COURSE OUTLINE BRIEFS

DEPARTMENT OF BOTANY

SARGODHA UNIVERSITY
Pathway to Progress

FACULTY OF SCIENCES

Academic Programs Offered:

1. BS Botany
2. MSc Botany
3. MPhil Botany
4. PhD Botany

BS Botany

Eligibility: At least 45% marks in intermediate with biology as an elective subject.
Duration: 04 Year Program (08 Semesters)
Degree Requirements: 132 Credit Hours

Semester-1

Course Code	Description	Credit hours
BOTN-5101	Diversity of Plants	4(3+1)
ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3+1)
CHEM-5101	Physical Chemistry	4(3+1)
URCE-5101	Grammar	3(3+0)
URCP-5106	Pakistan Studies	2(2+0)
Total Credit hours		17

Semester-2

Course Code	Description	Credit hours
BOTN-5102	Plant Systematics, Anatomy and Development/ Embryology	4(3+1)
ZOOL-5102	Animal Diversity-II (Chordates)	4(3+1)
CHEM-5102	Inorganic Chemistry	4(3+1)
URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
URCI-5105	Islamic Studies	2(2+0)
URCC-5110	Citizenship Education and Community Engagement	0(0+0)
Total Credit hours		17

Semester-3

Course Code	Description	Credit hours
BOTN-5103	Cell Biology, Genetics and Evolution	4(3+1)
ZOOL-5103	Animal Form and Function- I (*A Comparative Perspective*)	4(3+1)
CHEM-5103	Organic Chemistry	4(3+1)
URCE-5103	Academic Writing	3(3+0)
URCI-5109	Introduction to Information & Communication Technologies	3(3+0)
Total Credit hours		18

Semester-4

Course Code	Description	Credit hours
BOTN-5104	Plant Physiology and Ecology	4(3+1)
ZOOL-5104	Animal Form and Function-II	4(3+1)
CHEM-5104	Chemistry Special Topics	4(3+1)
BOTN-5105	Biodiversity and Conservation	3(2+1)
URCM-5101	Introduction to Mathematics	3(3+0)
Total Credit hours		18

Semester-5

Course Code	Description	Credit hours
STAT-6134	Biostatistics	3(2+1)
BOTN-6107	Bacteriology and Virology	3(2+1)
BOTN-6108	Phycology and Bryology	3(2+1)
BOTN-6109	Mycology and Plant Pathology	3(2+1)
BOTN-6110	Diversity of Vascular Plants	3(2+1)
BOTN-6111	Plant Systematics	3(2+1)
Total Credit hours		18

Semester-6

Course Code	Description	Credit hours
BOTN-6112	Plant Anatomy	3(2+1)
BOTN-6113	Genetics-I	3(2+1)
BOTN-6114	Plant Biochemistry-I	3(2+1)
BOTN-6115	Plant Ecology-I	3(2+1)
BOTN-6116	Plant Physiology-I	3(2+1)
BOTN-6117	Cell Biology	3(2+1)
Total Credit hours		18

Semester-7

Course Code	Description	Credit hours
BOTN-6118	Molecular Biology	3(2+1)
BOTN-6119	Plant Biochemistry-II	3(2+1)
BOTN-6120	Plant Ecology-II	3(2+1)
BOTN-XXXX	Elective-I /Optional paper/Thesis/Internship/ Research Report	3(2+1)
BOTN-6121	Research Methodology	2(2+0)
Total Credit hours		14

Semester-8

Course Code	Description	Credit hours
BOTN-6122	Genetics-II	3(2+1)
BOTN-6123	Plant Physiology-II	3(2+1)
BOTN-6124	Environmental Biology	3(2+1)
BOTN-61XX	Elective-II/Optional paper/Thesis/Internship/ Research Report	3(2+1)
Total Credit hours		12

Total number of Credit Hours: 132
Elective subjects will be offered as per available expertise of the university.

