECIFIC CORE COURSE (DSC)	DISCIPLINE SPECIFIC ELECTIVE COURSE (DSE)
VIII	ZOO-DSC-20: Comparative Physiology of Vertebrates	Zoo -DSE-21: Evolutionary Immunobiology of Animals*
		Zoo -DSE-22: Reproductive Endocrinology
		Zoo -DSE-23: Faunal Conservation and Restoration

***Mandatory DSE to be offered in Semester VIII**

SEMESTER	GENERIC ELECTIVE COURSE (GE)
VIII	Zoo- GE- 21: Neurobiology
	Zoo- GE- 22: Classical and Molecular Cytogenetics
	Zoo- GE- 23: Concepts of Evolutionary Ecology

DISCIPLINE SPECIFIC CORE COURSE -20
Comparative Physiology of Vertebrates
Zoo-DSC-20

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Comparative Physiology of Vertebrates Zoo-DSC-20	4	2	0	2	As per the Program Eligibility	Basic understanding of Zoology

Learning objectives:

This course focuses on:

- Understanding the physiological mechanisms that enable vertebrates to adapt and evolve over time.
- Exploring how different vertebrates, from fish to mammals, have developed unique physiological adaptations to meet the demands of their environments.

Learning outcomes:

At the end of this course students should be able to:

- Learn the significance of variations in the digestive system based on different diets.
- Understand the mechanisms of extracting oxygen from the environment using different respiratory structures.
- Appreciate the design of the cardiovascular system in different vertebrates as an efficient gas transport mechanism.
- Appreciate the variations in the reproductive strategies in accordance with the environment.
- Understand the various strategies for maintaining a steady physiological state and respond to extreme environmental conditions.

SYLLABUS**THEORY 30 hrs****UNIT 1: Physiological Processes 10 hrs**

Digestion: Monogastric, digastric and polygastric digestive systems; Respiration: Gills, swim bladder, skin and lungs as respiratory organs; Circulation: Single-circuit and double-circuit circulatory designs.

UNIT 2: Reproduction 6 hrs

Reproductive Cycles in seasonal and non- seasonal breeders.

UNIT 3: Homeostasis 10 hrs

Osmoregulation in freshwater, marine and terrestrial vertebrates. Thermoregulation in poikilotherms and homeotherms.

UNIT 4: Adaptations 4 hrs

Physiological responses to specific environmental challenges, like desert conditions, high altitude and starvation.

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Physiological Response of *Drosophila*/fish/stored grain pests to environmental stressors like temperature extremes/starvation.
2. Comparison of Hemoglobin content of fish blood in fish kept in normal and low-oxygen water.
3. Comparison of blood cells in a blood smear of a fish and human.
4. Study of the Estrous cycle of rats through permanent slides of vaginal smears during different phases of the cycle.

PROJECT WORK

Project report (group activity) on effect of exercise/ yoga/meditation/adequate sleep/excessive mobile gaming on cardiovascular health (Heart rate, BP and SpO2 using pulse oximetry) to be submitted at the end of the semester.

Essential/Recommended Readings:

1. How Animals work by Knut Schmidt-Nielsen, Cambridge University Press
2. Animal Physiology: Adaptation and Environment by Knut Schmidt-Nielsen, Cambridge University Press

Suggested Readings:

1. Animal Physiology by Hill et al, Sinauer Associates Inc.
2. Environmental Physiology of Animals by Willmer et al, John Wiley (original)
3. Principles of General and comparative physiology by Carpenter, W B, Forgotten Books.
4. Experiments with *Drosophila* for Biology courses (ebook) by Lakhotia, SC, Indian National Academy of Sciences.
5. Manual of Experimental Ichthyology by Gahlawat, SK et al, Daya Publishing House.
6. Cardiopulmonary Exercise testing and cardiovascular health by Karlman Waserman, Wiley-Blackwell.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE -21
Evolutionary Immunobiology of Animals
Zoo-DSE-21

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lectures	Tutorial	Practical/ Practice		
Evolutionary Immunobiology of Animals ZOO-DSE-21	4	3	0	1	As per the Program Eligibility	Basic understanding of Animals.

Learning Objectives

The Learning Objectives of this course are as follows:

- To improve basic understanding about evolution of the immune system in different animals and group specific immunological adaptations.
- To increase student understanding about the evolution of complexity in the immune system as well as immunological repertoire among animals.
- To help students analyze immunological manifestations during experimentation and research.

The Learning Outcomes of this course are as follows:

After studying this course, learners can:

- Understand the basic organization of the immune system among different groups of animals.
- Gain knowledge about the evolution of primitive forms of the immune system and their functioning among invertebrates.
- Enhance student proficiency in understanding of immune system organization and their pathology in perturbation.

Unit 1: Evolution of innate immunity:**15 hrs**

Basics of unicellular to metazoan immunity, evolution of immunological armament across the animal phyla, hematopoiesis and functions of hemocytes in invertebrates (Insects, Crustaceans, Molluscs and Tunicates) humoral factors of tunicates. Evolution of *Drosophila* Toll-1 receptors and mammalian Toll-like receptors and antimicrobial host-defense of *Drosophila*.

Unit 2: Evolution of adaptive immunity:**14 hrs**

Origin and evolution of adaptive immunity in animals, a comparative account of lymphocyte development in vertebrates, humoral and cell mediated immunity in vertebrates, recognition of self/non-self, development of immunological memory. Major lymphoid organs and their distribution in fishes, nonspecific defense reaction of fishes. Peripheral lymphoid organs CALT, GALT, BALT, HALT and mural nodules in birds and other vertebrates.

Unit 3: Evolution of Cytokines in Vertebrates**08 hrs**

Evolutionary Diversification of Cytokines. Pro-inflammatory, inflammatory and antimicrobial mediators of vertebrates and their functions.

Unit 4: Major Histocompatibility Complex**08 hrs**

Genomic organization of MHC genes in vertebrates, evolution of Major Histocompatibility Complex in Teleosts.

PRACTICALS**30 hrs**

(Laboratory periods: 15 classes of 2 hours each)

1. Identification of organs of the immune system in Fishes, Amphibians, Aves and Mammals through slides/photographs.
2. Histological study of organs of the immune system of vertebrates.
3. Staining and identification of plasmatocytes of *Drosophila*.
4. Identification of different types of cells in the stained blood smears of Fish/Frog.
5. Study of techniques for the identification and quantification of cytokines and their expression.

Essential/Recommended readings:

1. Evolutionary Concepts in Immunology by Robert Jack, Louis Du Pasquier. Publisher: Springer Nature Switzerland.
2. Evolution and Comparative Immunology of Immune Systems in Marine Organisms by Gyri T. Haugland, Sissel Jentoft, Monica Hongroe Solbakken. Publisher: Frontiers.

Suggestive readings

1. The Evolution of the Immune System Conservation and Diversification by Davide Malagoli. Publisher: Academic Press.
2. Roitt's Essential Immunology by Peter J. Delves, Seamus J. Martin, Dennis R. Burton, Ivan M. Roitt. Publisher: Wiley.
3. Veterinary Immunology by Ian R. Tizard. Publisher: Elsevier.

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC ELECTIVE COURSE 22
Faunal Conservation and Restoration
Zoo-DSE-22

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Faunal Conservation and Restoration Zoo-DSE-22	4	3	0	1	As per the Program Eligibility	Studied Biology at 10+2

Learning Objectives

The Learning Objectives of this course are as follows:

- To understand the faunal diversity in context to the Indian sub-continent, and recognise it as an integral part of global ecosystem.
- To understand theoretical concepts, ethical principles and legal frameworks governing animal conservation.
- To expose students to the various threats to biodiversity.
- To identify contemporary issues related to wildlife conservation such as habitat loss, poaching, climate change, or biodiversity decline.
- To have an in-depth exploration of different strategies used in faunal conservation, such as protected areas, captive breeding, rewilding, or community-based conservation.

Learning Outcomes

After studying this course, learner can:

- Understand the ethical, historical, and cross-cultural context of environmental issues related to fauna.
- Provide novel perspectives or solutions to conserve faunal species.
- Provide proposals for future research, policy changes, or conservation laws.

Syllabus**THEORY 45 hrs****UNIT 1: Fundamentals and Value of biodiversity 8 hrs**

Species diversity, genetic diversity and ecosystem diversity. Faunal biodiversity hotspots of India: Himalayan region, western ghats and north-eastern region. Sentinel species/ environmental guardians. Ecological economics, Ethical values, Evaluating development projects (any project of India).

UNIT 2: Threats to biodiversity 14 hrs

Pollution Ecology: Air, water, soil and radioactive. Emerging contaminants. Habitat destruction, fragmentation and degradation; Overexploitation. Global climate change, acid rain; Invasion Ecology; Ecotoxicology. Wildlife forensics- forensic protocols for species identification from different parts of reptiles, birds and mammals; wildlife crime case studies.

UNIT 3: Conservation and Restoration 15 hrs

Sustainable utilization of natural resources; Bioprospecting; People biodiversity register; Role of indigenous knowledge system; Ecological footprinting; Protected areas; Policies and laws; Environmental impact assessment; GIS and remote sensing. Restoration: Factors involved in implementing ecological restoration: Restoration of major communities; Bioremediation.

UNIT 4: Social issues and environment 8 hrs

Global issues and sustainable development; Biodiversity crisis: how biodiversity is interconnected with ecosystem processes, and it's decline with emphasis on impact on human health. Release of GMOs in the environment.

PRACTICALS 30 hrs

(Laboratory periods: 15 classes of 2 hours each)

1. To study pollutants: phosphate, nitrates, sulphates in the water sample (control and polluted)
2. To analyze and compare phosphorus, nitrogen, organic matter, particle size of the soil samples.
3. To perform toxicological bioassay tests: LC50/ EC50 on organisms such as zooplankton, stored grain pests etc.
4. Study any eight endangered animal species of India with focus on their conservation efforts
5. To study principle of Global Positioning System (GPS) and Geographic Information System (GIS)

PROJECT WORK

Project Report on hypothesizing and designing experiment based on field or laboratory visit

Essential/Recommended Readings:

1. Richard, B. Primack, Essentials of Conservation Biology. (6th edition), Sinauer Associates.
2. Gabriel, M. Biodiversity and Conservation, Oxford and IBH Publishing.
3. Sharma, P.D., Ecology and Environment, Rastogi Publications.
4. Nair, S.M. Endangered Animals of India and their Conservation, National Book Trust of India.
5. Joseph, B., Environmental studies, Tata Mc Graw Hill.
6. Ghosh, S.K., Singh, R. 2003. Social Forestry and Forest Management. Global Vision Pub.
7. Sinha, S. 2010. Handbook on Wildlife Law Enforcement in India. TRAFFIC, India.

Suggested Readings:

1. Mohapatra Textbook of Environmental Biotechnology, IK Publication.
2. Thakur, I. S., Environmental Biotechnology, IK Publication.
3. Divan Rosencraz, Environmental Laws and Policies in India, Oxford Publication.
4. Allabay, M., Basics of Environmental Science, Routledge Press.
5. Rana SVS, Environmental pollution – Health and Toxicology, Narosa Publication.
6. Miller, G.T. 2002. Sustaining the Earth, an Integrated Approach. (5th edition) Books/Cole, Thompson Learning, Inc.
7. Chapman, J.L., Reiss, M.J. 1999. Ecology: Principles and Applications (2nd edition) Cambridge University Press.

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DISCIPLINE SPECIFIC ELECTIVE COURSE 23
Reproductive Endocrinology
Zoo-DSE-23

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Reproductive Endocrinology Zoo-DSE-23	4	3	0	1	As per the Program Eligibility	Basic understanding of Zoology

Learning Objectives

The Learning Objectives of this course are as follows:

- To familiarize students with the reproductive anatomy, physiology and endocrinology of males and females.
- To introduce and discuss the interrelationships between reproductive hormones produced by the brain and reproductive glands and how they interact to control the reproductive processes like pregnancy, parturition and lactation.
- To introduce and discuss reproductive management practices and understand endocrine disorders.

Learning Outcomes

At the end of this course students will be able to:

- Appreciate the reproductive anatomy
- Learn the significance of physiology of the reproductive system, pregnancy and post pregnancy.
- Understand the various reproductive disorders

SYLLABUS- DSE-23**THEORY 45 hrs****UNIT 1: Reproductive Anatomy- Male Reproductive System 10 hrs**

Primary and accessory sex organs and secondary sex characters. Histology of testis. Endocrine functions of testis. Spermatogenesis. Hypothalamic control of testicular functions.

UNIT 2: Reproductive Anatomy- Female Reproductive System 15 hrs

Histology of ovary. Ovarian hormones and their functions. Oogenesis and ovulation. Formation and functions of corpus luteum. Hypothalamic control of ovarian functions. Menstrual cycle and its regulation. Abnormalities in menstrual cycle. Onset of menopause and postmenopausal changes.

UNIT 3: Physiology of Pregnancy, parturition and lactation 10 hrs

Structure and functions of placenta. Maintenance of pregnancy and role of hormones. Development of mammary gland and lactation - role of hormones. Parturition. Pregnancy tests. Development of mammary glands, lactation and their hormonal control.

UNIT 4: Reproductive Disorders 10 hrs

Sexual differentiation & developmental abnormalities – male & female Menstrual disorders – Precocious, delayed or absent puberty; Amenorrhea Fertility disorders – Sexual dysfunction; Infertility; Spontaneous pregnancy loss Pregnancy disorders – Pre-eclampsia, IUGR, Labour abnormalities Endocrine disorders – Hyperprolactinemia Autoimmune Disorders Genetic disorders (mutations and syndromes) Cancers and biomarkers – Testicular; Prostate; Ovarian; Endometrial; Cervical and Breast.

PRACTICALS 30 hrs**(Laboratory periods: 15 classes of 2 hours each)**

1. To study surgical techniques via videos 1. Ovariectomy 2. Castration.
2. Histological and histochemical techniques - Study of the different phases of the estrous cycle of rat using permanent slides of its vaginal smears during the different stages of the cycle..
3. To study sections of ovary, uterus, fallopian tube, testis, epididymis.
4. Study of Sperm count and motility and effect of some antifertility agents.
5. Study of modern contraceptive devices.

PROJECT WORK

Project report on survey of reproductive health in any small human community.

Essential/Recommended Readings

1. Endocrinology, Mac E. Hadley, Pearson Education.
2. Vander's Human Physiology, E.P. Widmaier et al., McGraw-Hill, Higher Education.
3. Endocrinology. Vols.I, II and III by L.O. DeGroot. W.B. Saunders Co.

Suggested Readings:

1. Human Physiology An Integrated Approach by D.U. Silverthorn, Pearson.
2. Medical Physiology, A.B. Singha Mahapatra, Current Books International.
3. "Pathways to Pregnancy and Parturition" (3rd Edition 2012, P. L. Senger)

NOTE: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVE COURSE -21**Neurobiology****Zoo-GE -21****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Neurobiology Zoo-GE-21	2	2	0	2	As per the Program Eligibility	Zoology

Learning Objectives

The learning objectives of this course are to:

- Understand the fundamental structure and function of the nervous system.
- Explore key concepts in Neurobiology in relation to non-zoology disciplines.
- Analyze the relationship between neurobiology and other areas of study.
- Develop critical thinking skills in evaluating neurobiological principles.

Learning Outcomes

By studying this course, students will be able to:

- Comprehend the structure and function of the nervous system, including neurons, glial cells, and synaptic transmission.
- Apply knowledge of neurophysiology, including action potentials, membrane potentials, and sensory-motor systems.
- Analyze the relationship between basic principles of neurophysiology and higher brain functions such as learning, memory, and behaviour.
- Identify and discuss common neurological disorders and their underlying neurobiological mechanisms.
- Evaluate interdisciplinary applications of neurobiology in fields such as psychology, medicine, and technology.
- Develop critical thinking skills through discussions, assignments, and examinations, fostering an understanding of neurobiological principles applicable to non-zoology disciplines.