Optional Courses

Course Code	Title	Credit Hours	Course Code	Title	Credit Hours
BOTN-6125	Plant Water Relations	3(2+1)	BOTN-6126	Plant Micro Techniques	3(2+1)
BOTN-6127	Plant Seed Physiology	3(2+1)	BOTN-6128	Palynology	3(2+1)
BOTN-6129	Plant Tissue Culture	3(2+1)	BOTN-6130	Plant Biotechnology	3(2+1)
BOTN-6131	Advanced Environmental Biology	3(2+1)	BOTN-6132	Plant-Conservation Management	3(2+1)
BOTN-6133	Conservation Genetics	3(2+1)	BOTN-6134	Basic Ecological Genetics	3(2+1)
BOTN-6135	Medicinal Plants	3(2+1)	BOTN-6136	Ethnobotany	3(2+1)
BOTN-6137	Biodegradation and Bioremediation	3(2+1)	BOTN-6138	Water Pollution Management	3(2+1)
BOTN-6139	Air Pollution Management Strategies	3(2+1)	BOTN-6140	Conservation Ecology	3(2+1)
BOTN-6141	Plant Stress Physiology	3(2+1)	BOTN-6142	Advanced Plant Anatomy	3(2+1)
BOTN-6143	Seed Production Technology	3(2+1)	BOTN-6144	Seed Pathology	3(2+1)

MSc Botany

Eligibility: At least 45% marks in BSc with Botany and Zoology (compulsory) and Chemistry /Psychology/ Geography) etc. as an elective subject.
Duration: 02 Year Program (04 Semesters)
Degree Requirements: 66 Credit Hours

Semester-1

Course Code	Description	Credit hours
BOTN-6201	Biostatistics	3(2+1)

BOTN-6202	Bacteriology and Virology	3(2+1)
BOTN -6203	Phycology and Bryology	3(2+1)
BOTN -6204	Mycology and Plant Pathology	3(2+1)
BOTN -6205	Diversity of Vascular Plants	3(2+1)
BOTN -6206	Plant Systematics	3(2+1)
Total Credit hours		18

Semester-2

Course Code	Description	Credit hours
BOTN-6207	Plant Anatomy	3(2+1)
BOTN-6208	Genetics-I	3(2+1)
BOTN -6209	Plant Biochemistry-I	3(2+1)
BOTN -6210	Plant Ecology-I	3(2+1)
BOTN -6211	Plant Physiology-I	3(2+1)
BOTN -6212	Cell Biology	3(2+1)
URCC-5110	Citizenship Education and Community Engagement	0(0+0)
Total Credit hours		18

Semester-3

Course Code	Description	Credit hours
BOTN-6213	Molecular Biology	3(2+1)
BOTN-6214	Plant Biochemistry-II	3(2+1)
BOTN-6215	Plant Ecology-II	3(2+1)
BOTN-6216	Research Methodology	2(2+0)
BOTN-6217	Seminar	1(1+0)
BOTN-62XX	Elective-I/Optional paper/Thesis/Internship/ Research Project	3(2+1)
Total Credit hours		15

Semester-4

Course Code	Description	Credit hours
BOTN-6218	Plant Physiology-II	3(2+1)
BOTN-6219	Genetics II	3(2+1)
BOTN-6220	Environmental Biology	3(2+1)
BOTN-6221	Biodiversity and Conservation	3(2+1)
BOTN-62XX	Elective-II/Optional paper/Thesis/Internship/ Research Project	3(2+1)
Total Credit hours		15

Total number of Credit Hours: 66

Elective subjects will be as per available expertise of the university.

Optional Courses

Course	Title	Credit Hours	Course	Title	Credit Hours
BOTN-6222	Plant Water Relations	3(2+1)	BOTN-6223	Plant Micro techniques	3(2+1)
BOTN-6224	Plant Seed Physiology	3(2+1)	BOTN-6225	Palynology	3(2+1)
BOTN-6226	Plant Tissue Culture	3(2+1)	BOTN-6227	Plant Biotechnology	3(2+1)
BOTN-6228	Advanced Environmental Biology	3(2+1)	BOTN-6229	Plant Conservation Management	3(2+1)
BOTN-6230	Conservation Genetics	3(2+1)	BOTN-6231	Basic-Ecological Genetics	3(2+1)
BOTN-6232	Medicinal Plants	3(2+1)	BOTN-6233	Ethnobotany	3(2+1)
BOTN-6234	Biodegradation and Bio remediation	3(2+1)	BOTN-6235	Water-pollution Management	3(2+1)
BOTN-6236	Air Pollution Management Strategies	3(2+1)	BOTN-6237	Conservation Ecology	3(2+1)
BOTN-6238	Plant Stress Physiology	3(2+1)	BOTN-6239	Advanced-Plant Anatomy	3(2+1)
BOTN-6240	Seed Production Technology	3(2+1)	BOTN-6241	Seed Pathology	3(2+1)