SYLLABUS**THEORY****30 Hrs****UNIT 1: Introduction to Neurobiology****3 hrs**

Overview of the nervous system and its subdivisions; Structural and functional differences between Neurons and Neuroglial cells; Composition and role of CSF, Blood-Brain barrier.

UNIT 2: Neurophysiology**3 hrs**

Excitability of Neurons; Ion channels and membrane potentials, Generation of Action potentials. Excitatory and Inhibitory post-synaptic potential.

UNIT 3: Neuronal Communication and Higher Brain Functions**14 hrs**

Types of Synapses, Receptors, and Neurotransmitters. Information processing by the nervous system: Sensory receptors and their types; Responses to key sensory stimuli/ impulses: Light (Vision), Smell (Olfactory), Auditory (Hearing), Touch (Tactile) and Taste (Gustatory). Higher Brain Functions: Brain regions and their specialized functions: Learning and Memory, Emotions and Behaviour. Overview of some Neurological Disorders (Alzheimer's, Parkinson's, Schizophrenia, etc.).

UNIT 4: Neurobiology and Interdisciplinary Studies**10 hrs**

Applications of Neurobiology in Psychology, and Medicine: Neural mechanisms in maintenance of Circadian rhythms and their relationship to sleep-wake cycles; Sleep-related disorders: insomnia, sleep apnea, and shift work disorder; Role of sleep in mood regulation, stress (anxiety and depression) management; Mental wellness: Role of lifestyle, mindfulness, and early intervention; Advances in neuroscientific research: Brain imaging tools (EEG, fMRI, PET) Brain-Computer Interfaces (BCIs).

PRACTICALS**60 hrs****(Laboratory periods: 15 classes of 4 hours each)**

1. Microscopic examination of neuron structure using prepared slides.
2. Identification of different types of neurons (e.g., motor neurons, sensory neurons) and glial cells (e.g., astrocytes, oligodendrocytes) under the microscope.
3. Study of Anatomy of the Mammalian Brain (from slaughterhouse) or by using brain models (Plastic or clay anatomical teaching models, graphics, videos, etc. can be used).
4. Histological study of neurons and myelin sheath (Nissl and Luxol Fast Blue staining.)
5. Analysis of neurological and psychiatric disorders (e.g., Alzheimer's, Parkinson's, Schizophrenia) through clinical case vignettes and brain imaging.

Project on any one of the following topics:

1. Reaction Time and Sensory Coordination
2. Sleep Diary and Memory Recall Analysis
3. Case Study on Ethical Implications of BCIs or Neuro-prosthetics

4. Role of Brain Science in Advancing Artificial Intelligence

Essential/recommended readings:

1. Mark F. Bear, Barry W. Connors, and Michael A. Paradiso (2015). Neuroscience: Exploring the Brain. IV Edition.
2. Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (2000). Principles of Neural Science. IV Edition, McGraw-Hill Companies.
3. Kandel, E.R., Schwartz, J.H. and Jessell, T.M. (1995). Essentials of Neural Science and Behavior. I Edition, New York: McGraw-Hill

Suggested readings:

1. Squire, L., Berg, D., Bloom, F. E., du-Lac, S., Ghosh, A., Spitzer, N. C. (2012). Fundamental Neuroscience, IV Edition, Academic Press Publications.
2. Purves, D. et al., (2017) Neuroscience, VI Edition. Oxford University Press.
3. Neuroethics: Defining the issues in THEORY, practice, and policy (2nd edn). Edited by Judy Illes
4. Brain-Computer Interfaces: Principles and Practice (2012). Editors: Jonathan R. Wolpaw, Elizabeth Winter Wolpaw. Oxford University Press

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GENERIC ELECTIVE COURSE -22**Classical and Molecular Cytogenetics****Zoo-GE -22****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Classical and Molecular Cytogenetics Zoo-GE-22	4	2	0	2	As per the Program Eligibility	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Understand the structure of chromosomes and its classification along with the condensation of DNA into chromosomes.
- Explore the transmission of the chromosomes from a generation to the next.
- Explain the organization and complexity of the human genome at the cytogenetic level.
- Investigate the nature of chromosomal abnormalities and related cytogenetic disorders.
- Evaluate appropriately the family pedigree and population and ethnic aspects of inherited disorders.
- Estimate the risk of recurrence of various inherited disorders in affected families.
- Acquire knowledge of the molecular cytogenetic tools which aid in prenatal diagnosis..

Learning Outcomes

By studying this course, students will be able to:

- Describe the condensation process of chromosomes along with their structural details.
- Have an in-depth understanding of chromosome transmission.
- Comprehend and analyze the factors leading to cytological disorders.
- Appreciate the role of genetic counseling in the prenatal stage.

- Develop essential skills for handling of cytogenetic tools such as FISH, PCR, and NSG used in genetic diagnostics.

SYLLABUS

THEORY 30 Hrs

UNIT 1: Introduction to Cytogenetics 3 hrs

Overview of cytogenetics and its historical development. Relationship between genetics, cytogenetics, and cytogenomics.

UNIT 2: Genomes and chromosomes 8 hrs

Cell division: Mitosis, Meiosis, and the Cell Cycle. Sex chromosomes and their determination. Chromosome morphology and structure. Chromosomal aberrations and associated genetic diseases. Epigenetic mechanisms. Genomic analysis techniques.

UNIT 3: Techniques and Molecular Markers Cytogenetics 14 hrs

Principles and applications of cytogenetic tools: Karyotyping, FISH, CGH, DNA microarray, PCR, NGS, and CRISPR-Cas9. Basics of probe design and labelling. Emerging trends in the field. Molecular markers: Microsatellites, Single nucleotide polymorphisms (SNPs), DNA sequencing techniques

UNIT 4: Clinical Cytogenetics 5 hrs

Genome instability and its role in cancers. Genetic counselling and Prenatal diagnosis.

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Demonstration of cell culture techniques.
2. Study of Mitosis and Meiosis using permanent slides and squash techniques.
3. Chromosome staining methods: G-banding
3. Karyotype preparation and analysis of metaphase chromosomes for genetic disorders/abnormalities.
4. To study the methods, principles, and procedures of FISH
5. Demonstration of DNA microarray
6. To study applications of Next-generation sequencing (NGS) in cytogenetics
7. To perform Polymerase chain reaction (PCR) and Primer designing.

Essential/recommended readings

1. Textbook 1. Marilyn S. Arsham and Margaret J. Barch (2017) The AGT Cytogenetics Laboratory Manual, 4th Edition
2. J. McGowan-Jordan and A. Simons (2016) An International System for Human Cytogenomic Nomenclature Reprint of: Cytogenetic and Genome Research, Vol. 149, No. 1-2
3. Rooney D.E., Czepulkowski B.H. (2001) Human Cytogenetics: A Practical Approach. Volume I og II, Oxford University Press.
4. Wolpert, L. (2002). Principles of Development. II Edition, Oxford University Press.

Suggested readings

1. Susan Mahler Zneimer (2014) Cytogenetic Abnormalities: Chromosomal, FISH, and Microarray Based Clinical Reporting and Interpretation of Result
2. Steven L. Gersen and Martha B. Keagle (2004) The Principles of Clinical Cytogenetics

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GENERIC ELECTIVE COURSE -23**Concepts of Evolutionary Ecology****Zoo-GE -23****CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE**

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course	Department offering the course
		Lectures	Tutorial	Practical/ Practice			
Concepts of Evolutionary Ecology ZOO-GE-23	4	2	0	2	As per the Program Eligibility	Nil	Zoology

Learning Objectives

The learning objectives of this course are to:

- Explore the interface of ecological and evolutionary forces that lead to the diversity of the form.
- Understand the function, and behaviour among animals.
- Impart an understanding of the evolutionary origin and drivers of biological variation and diversity, including the significance of genetic variation, natural selection, and genetic drift.
- Unravel the evolution of animals, sexual selection, evolution of mating systems, animal interactions, reaction norms and plasticity.
- Learn about co-evolution between species and ecology from a phylogenetic perspective and compare evolutionary processes behind reproductive and ecological adaptations.
- Understand how communities and species interact with their environment at large-spatial and temporal scales.

Learning Outcomes

- By studying this course, students will be able to :
- Better understand the diverse relationships that the organisms have in the environment.
- Analyze the patterns of distribution of animals in different regions and ecosystems.
- Gain insight into the major events in history of life

- Know the fundamental concepts of natural selection, speciation, mass extinction and macro-evolution.
- Explain the characteristics, dynamics, and growth of populations.
- Appreciate the characteristics of the community, ecosystem development and climax theories.
- Gain knowledge about the relationship of evolution of various species and the environment they live in.

SYLLABUS

THEORY 30 Hrs

UNIT 1: Overview of Evolutionary Ecology 5 hrs

Introduction to the relationship between evolution and ecology, Origin of life: chemogeny and endosymbiotic theory. Natural selection, adaptation and fitness. Ecological adaptations of animals to their environment.

UNIT 2: Population Ecology and Community Interactions 13 hrs

Density, mortality, natality, dispersal and dispersion, life tables, fecundity tables, survivorship curves, age and sex ratios. Population growth- exponential and logistic. Life history traits - r and K selection. Population regulation, positive and negative interactions. Community interactions: Community Characteristics: species richness, dominance, diversity and abundance. Organisation of community– habitat, niche, guilds, and dominant species. Interspecific interactions with examples. Species diversity indices. Categories of ecological succession. Climax community, Concept of keystone, flagship, umbrella species with examples.

UNIT 3: Evolutionary Progressions and Concept of Species 7 hrs

Natural selection and its types, Genetic drift, Artificial selection. Species concept, Isolating mechanisms, Modes of speciation (Allopatric, Sympatric, Parapatric and Peripatric), Adaptive radiation/macroevolution (Darwin's finches).

UNIT- 4: Concept of Coevolution 5 hrs

Forms of coevolution (pairwise coevolution, diffuse coevolution, and gene-for-gene coevolution); Co-evolutionary interactions (Coevolution of competitors, Predator-prey coevolution, Host-parasite coevolution, Coevolution of mutualists); Evolutionary equilibria. Co-speciation and diversification.

PRACTICALS 60 hrs

(Laboratory periods: 15 classes of 4 hours each)

1. Study of an aquatic ecosystem- phytoplankton and zooplankton: Sample collection of specimens from an ecosystem (pond/river/lake/forest/garden) to study its biotic components.
2. Estimation of turbidity/penetration of light, temperature, Dissolved Oxygen content (Winkler's method), determination of pH.
3. Determination of population density in a natural/hypothetical community by quadrat method and calculation of Shannon-Weiner diversity index for the same community.
4. Plotting of different types of survivorship curves from the provided life tables of the hypothetical/real data.
5. Understanding the homology, analogy and homoplasy from suitable specimens.
6. Construction of cladograms based on morphological characters.
7. Study and verification of Hardy-Weinberg Law by Chi-square analysis

PROJECT WORK

Project report based on the visit to the natural history museum/National Park/Biodiversity Park/Wildlife Sanctuary.

Essential/recommended readings

1. Futuyma, Douglas and Mark, Kirkpatrick (2017) 3rd Ed. Evolutionary Biology, Oxford University Press
2. Hall, B.K. and Hallgrimson, B. (2013) Evolution; 5th Edition, Jones and Barlett Publishers.
3. Zimmer C. and Emlen D. J., (2013) 1st Ed. Evolution: Making Sense of Life, Roberts & Co.
4. Chapman, J., and Reiss, M. (2012). Ecology Principles and Applications; Cambridge University Press.
5. Odum, E. P. and Barrette, G. W. (2008) Fundamentals of Ecology; 5th Indian edition; Brooks/Cole
6. Miller, T., and Spoolman, S. (2008) 12th Edition Environmental Science- Problems, Concepts and Solutions; Thomson Brooks/Cole.

Suggested readings

1. Smith T. M. and Smith R. L. (2015). Elements of Ecology. 9th International Edition. Publisher: Benjamin Cummings.
2. Ridley, M. (2004). Evolution. III Edition, Blackwell publishing.
3. Southwood, T. R. E., & Henderson, P. a. (2000). Ecological Methods, 3rd Edition; Blackwell Science Ltd. (Vol. 278, Issue 5705).

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Based on Undergraduate Curriculum Framework 2022

UNIVERSITY OF DELHI

UNDERGRADUATE PROGRAMMES OF STUDY

STRUCTURE, COURSES & SYLLABI OF SEMESTER -VII



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Geology

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

**Bachelor of Geology (Honours with Research/Academic Project/Entrepreneurship) or
(Honours with Research in Geology (Major) with Discipline 2 (minor))**

Structure of VIIth Semester in Geology

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhancement Course (AEC) – 2 credits	Skill Enhancement Course (SEC) – 2 credits	Value addition course (VAC) 2 credits		Total Credits
VII	DSC-19 (4) Crustal Evolution through time (L3, T1)	3 DSE (12) i) Marine microfossils and biostratigraphy (L3, P1) ii) Earthquake Geology (L3, P1) iii) Environmental Geology (L3, P1) Or 2 DSE (8) + 1 GE (4) Or 1 DSE (4) + 2 GE (8)	GE: Geoheritage and Geotourism (L3, T1)	NA	NA	NA	Dissertation on major (6) Or Dissertation on minor (6) Or Academic Project/Entrepreneurship (6)	22 credits

A student who pursues an undergraduate programme with Geology as a single core discipline is offered the following courses:

1 Discipline Specific Cores (DSCs) - 4 credits (offered by the parent Department i.e., Department of Geology)

3 Discipline Specific Electives (DSE) – DSE course in Semester VII (offered by the parent Department i.e., Department of Geology as choice-based electives- 12 Credits)

Generic Elective (GE) – 4 credits each (To be chosen from the common pool of GE courses offered by Departments other than the parent Department)

Dissertation on major (6) **Or** Dissertation on minor (6) **Or** Academic Project/ Entrepreneurship -6 credits

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DISCIPLINE SPECIFIC CORE COURSE - DSC-19
Crustal Evolution through Time

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-19 Crustal Evolution through Time	4	3	1	0	12th pass with science	Studied Earth System Science and Equivalent

Learning Objectives

1. To understand the origin and early differentiation of the Earth using geochemical and geochronological proxies.
2. To study the formation and significance of early crustal rocks such as TTG suites and greenstone belts.
3. To analyze the evolution of Earth's atmosphere, hydrosphere, and lithosphere including major events like the Great Oxidation Event (GOE).
4. To examine supercontinent cycles and regional crustal evolution with special focus on the Indian craton and the Himalayas.

Learning Outcomes

After completing the course students will be able to:

1. Explain the origin and differentiation of early Earth using mineral evolution, geochemical, and geochronological proxies.
2. Identify and analyze the formation of TTG suites, greenstone belts, and their role in early crustal tectonics.
3. Describe the Archean-Proterozoic transition, including the Great Oxidation Event, and relate it to early Earth dynamics and environmental evolution.
4. Interpret supercontinent cycles and assess crustal evolution in global and regional contexts, with a focus on the Indian craton and the Himalayas.