MPhil Botany

Eligibility: MSc/BS 4-Year or equivalent (16 years of Education) in the relevant field or equivalent degree from HEC recognized institution with at least second Division or CGPA 2.00 out of 4.00.
Duration: 02 Year Program (04 Semesters)
Degree Requirements: 30 Credit Hours

Semester	Course Code	Name of courses	Credit. Hours
1st	BOTN-xxx	Compulsory course	3(2+1)
	BOTN-xxx	Compulsory course	3(2+1)
	BOTN-xxx	Optional course	3(2+1)
	BOTN-xxx	Optional course	3(2+1)
2nd	BOTN-xxx	Compulsory course	3(2+1)
	BOTN-xxx	Compulsory course	3(2+1)
	BOTN-xxx	Optional course	3(2+1)
	BOTN-xxx	Optional course	3(2+1)

Any four courses from the list of compulsory courses Annexure- I and any four courses from the list of optional courses Annexure II can be taken depending upon resources of the department by MPhil students's Research thesis comprises of minimum two semester having credit hours 6.

List of Compulsory Courses

Course Code	Name of courses	Credit Hours
BOTN-7101	Advanced Techniques in Molecular Biology	3(2+1)
BOTN-7102	Advanced Plant Ecology	3(2+1)
BOTN-7103	Advanced Plant Physiology and Biochemistry	3(2+1)
BOTN-7104	Plant Nutrition Management	3(2+1)
BOTN-7105	Environmental Toxicology and Impact Assessment	3(2+1)
BOTN-7106	Recombinant DNA Technology	3(2+1)
BOTN-7107	Applications of Plant Biotechnology	3(2+1)
BOTN-7108	Plant Microbe Interaction	3(2+1)
BOTN-7109	Phytochemistry	3(2+1)

List of Optional Courses

Course Code	Name of courses	Credit Hours
BOTN-7110	Biosystematics	3(2+1)
BOTN-7111	Phytoremediation	3(2+1)
BOTN-7112	Economic Botany	3(2+1)
BOTN-7113	Advances in Physiology and Molecular Biology of Plants	3(2+1)
BOTN-7114	Proteomics and Genomics	3(2+1)
BOTN-7115	Modern Molecular Biology	3(2+1)
BOTN-7116	Biotechnology for Sustainable Development	3(2+1)
BOTN-7117	Radiation Biology	3(2+1)
BOTN-7118	Plant Developmental Processes	3(2+1)
BOTN-7119	Biohazards and Biosafety	3(2+1)
BOTN-7120	Food Industrial Waste Management	3(2+1)

Semester 3-4

	Dissertation	6(0-6)

PhD Botany

Eligibility: MPhil/MS Botanyin the relevant field from HEC recognized institution with at least CGPA 3.00 out of 4.00.
Duration: 03 Year Program (06 Semesters)
Degree Requirements: 18 Credit Hours Course Work + Dissertation

Recommended Syllabus: PhD Botany

Course Code	Name of courses	Credit Hours
BOTN-8101	Methods in Plant Cell Tissue and Organ Culture	3(2+1)
BOTN-8102	Ecological Genetics	3(2+1)
BOTN-8103	Forensic Botany	3(2+1)
BOTN-8104	Molecular Basis of Morphogenesis	3(2+1)
BOTN-8105	Environmental Biotechnology	3(2+1)
BOTN-8106	Advanced Cell and Molecular Biology	3(2+1)
BOTN-8107	Conservation and Management of Plant Resources	3(2+1)
BOTN-8108	Bioinformatics	3(2+1)
BOTN-8109	Fermentation Technology	3(2+1)
BOTN-8110	Environmental and Nutritional Physiology	3(2+1)
BOTN-8111	Advanced Conservation Ecology	3(2+1)
BOTN-8112	Bioethics	3(2+1)
BOTN-8113	Semi-Arid Region Ecology	3(2+1)
BOTN-8114	Biology of Halophytes	3(2+1)
BOTN-8115	Bioinstrumentation	3(2+1)

Students enrolled in the Ph.D. program must have to take course work of 18 Cr. Hr. from Annexure- I with the recommendation of their respective Supervisors/Chairman. A specific subject taken in MPhil. would not be allowed in PhD. Minimum Credit Hours for Ph.D. are 18 and maximum time for research thesis is four years.