THEORY

(45 hours)

UNIT – I

(10 hours)

Origin of the Earth and initial Earth: common perceptions. Evolution of minerals and early differentiation. Geochemical and geochronological proxies

UNIT – II

(10 hours)

Origin of Tonalite-trondhjemite-granite (TTG) suite of rocks and granites. Greenstone belts and related tectonics

UNIT – III

(12 hours)

Geological time scale and Archean-Proterozoic boundary; Evolution of early atmosphere and hydrosphere; Great Oxidation Event (GOE), Early geodynamics of the Earth; initiation of plate tectonics and related debates

UNIT – IV

(13 hours)

‘Supercontinent’ cycles, crustal evolution and proxies. Drawing link between evolution of lithosphere, atmosphere, hydrosphere and biosphere.

Crustal evolution of the Indian craton, The Himalayas: evidence of dynamic crustal evolution

Tutorial:

(15 Hours)

Exercises related to theory. Petrogenetic plots, Tectonic discrimination diagrams

Essential/recommended Readings

Plate Tectonics and Crustal Evolution by Kent C. Condie 4th Edition Oxford: Butterworth/Heinemann

Suggestive Readings

Plate Tectonics and Crustal Evolution by Kent C. Condie 4th Edition Oxford: Butterworth/Heinemann

Discipline Specific Elective 3 DSE (12 credits): (i) Marine microfossils and biostratigraphy (L3, P1), (ii) Earthquake Geology (L3, P1), (iii) Environmental Geology (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-5 Marine microfossils and biostratigraphy	4	3	0	1	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives

This course aims to:

- Introduce students to the role of microfossil evolution in establishing relative time within marine sedimentary sequences.
- Enable students to understand the distribution of marine microfossils in oceanic sediments.
- Train students to apply biostratigraphic zonation, quantitative stratigraphic correlation, and magnetic stratigraphy for interpreting relative ages.
- Teach students various methods for integrated stratigraphic correlation at regional and global scales.
- Provide training in integrated stratigraphy, including biostratigraphy combined with magneto-, chemo-, event stratigraphy, and its calibration with the astronomical time scale.

Learning outcomes

Upon successful completion of the course, students will be able to:

- Use microfossil distributions in deep-sea cores to apply biostratigraphic zonation and interpret relative geological age.
- Correlate oceanic sediment sections from one region of the world to another and calculate rates of sediment accumulation.
- Independently conduct biostratigraphic studies of marine sections and evolve integrated stratigraphic frameworks.
- Perform stratigraphic correlation of marine sections at regional and global levels.

- Understand and interpret the cause-and-effect relationships in the ocean–climate system and recognize teleconnections.

THEORY

(45 Hours)

UNIT – I

12 Hours

Definition and scope of Micropaleontology. Relationship of Micropaleontology with Ocean Science. Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Program (IODP) and its aims and objectives; Sampling Modern Ocean Biogenic Flux including Joint Global Ocean Flux Studies (JGOFS). Introduction to important Deep Sea Drilling Vessels like Sagar Kanya, GLOMAR Challenger, JOIDES Resolution and Chikyu.

UNIT – II

12 Hours

Sample processing techniques and brief idea about Equipment like mass spectrometer, scanning electron microscope and stereo zoom binocular microscope which are used for micropaleontological studies.

UNIT – III

11 Hours

A brief study of various types of microfossils including calcareous (Foraminifera, Calcareous nannofossils, Ostracoda, Pteropods, Calpionellids and Calcareous algae), Siliceous microfossils (Diatoms, Radiolaria and Silicoflagellates), Phosphatic microfossils (Conodonts) and Organic walled microfossils (Acritarchs and Dinoflagellates, Pollens and spores) and their application in biostratigraphy.

UNIT – IV

10 Hours

Application of microfossil biostratigraphy in hydrocarbon exploration. Basic concepts of Biostratigraphy, Chemostratigraphy, magnetostratigraphy, and astronomical tuning. Regional and global stratigraphic correlation. Diachronism and methods to identify the extent of diachronism. Diachronism and paleoceanographic interpretation.

PRACTICALS:

30 Hours

1. Techniques of separation of microfossils from the matrix
2. Microscopic identification of (a) Types of microfossils: Calcareous, Siliceous, Phosphatic and organic-walled microfossils
3. Microscopic study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy
4. Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India
5. Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and the Pacific Ocean
6. Exercises on Integrated Oceanic Biostratigraphy for regional and global correlation.

Essential/Recommended readings

Bignot, G, 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham & Trotman, London, United Kingdom.

Braiser, M.D., 1980. Microfossils, George Alien and Unwin Publisher.

Fischer, G and Wefer, G, 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer,

Recommended readings

Gross, M.G, 1977. Oceanography: A view of the Earth, Prentice Hall.

Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.

Haslett, S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.

Jones, R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.

Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross, USA. 9.

Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-6 Earthquake Geology (L3, P1)	4	3	0	1	12 th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives

This course aims to:

- Highlight the unpredictability and catastrophic impact of earthquakes on human life and infrastructure.
- Emphasize that a significant portion of the population in India and globally is at risk from earthquakes.
- Explain how mitigation strategies such as: Earthquake microzonation, Earthquake-resistant design etc. can help reduce earthquake-related vulnerabilities.
- Provide foundational knowledge in earthquake science for students interested in: Earth sciences, Seismology, Disaster management, Geotechnical engineering and related fields.

Learning outcomes

Upon completing the course, students will be able to:

- Understand the basics of earthquake sources, their size, and how they are determined.
- Distinguish between different types of earthquake waves, their properties, and hazard potential.
- Explain the influence of geological structures and processes on earthquake hazards.
- Gain an introductory understanding of advanced techniques for crustal deformation measurement used in earthquake analysis.
- Learn and apply basic disaster-related terminology and recognize its significance.
- Identify and assess secondary hazards associated with earthquakes (e.g., landslides, tsunamis, liquefaction).

THEORY

(45 Hours)

UNIT – I

(10 Hours)

Earthquake definition and parameters: Earthquake definition and sources. Earthquake parameters- epicenter, focus, magnitude and intensity.

UNIT –II

(10 Hours)

Seismic waves and instrumentation: Types of seismic waves- body waves and surface waves; Seismograph and seismogram; Determining the epicenter and magnitude. Ground motion parameters: peak ground acceleration (PGA).

UNIT –III

(12 Hours)

Seismotectonics: Plate-boundaries and earthquakes, Style of faulting, active faults, Earthquake source zone in Indian subcontinents. Historical large earthquake of India.

UNIT –IV

(13 Hours)

Geodetic measurement of crustal deformation: Geodetic data/measurement of interseismic deformation, trilateration, SAR interferometry of earthquake.

Earthquake hazard and mitigation measures: Concepts of earthquake Hazard and Risk and disaster, Secondary hazards of earthquake: liquefaction, landslides, Avalanches, Tsunami; seismic hazard zonation, basics of earthquake safety: safety of structure; awareness.

PRACTICALS:

30 hours

Earthquake size determination and calculation: Calculation of earthquake magnitude and intensity. Identification of different phases of earthquake wave in seismogram. Calculation of epicenter location using triangulation method. Earthquakes and plate boundaries: Plotting of important earthquake epicenters on the tectonic map. Plotting of seismic source zones and important historical earthquakes of India. Plotting fault plane solutions.

Essential Readings

- Lowrie, W., (1997). Fundamental of Geophysics. Cambridge University Press. The Edinburgh Building, Cambridge CB2 8RU, UK
- Kayal, J.R., (2008). Microearthquake Seismology and seismotectonics of south Asia. Springer. Capital Publishing Company, New Delhi

Recommended Readings

- S. Stein and M. Wysession. (2003). An Introduction to Seismology, Earthquakes, and Earth Structure. Blackwell Publishing, Boston; ISBN 0-865-42078-5.
- Yeats, R.S., Sieh, K. and Allen, C.R., (1997). The Geology of Earthquakes. Oxford University Press

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-7 Environmental Geology	4	3	0	1	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives :

The course aims to:

- Equip students with an understanding of the interactions between geologic processes, ecological processes, and society.
- Emphasize that the future standard of life and quality of living will be influenced by how Earth's resources are utilized.
- Introduce the concept of environmental geology as the application of geologic information to understand and manage the interactions between people and the physical environment.