Semester 3-6

	Dissertation	

BS
BOTANY

BOTN-5101 **Diversity of Plants** **4(3+1)**

This course offers an evolutionary survey of the origin and diversification of land plants through geological time. The course will start with the green algae and on how plants may have transitioned from aquatic to the land environment. Land plants that will be discussed include bryophytes, lycophytes, pteridophytes, gymnosperms and angiosperms with emphasis on representative fossil and living taxa. Lectures will emphasize on life histories, anatomical and morphological adaptations, ecology and climate change, extinction, phylogenetics, economic importance, and conservation strategies of representative taxa. Plants are one of the most successful and abundant groups of organisms on earth, comprising the majority of terrestrial biomass, being integral to ecosystem structure, and providing humans with food, shelter, and materials. The laboratory will provide ample hands-on opportunities for analysis of plant anatomy and morphology, reproductive mechanisms, evolutionary adaptations, and identification of a variety of living and preserved specimens. Plants are multi-cellular and mostly photosynthetic organisms which found essentially everywhere, both in water and on land.

Contents

1. Comparative study of life form, structure, reproduction and economic significance of:
2. Viruses (RNA and DNA types) with special reference to TMV
3. Bacteria and Cyanobacteria (*Nostoc, Anabaena, Oscillatoria*) with specific reference to bio fertilizers, pathogenicity and industrial importance;
4. Algae (*Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia*)
5. Fungi (*Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus*) their implication on crop production and industrial applications.
6. Lichens (*Physcia*)
7. Bryophytes (*Riccia, Anthoceros, Funaria)*
8. Pteridophytes: Psilopsida (*Psilotum*) ,Pteropsida (*Marsilea*), Sphenopsida (*Equisetum*) Lycopsida (*Selaginella*)
9. Gymnosperms (*Cycas,Pinus, Ephedra)*
10. Angiosperms: Monocot (Poaceae) , Dicot (Solanaceae)

Lab work

1. Culturing, maintenance, preservation and staining of microorganisms.
2. Study of morphology and reproductive structures of the types mentioned in theory.
3. Identification of various types mentioned from prepared slides and fresh collections.

Recommended Texts

1. Bellinger, E. G., & Sigee, D. C. (2015). *Freshwater Algae*. New Jersey: Wiley Publishers.
2. Prestre, P. G. (2017). *Governing Global Biodiversity: The Evolution and Implementation of the Convention on Biological Diversity*. Abingdon: Routledge Publishers.

Suggested Readings

1. Şen, B., & Grillo, O. (2018). *Selected Studies in Biodiversity*. London: Intech Open Publishers.
2. Zotz, G. (2016). *Plants on Plants: The biology of vascular epiphytes*. Berlin: Springer-Verlag.
3. Cronk, J. K., & Fennessy, M. S. (2016). *Wetland plants: biology and ecology*. Florida: CRC Press.
4. Pullaiah T., Bahadur, B., & Murthy, K. (2015). *Plant biodiversity*. Berlin: Springer-Verlag.

ZOOL-5101 Animal Diversity-I (Invertebrates) 4(3+1)

This course will provide the knowledge of evolutionary/phylogenetic relationship. It imparts the basic taxonomic characteristics and classification of all the in vertebrate phyla. This includes more than 95% of all of the described species of animals and far more than 99% of all of the individual animals on the planet. The central theme running throughout this course will be phylogeny. It provides understanding of body organization, mode of feeding, digestion, reproduction and development of invertebrates. It delivers information to students about economic and ecological importance of invertebrates. Students will understand invertebrate organismal concepts in laboratory and field. The primary objectives for the laboratory section of this course includes; introduction of structure, function and behavior of selected invertebrate types through the observation of both living and preserved specimens, to reinforce basic laboratory skills of students like microscopy, dissection and careful observation, to provide students with the ability to recognize the major groups of invertebrate and to increasing understanding of the methods of investigating animal evolution.