Learning Outcomes :

Upon completing the course, students will be able to:

- Understand the basic concepts and principles of physical and environmental geology, with a focus on Earth materials and processes.
- Gain knowledge about natural hazards and their relation to the geologic environment.
- Develop a clear understanding of the relationship between natural resources and pollution.
- Attain a systematic understanding of environmental management concepts as they relate to geology, in areas such as: Waste management, Environmental health, Global change, and Environmental assessment.

THEORY

(45 Hours)

UNIT – 1:

(12 hours)

Concept and definition of Environmental Geology. Components of Earth System and their mutual inter-relations and interactions (atmosphere, hydrosphere, lithosphere and biosphere).

Concept of biodiversity

UNIT – 2:

(13 hours)

Earth Processes and Natural Hazards: Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. Seismic hazard maps. Impact of seismic hazards on long and short term environmental conditions. Mechanism of landslides, causes of major floods, Coastal hazards, cyclones and storms

UNIT – 3:**(10 hours)**

Resources and Pollution: Soil degradation and changing land use pattern. Soil contamination due to urbanization, industrialization and mining. Water pollution: Impact assessment of water availability, quality and contamination of surface water and groundwater. Major Water Pollutants, Surface-Water Pollution and Treatment, Groundwater Pollution and Treatment, Water-Quality Standards, Wastewater Treatment, Air pollution: Introduction to Air Pollution, Pollution of the Atmosphere, Sources of Air Pollution, Air Pollutants, Urban Air Pollution, Indoor Air Pollution, Control of Air Pollution, Air Quality Standards, Deforestation

UNIT – 4:**(10 hours)**

Environmental management: Global Climatic Change, Anthropogenic influence on environment, Basic tenets of environmental laws. Environmental Protocols. Environmental Planning: Site Selection Environmental Impact Analysis and Use and Planning

PRACTICALS**(30 hours)**

Study of maps of seismic zones, earthquake-prone, landslide-prone and flood-prone areas in India. Methods of water analyses for physical, chemical and biological parameters.

Classification of groundwater for use in drinking and industrial purposes. Evaluation of environmental impact of air pollution, groundwater pollution, landslides, deforestation.

Essential Readings:

- Valdiya, K.S., 2013. Environmental Geology – Ecology, Resource and Hazard Management, 2nd Edition, McGraw Hill (Education) Pvt. Ltd. India.
- Richards J.S., 2013. Environmental Geology. 2nd Edition, McGraw-Hill Science Engineering
- Smith, K., 2013. Environmental Hazards. Assessing Risk and Reducing Disaster, 6th Edition, Routledge, London.
- Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International
- Kellar, E. A. 2017. Introduction to Environmental Geology. 5th Edition, Pearson

Recommended Readings:

- Botkin, D.B. and Keller, E. A. Environmental Science: Earth as a Living Planet, 9th Edition, Wiley.
- Merritts, D., de Wet, A. and Menking, K. 1998. Environmental Geology: an earth system science approach. W.H. Freeman & Co., N. Y.
- Keller, E.A, DeVecchio, D.E and Blodgett, R.H., 2019. Natural Hazards: Earth's Processes as Hazards, Disasters, and Catastrophes 5th Edition, Routledge, London.

GE-7: Geoheritage and Geotourism (L3, T1)

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-7 Geoheritage and Geotourism	4	3	1	0	12 th Pass	Nil

Learning Objectives

This course aims to:

- Consider strategies to sample, understand, and address geoconservation and geotourism issues.
- Develop the skills and knowledge to: Conduct and curate (geo) heritage inventories, Assess prospective sites for geotouristic and geoeducational purposes, Propose new geotouristic experiences and Develop materials for geoconservation and geotourism consumers and operators
- Offer an applied learning experience where students learn to combine and optimize tourism potential of spectacular geological features.

Learning Outcomes

Upon completion of the course, students will be able to:

- Learn, distinguish, and identify potential geological sites of tourist interest.
- Recognize and assess: Spectacular geosites such as geomorphic landforms and structural features; Intrinsic geosites including major time boundaries, fossil sites, large igneous provinces (LIPs), transgressions, and regressions
- Understand the economic aspects of geotourism.
- Learn to link geospots with other tourist destinations to develop thematic geotourism experiences.

THEORY

(45 Hours)

UNIT – I

(9 Hours)

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of geoheritage in relation to other historical heritages, Tourism and its different forms and their interrelations, Geotourism: definition, characteristics and international/national perspectives, Eco-tourism and Geo-tourism, Defining the geoheritage sites and the concept of Geoheritage parks (UNESCO guidelines). Geographical context and contemporary geoheritage challenges, Geoheritage inventory of India and its curation context, legal framework of geoheritage, Relevance of geoheritage to Sustainable Development Goals (SDG).

UNIT – II

(9 hours)

Education as a key tenet of geotourism and Earth Science Education & Geotourism

Geoheritage and public geoliteracy: opportunities for effective geoscience education within geosites Earth Science Museums and their role in promotion of Geotourism

Examples of Geotourist sites from India - e.g. Glacier features, Ox-bow lakes, Deltas etc.

UNIT – III

(10 Hours)

Geotourism, Society and Sustainability: Public–private partnership framework for sustainable geopark development. Geotourism—a focus on the urban environment including historical Geotourism. Geotourism and cultural heritage. Potential of Geotourism in Economic development of any region. Role of Tourism sector in terms of world economy/ Indian economy. Role of Geotourism in Tourism industry with special reference to Indian scenario Entrepreneurship and start-up.

UNIT – IV

(17 Hours)

Geotourism and geoparks: UNESCO Global Geoparks and Geoconservation

Geo site developed by Geological Survey of India. The application of geographical information systems in geotourism. Geotourism potential of the Indian geoheritage sites- societal and economic context including case studies

Geoheritage in Indian Context: Study of Geological Map of India

Plotting the established geosites, geoparks and geo monuments of India on map.

Plotting geosites, geoparks and geo monuments on map of World. Detailed study of geosites of India- Locality, Approach, Geological importance and foot fall. Five Case studies from India where geosites can be developed.

Tutorial

(15 hours)

Students in different batches or groups will be given exercises to prepare short reports about the life evolution and extinction through different geological times on Earth.

Essential/recommended readings

- T.A. Hose (Ed.) (2016). Appreciating Physical Landscapes: Three Hundred Years of Geotourism, Geological Society Special Publication No. 417, London.
- Thomas A. Hose (Ed.) (2016). Geoheritage and Geotourism- a European Perspective, Boydell Press Woodbridge, UK
- Ross Dowling & David Newsome (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.
- A monograph on National Geoheritage Monuments of India. Indian National Trust for Art
- and Cultural Heritage (INTACH) Natural Heritage Division, New Delhi (2016).
- National Geological Monuments. Geological Survey of India, Kolkata, Special Publication No. 6 1 (2001)

- Kale, V.S. (ed.) (2014). Landscapes and Landforms of India, Springer, Dordrecht.
- C. V. Burek and C.D. Prosser (Eds.) (2008) History of Geoconservation Special Publication 300, Geological Society of London

Suggestive readings

- Young C.Y. Ng. &Yunting Lu (2015). The Principles of Geotourism, Anze Chen, (Springer).
- Dowling, R. & Newsome, D. (Eds) (2018). Handbook on Geotourism, Edward Elgar Publishing.
- National Geological Monuments. (2001) Geological Survey of India, Kolkata, Special Publication No.61
- Burek, C.V. & Prosser, C.D. (Eds.) (2008). History of Geoconservation Special Publication 300, Geological Society of London.
- Santangelo, N. and Valente, E. (Eds.) (2020). Geoheritage and Geotourism Resources, MdpiAG

COURSES OFFERED BY DEPARTMENT OF Geology

Category I

Geology Courses offered for UG Programme of study with Geology as single core discipline