Contents

1. Introduction: classification of organisms, evolutionary relationships
2. Animal-like Protists: the Protozoa
3. Multicellular and tissue levels of organization: evolutionary perspective, origins of multice llularity
4. Animal origins, Phylum Porifera, Cnidaria, Ctenophora
5. The triploblastic acoelomate body plan: Phylum Platyhelminthes, Phylum Nematode, gastrotricha
6. Pseudocoelomate body plan: Phylum Aaschelminths, Phylum Rotifera, Phylum Nematoda and Phylum kinorhyncha. Some important nematode parasites of humans
7. Phylum Mollusca, Annelida, Arthropoda,(the hexapods and myriapods), Phylum Echinodermata
8. Some lesser known invertebrates: lophorates, entoprocts, cycliophores, and cheatognaths

Lab work

1. Study of representatives of phylum Protista, Porifera and prepared slides of spicules of sponges
2. Study of principal representatives of classes of phylum Coelenterate, Platyhelminthes, rotifer, nematode, Mollusca, Annelida, Arthropoda, Echinodermata
3. Preparation of permanent mount of obelia, hydra, proglottid, parapodia, insect mouthparts

Recommended Texts

1. Miller, A. S., & Harley, J. B. (1999, 2002, 2007, 2009, 2012 & 2016). *Zoology* (4^{th}, 5^{th}, 6^{th}, 7^{th}, 8^{th}, 9^{th}, 10^{th}ed.). Singapore: McGraw Hill.
2. Hickman, C. P., Roberts, L. C., & Larson, A. (2018). *Integrated principles of zoology* (15^{th}ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Pechenik, J. A. (2015). *Biology of invertebrates* (7^{th}ed.). Singapore: McGraw-Hill
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.

CHEM-5101 Physical Chemistry 4 (3+1)

This course is the first part of this program, introduction to Physical Chemistry. This foundation course of physical chemistry covers basic knowledge and its application for learning chemical principles of physics to chemistry. This offer complementary approaches to the fundamental understanding of chemical systems. Students will acquire knowledge to enable themselves to understand the kinetic theory of gases, collision theory of reactions, fundamental principles and laws of thermodynamics and chemical equilibrium and to investigate the physical properties of ideal/non-ideal binary solutions. Students will also be able to study the rates of reactions and perform related calculations. The general goal of learning physical chemistry is to obtain a vision of matter-energy relationship in physical and chemical systems. Learning objectives emphasized in CHEM 5101 involve developing an understanding of basic principles of physical chemistry. Students learned in class to modern physical chemistry techniques which give them opportunities to see how Physical Chemists are solving current, real-world problems.

Contents

1. Elementary Mathematics: Logarithmic, exponential and trigonometric functions, differentiation of elementary functions, methods of differentiation and integration
2. Physical States of Mater: Gases, Liquids and Solids
3. Atomic Structure: De Brogile equation,
4. Schrodinger wave equation, solution for particle in 1D box
5. Chemical Thermodynamics: laws of thermodynamics, Spontaneous and non-spontaneous processes
6. Chemical Equilibrium: Law of Mass Action, equilibrium constant, and LeChaterlier's Principle
7. Solutions: composition, ideal and non-ideal solutions. Raoult's law. Colligative properties
8. Chemical Kinetics: Zero, first and second order reaction, Arrhenius equation, activation energy
9. Electrochemistry: Conductance, Kohlrausch's law and its applications

Lab work

1. Determination of surface tension and Parachor value by stalagmometer and percentage composition.
2. Determination of viscosity and Rhechor value of liquids from viscosity measurement.
3. Determination of refractive index and molar refractivity by refractometer.
4. Determination of heat of solution by solubility method.
5. Determination of boiling point and lowering of freezing point

Recommended Texts

1. Atkins, P., Paula, J., & Keeler, J. (2017). *Atkins' Physical Chemistry* (11th ed.), London: Oxford University Press.
2. Kuhn, H. Försterling, H. Waldeck, D.H. (2009). *Principles of Physical Chemistry* (2nd ed.), New Jersey: Wiley Publisher.

Suggested Readings

1. Akhtar, M.N. and Nabi, G. (2006). *Text Book of Physical Chemistry.* Lahore: IlmiKitabKhawna. Das, R.C., and Behera, B. (2003). *Experimental Physical Chemistry.* New Dehli: Tata McGraw Hill.

URCE-5101 **Grammar** **3(3+0)**

The course introduces the students to the underlying rules to acquire and use language in academic context. The course aims at developing grammatical competence of the learners to use grammatical structures in context in order to make the experience of learning English more meaningful enabling the students to meet their real life communication needs. The objectives of the course are to, reinforce the basics of grammar, understand the basic meaningful units of language, and introduce the functional aspects of grammatical categories and to comprehend language use by practically working on the grammatical aspects of language in academic settings. After studying the course, students would be able to use the language efficiently in academic and real life situations and integrate the basic language skills in speaking and writing. The students would be able to work in a competitive environment at higher education level to cater with the long term learners' needs.

Contents

1. Parts of speech
2. Noun and its types
3. Pronoun and its types
4. Adjective and its types
5. Verb and its types
6. Adverb and its types
7. Prepositions and its types
8. Conjunction and its types
9. Phrases and its different types
10. Clauses and its different types
11. Sentence, parts of sentence and types of sentence
12. Synthesis of sentence
13. Conditional sentences
14. Voices
15. Narration
16. Punctuation
17. Common grammatical errors and their corrections

Recommended Texts

1. Eastwood, J. (2011). *A basic English grammar*. Oxford: Oxford University Press.
2. Swan, M. (2018). *Practical English usage*(8^{th}ed.). Oxford: Oxford University Press.

Suggested Readings

1. Thomson, A. J., & Martinet, A. V. (1986). *A practical English grammar*. Oxford: Oxford University Press
2. Biber, D., Johansson, S., Leech, G., Conrad, S., Finegan, E., & Quirk, R. (1999). *Longman grammar of spoken and written English*. Harlow Essex: MIT Press.
3. Hunston, S., & Francis, G. (2000). *Pattern grammar: A corpus-driven approach to the lexicalgrammar of English*. Amsterdam: John Benjamins.

URCP-5106 **Pakistan Studies** **2(2+0)**

The course is designed to acquaint the students of BS Programs with the rationale of the creation of Pakistan. Pakistan studies curriculum is the name of a curriculum of academic research and study that encompasses the culture, demographics, geography, history, and politics of Pakistan. The students would be apprised of the emergence, growth and development of Muslim nationalism in South Asia and the struggle for freedom, which eventually led to the establishment of Pakistan. While highlighting the main objectives of national life, the course explains further the socio-economic, political and cultural aspects of Pakistan's endeavours to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighboring and other countries are also included. This curriculum has been developed to help students analyze the socio-political problems of Pakistan while highlighting various phases of its history before and after the partition and to develop a vision in them to become knowledgeable citizens of their homeland.

Contents

1. Contextualizing Pakistan Studies
2. Geography of Pakistan: Geo-Strategic Importance of Pakistan
3. Freedom Movement (1857-1947)
4. Pakistan Movement (1940-47)
5. Muslim Nationalism in South Asia
6. Two Nations Theory
7. Ideology of Pakistan
8. Initial Problems of Pakistan
9. Political and Constitutional Developments in Pakistan
10. Economy of Pakistan: Problems and Prospects
11. Society and Culture of Pakistan
12. Foreign Policy Objectives of Pakistan and Diplomatic Relations
13. Current and Contemporary Issues of Pakistan
14. Human Rights: Issues of Human Rights in Pakistan

Recommended Texts

1. Kazimi, M. R. (2007). *Pakistan studies.* Karachi: Oxford University Press.
2. Sheikh, J. A. (2004). *Pakistan's political economic and diplomatic dynamics.* Lahore: Kitabistan Paper Products.

Suggested Readings

1. Hayat, S. (2016). *Aspects of Pakistan movement.* Islamabad: National Institute of Historical and Cultural Research.
2. Kazimi, M. R (2009).*A concise history of Pakistan.*Karachi: Oxford University Press.
3. Talbot, I. (1998). *Pakistan: A modern history*. London: Hurst and Company.

BOTN-5102 Plant Systematics, Anatomy and Development/Embryology 4(3+1)

Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny -the evolutionary history of a particular group; is the primary goal of systematics. Anatomical characters are conserved and stable and thus can be used as a "Taxonomic Character" for Plant Systematics of Plant Taxonomy. Anatomical characters of all the plant parts can be used such as the characters of stem, root, leaves, bark, stomata, trichomes, internal parts etc. The study systematics gives the order and relationships among the organism. This order and relationship arise from evolutionary processes. As a living thing, all of a plant's parts are made up of cells and this course will also lead towards the developmental processes that how they took place.