**Bachelor of Geology (Honours with Research/Academic Project/Entrepreneurship) or
(Honours with Research in Geology (Major) with Discipline 2 (minor))**

Semester	Core (DSC) 4 credits	Elective (DSE) 4 credits	Generic Elective (GE) 4 credits	Ability Enhancement Course (AEC) – 2 credits	Skill Enhancement Course (SEC) – 2 credits	Value addition course (VAC) 2 credits		Total Credits
VIII	DSC-20 (4) Advanced analytical and computational techniques in geoscience (L3, P1)	3 DSE (12) i) Mineral Resources and Economics (L3, P1) ii) Applied Stratigraphy (L3, P1) iii) Techniques of Sample collection & processing in Geology (L3, T1) Or 2 DSE (8) + 1 GE (4) Or 1 DSE (4) + 2 GE (8)	(GE: Groundwater management and water quality (L3, P1))				Dissertation on major (6) Or Dissertation on minor (6) Or Academic Project/ Entrepreneurship (6)	22 credits

Structure of VIIIth Semester in Geology

A student who pursues an undergraduate programme with Geology as a single core discipline is offered the following courses:

1 Discipline Specific Cores (DSCs) - 4 credits (offered by the parent Department i.e., Department of Geology)

3 Discipline Specific Electives (DSE) – DSE course in Semester VII (offered by the parent Department i.e., Department of Geology as choice-based electives- 12 Credits

Generic Elective (GE) – 4 credits each (To be chosen from the common pool of GE courses offered by Departments other than the parent Department)

Dissertation on major (6) Or Dissertation on minor (6) Or Academic Project/ Entrepreneurship -6 credits

DISCIPLINE SPECIFIC CORE COURSE - DSC-20 (4)
Research and Analytical Methods in Geoscience (L3, P1)

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-20 Advanced analytical and computational techniques in geoscience	4	3	0	1	12th pass with science	Studied Earth System Science and Equivalent

Learning Objectives :

This course aims to:

- Impart knowledge of advanced instrumentation and laboratory techniques in geoscience.
- Train students in quantitative analysis and computational tools.
- Develop competencies in interpreting complex geoscientific datasets.

Learning Outcomes :

After completion of this course, students will be able to:

- Apply modern analytical techniques in geoscience.
- Use computational tools (Python / R / MATLAB) for data analysis.
- Analyze and interpret complex geological data using statistical methods.
- Integrate field, laboratory, and modeling approaches for holistic understanding.
- Write scientifically structured reports and research papers.

THEORY

(45 hours)

UNIT – I

(10 hours)

Types of research: conceptual, empirical, quantitative, qualitative, etc. Application of instrumentation and computational techniques in geoscience. Research ethics and publication standards

UNIT – II

(10 hours)

Field methods: Introduction to basic instruments and techniques used to collect sedimentary, structural, geomorphic and other data in field. Sample and type of samples, sampling theory.

UNIT – III

(12 hours)

Laboratory techniques - X-ray diffraction, X-ray fluorescence and induced couple plasma (ICP) analysis- principles and instrumentation (TA), Reciprocal lattice, Ewald's Sphere, Crystal field theory. Raman and Mossbauer spectroscopy, Microbeam techniques- SEM, EPMA, Atomic Force Microscope, electron beam-matter interaction, secondary and back-scattered electrons, auger electrons, energy transitions and characteristic x-rays, EDS & WDS,

data generation, detection limits, matrix correction and data reduction, Total organic carbon analyzer, TL/OSL dating techniques, Fluid inclusion and analog and digital modeling.

UNIT – IV

(13 hours)

Quantitative methods: Basic Statistics- measures of central tendency, dispersion and asymmetry, simple and multiple correlation and regression; Plotting in Excel; Data collection and analysis; Interpolation techniques; Time series analysis; Standard error and error analyses.

Computing in Geosciences: Introduction to R/Python/Matlab. Information regarding software's used in different disciplines of geology. Testing hypothesis; Interpretation and Report writing.

PRACTICAL

(30 Hours)

Exercises using Python/R/MATLAB for data processing. Virtual or lab-based exposure to instrumentation data (e.g., SEM image interpretation). Integrating analytical and computational analysis

Essential/recommended readings:

Research Methodology: Methods and Techniques by C.R. Kothari, New Age International Publishers

Suggestive readings:

1. Matlab recipes for Earth Sciences by Marin H Trauth, Springer International Publishing.

Data Analysis in the Earth Sciences Using MATLAB by Gerard Middleton, This book is available for free on Mathworks website.

2. Python: Introduction to Scientific Programming with Python by Joakim Sundnes. This book is available for free from Springer

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 3 DSE (12):
(i) Mineral Resources and Economics (L3, P1), (ii) Applied Stratigraphy (L3, P1), (iii)
Techniques of Sample collection & processing in Geology (L3, P1)

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE - 8 Mineral Resources and Economics	4	3	0	1	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives:

- To develop an understanding of Earth's mineral resources.
- To explore their classification, distribution, and economic relevance.
- To examine mineral exploitation practices and their implications in global economic activity.
- To build awareness about policy, legal, and environmental considerations in mining and mineral economics.

Learning Outcomes:

After completing the course, students will be able to:

- Identify and classify various types of mineral resources and reserves.
- Understand the distribution of mineral deposits in India and globally, along with their economic importance.
- Explain key processes involved in mineral beneficiation and mining.
- Interpret national policies, global trends, and sustainability concerns in mineral resource management.

THEORY

(45 Hours)

UNIT – I

(12 Hours)

Mineral Resources: Resource and reserve definitions; mineral resources in industries; economic considerations; historical perspective and present. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

UNIT – II

(12Hours)

Distribution of economic mineral resources: Major mineral deposits of India: reserve, grade, mineralogy and exploitation through time. Major mineral deposits of the World: reserve, grade, mineralogy and exploitation through time

UNIT – III

(11 Hours)

Metallic, non-metallic, industrial, critical, strategic and gem minerals; Mineral beneficiation and mining.

UNIT – IV

(10 Hours)

Mineral economics: Global metal markets and projections; National mineral policy; Mineral conservation. UNFC classification; Legal, social and environmental aspects affecting the mine cycles.

PRACTICALS

(30 Hours)

1. Exercises related to mineral resources of India and World. Reserve estimation
2. Projection on Indian mineral resource

Essential/Recommended readings:

Evans, A.M., 2009. Ore geology and industrial minerals: an introduction. John Wiley & Sons.

Moon, C.J., Whateley, M.K.G. & Evans, A.M. 2006. Introduction to Mineral Exploration, Blackwell Publishing.

Chatterjee, K.K. (2004). An Introduction to Mineral Economics, New Age Publishers.

Recommended readings:

Wills, B.A. and Finch, J.A., 2015. Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-Heinemann.

Haldar, S.K., 2013. Mineral Exploration – Principles and Applications. Elsevier Publication.

Arogyaswami, R.P.N. 1996. Courses in Mining Geology. 4th Ed. Oxford-IBH.

Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons..

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-9 Applied Stratigraphy (L3, P1)	4	3	0	1	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives:

- Understand the concepts of dynamic stratigraphy.
- Analyze how eustasy, sediment supply, and tectonics influence basin filling history in the space-time domain.
- Learn the role of magnetic signatures and isotopic values in interpreting sedimentary basin evolution.

Learning Outcomes:

- Apply knowledge in the fields of oil and gas exploration, sustainable energy, and isotope geochemistry.
- Be equipped for advanced research and industry roles requiring stratigraphic and geochemical interpretation.

THEORY

(45 Hours)

UNIT I: Sequence Stratigraphy

(12 hours)

Historical developments. Definitions and key concepts. Base level changes, Geomorphic and Stratigraphic base level. Transgressions and regressions, T-R cycles.

Stratigraphic surfaces: Stratal terminations, sequence stratigraphic surfaces; surface and sub-surface signature

Unconformity and correlative conformity, Ravinement surface, Initial and maximum flooding surface.

Systems Tracts: Lowstand, Transgressive, Highstand, Falling stage.

UNIT II: Sequence models and their application in hydrocarbon sector **(11 hours)**

Sequence Models: Depositional sequence (Type I, II, III), Genetic stratigraphic sequence, Transgressive-Regressive sequence. Hierarchy of sequences and bounding surfaces.

Application of sequence stratigraphy in hydrocarbon exploration; stratigraphic trap delineation

Concepts of event stratigraphy.

UNIT III: Magnetic Stratigraphy**(11 hours)**

Principles, Earth Magnetism, The magnetization process, Inclination, Declination Paleomagnetism, Magnetic epochs, magnetic properties of marine sediments.

Fundamentals of reversal magneto-stratigraphy, The Plio-Pleistocene reversal record

Magnetic stratigraphy of Cenozoics

UNIT IV: Isotope stratigraphy**(11 hours)**

Geochemistry of stable isotope (C, O, S). Application of stable isotopes: Oxygen and hydrogen in Paleothermometry, and Paleoclimatology. Carbon in modern biosphere, sedimentary rocks of Precambrian age, and marine and nonmarine sediments.

PRACTICALS:

1. Problems on paleoenvironmental interpretation
2. Problems on sequence stratigraphic surfaces (unconformity, BSRF, Correlative conformity, Transgressive surface, Maximum flooding surface)
3. Problems of stratigraphic correlation and identification of proximal-distal relationship
4. Problems involving different branches of stratigraphy

Suggested Readings:

- Sequence Stratigraphy: D. Emery, and K. Meyers (1996) Blackwell Publishers
- Principles of Sequence Stratigraphy Octavian Cateneanu (2006) Elsevier
- Basin Analysis: Principles and Applications: P. A. Allen and J.R. Allen (1990) Blackwell Publishing
- The geology of stratigraphic sequences: A.D. Miall (1997) Springer

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-10 Techniques of Sample collection & processing in Geology	4	3	1	0	12th pass with science	Studied Earth System Science and Structural Geology, Hydrogeology or Equivalent

Learning Objectives:

The course aims to:

1. Introduce students to the scientific principles and objectives of geological sampling, with a focus on the diversity of sample types and collection methods across surface and subsurface environments.
2. Equip students with knowledge of field and laboratory techniques required for collecting, processing, and analyzing geological and environmental samples for varied academic, industrial, and exploration purposes.
3. Emphasize the significance of data quality, sample integrity, and ethical practices in geological sampling to ensure reliability in geochemical, geophysical, and geotechnical investigations.

Learning Outcomes:

After successful completion of the course, students will be able to:

1. Confidently plan and execute geological sampling strategies for rock, soil, water, and sediment from diverse terrains and depositional settings.
2. Select appropriate sampling techniques (e.g., grab, trench, core drilling, borehole) based on the exploration objective and sample type.
3. Process and prepare samples for analytical procedures, ensuring data quality through adherence to safety and ethical protocols.
4. Apply high-resolution and instrument-specific sampling methodologies for advanced studies such as geochronology, mineral exploration, and environmental monitoring.

THEORY

(45 Hours)

UNIT 1:

(10 hours)

Sample and Specimen; philosophy of sampling as dynamic and static stochastic system with precision. Samples in different form and purpose; samples for geochemical characterization (lithogeochemical, pedogeochemical, geobotanical, stream sediment); samples from rock and unconsolidated sediment/soil

UNIT 2: (10 hours)

Sampling from surface or underground workings. Grab, Channel, Chip sampling

Trench sampling, Geochemical and environmental Sampling, Water samples, Run of mine ore feed, Crusher product sampling. Core Drilling, Reverse circulation drilling, Auger Drilling Borehole sampling, Core sampling

UNIT 3: (13 hours)

Sampling in mineral exploration or mineral deposits: Placer deposit; stratiform or strata-bound ore bodies

Sample processing for different scientific and industrial purposes; Clean processing laboratory. Heavy mineral separation. Safety protocols and ethics

UNIT 4: (12 hours)

High-resolution thematic sampling, Sampling with logging. Sampling for total metal content, Soluble metal content, Content of non-metal commodities. Sampling for heat content for coal and oil shale, ash content after combustion. Sampling for in situ density, Porosity, Permeability, Compressive strength, Compaction, Grinding index. Samples for geochronology and paleomagnetic study

Tutorials (15 hours)

Exercises related to different sampling techniques; surface, sub-surface etc.

Essential Readings

- Pal, S.K., 2021 Soil sampling and methods of analysis, New India publishing Agency
- Watson I., Lemon R., Krupa S.L. (1988) Samples, sampling. In: General Geology. Encyclopedia of Earth Science. Springer, Boston, MA. https://doi.org/10.1007/0-387-30844-X_97

GE from GE pool (GE-8): Groundwater management and water quality

Credit distribution, Eligibility and Pre-requisites of the Course GE-5

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
GE-8 Groundwater management and water quality	4	3	0	1	12th Pass	Nil

Learning Objectives:

The course aims to:

- Introduce students to the fundamental principles of groundwater science, including geodiversity, geoheritage, and the hydrologic cycle.
- Familiarize students with the concepts of aquifers, groundwater flow, and aquifer properties, along with basic hydrogeological laws such as Darcy's law.
- Enable understanding of the principles and practices of groundwater management, including rainwater harvesting and artificial recharge.
- Develop awareness about water quality issues, pollution, contamination, and criteria for domestic and agricultural water use.

Learning Outcomes:

By the end of the course, students will be able to:

- Explain the interaction of surface and subsurface water and describe the distribution of groundwater in various geologic formations.
- Identify and classify aquifers, aquitards, aquicludes, and aquifuges and apply the concept of porosity, permeability, and Darcy's Law in hydrogeological studies.
- Demonstrate understanding of groundwater estimation, watershed management, rainwater harvesting, and artificial recharge techniques.
- Assess and interpret water quality parameters (BOD, COD, DO, etc.) and use graphical tools such as trilinear diagrams to classify water based on its quality for potable and irrigation purposes.

THEORY

(45 Hours)

UNIT – I

(10 Hours)

Geodiversity, Geoheritage, Geoconservation and their relationship to geotourism. Concept of Water science and its societal relevance, Hydrologic cycle and interaction of the surface and subsurface water, Vertical distribution of subsurface water.

UNIT – II

(10 hours)

Introduction to the concept of porosity and permeability, classification of rocks and sediments as aquifer, aquitard, aquiclude and aquifuge. Types of Aquifer, concept of the piezometric surface and water table and aquifer parameters.

Introduction to Darcy's law and the concept of : static water level, pumping water level, drawdown, radius of influence, cone of depression, specific capacity etc.

UNIT – III

(13 Hours)

Introduction to: the basic concept of water balance and the groundwater resources estimation; principles of the groundwater management; rainwater harvesting and artificial recharge to groundwater; aspects of watershed management as an integral part of groundwater management .

UNIT – IV

(12 Hours)

Introduction to the concept of water quality, contamination, pollution and water quality parameters: Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), organoleptic; physical; chemical; radioactive and bacteriological parameters. The criteria for portable and irrigation use and graphical representation of the water quality data.

Practical (30 hours)

Preparation and interpretation of water level contour maps and depth to water level maps. Graphical representation of chemical quality data and water classification (Trilinear diagrams). Fundamental exercise on groundwater resources estimation. Basic fundamental exercises on aspects related to designing rainwater harvesting and artificial recharge structures.

Essential/recommended readings:

Todd, D. K. (1980). *Groundwater hydrology*, 2ed. John Wiley. (p. 535).

Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw- Hill Pub. Co. Ltd.

Suggestive readings:

Freeze, R. A., & Cherry, J. A. (1979). Groundwater (p. 604). *New Jersey: Prentice Hall Inc Englewood cliffs*.

Syed Tajdarul Hassan. 2017. Introduction to Hydrology. E-PG Pathshala, UGC, MHRD, Govt. of India.