Contents

1. Plant Systematic: Introduction to Plant Systematic: aims, objectives and importance. Classification: Brief history of various systems of classification, Brief introduction to nomenclature, importance of Latin names and binomial system,
2. Morphology: A detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types, Diagnostic characters, economic importance and distribution pattern of the families
3. Anatomy: Cell wall: structure and chemical composition, Concept, structure and function of various tissues, Meristem, Vascular cambium, Structure and development of root, stem and leaf, Primary and secondary growth of dicot stem, periderm, Characteristics of wood and annual rings.
4. Development/Embryology: Early development of plant body*: Capsella bursa*-pastoris, Structure and development of Anther and ovule, Endosperm formation, Parthenocarpy, Polyembryony

Lab work

1. Study of stomata and epidermis, Tissues of primary body of plant, Study of xylem 3-dimensional plane of wood, T. S of angiosperm stem and leaf, Anatomy of germinating seeds, Study of pollens
2. Identification of families given in syllabus with the help of keys, Technical description of common flowering plants belonging to families, Field trips shall be undertaken to study and collect local plants, Students shall submit 40 fully identified herbarium specimens.

Recommended Texts

1. Clive A., Stace, C. A. & Crawley, M. J. (2015). *Alien plants*. New York: Harper Collins Publishers.
2. Hather, J. G. (2016). *Archaeological parenchyma*. London: Routledge Publishers.

Suggested Readings

1. Steeves, T. A. & Sawhney, V. K. (2017). *Essentials of Developmental Plant Anatomy*. Oxford: Oxford University Press**.**
2. Spichiger, R. E. (2019). *Systematic Botany of Flowering Plants: A New Phytogenetic Approach of the Angiosperms of the Temperate and Tropical Regions*. Florida: CRC Press.

ZOOL-5102 Animal Diversity-II (Chordates) 4(3+1)

This course will enable students to understand the taxonomic characteristics of protochordates and chordates. It provides knowledge about the phylogenetic relationships of protochodates and various classes of chordates. Students will understand the phylogenetic relations, physiological adaptations, behavior and diversity of Pisces, amphibians, reptiles and mammals and able to analyze the process of micro evolution within chordates. After this course the students will understand what the chordates are, can recognize different categories of chordates, understands the level of organization in chordate subphylum, can comprehend the general characters of chordates and know about the origin and evolutionary relationship in different subphylum of chordates. Upon successful completion of this subject students will be able to describe unique characters of urochordates, cephalochordates and fishes, can recognize difference in life functions of urochordates and fishes, will understand the interactions and ecological role of different groups of chordates and understand the diversity of chordates.

Contents

1. Protectorates: phylogeny, classification, anatomy, reproduction and metamorphosis
2. Fishes: phylogeny, classification, locomotor adaptations, anatomy, physiology and development
3. Amphibians: phylogeny, classification, adaptations in digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion, reproduction, and development
4. Reptiles: phylogeny, classification, adaptations in digestive system, circulation, gas exchange temperature regulation, nervous and sensory functions, excretion, reproduction, and development
5. Birds: phylogeny, classification, adaptations in digestive system, circulation, gas exchange temperature regulation, nervous and sensory functions, excretion, reproduction, and development
6. Mammals: phylogeny, classification, adaptations in digestive system, circulation, gas exchange temperature regulation, nervous and sensory functions, excretion, reproduction, and development

Lab work

1. Classification and study of lab specimens of hemichordates, fishes, amphibians, reptiles, birds and mammals.
2. Visit to PMNH for the study of diversity of chordates.

Recommended Texts

1. Campbell, N. A. (2011). *Biology* (9th ed.). California: Benjamin Cummings.
2. Miller, S. A., & Harley, J. B. (2010). *Zoology* (8th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Miller, S. A. (2002). *General zoology laboratory manual* (5th ed.). Singapore: McGraw-Hill
2. Hickman, C. P., Roberts, L. C., & Larson, A. (2009). *Integrated principles of zoology* (14th ed.). Singapore: McGraw-Hill

CHEM-5102 Inorganic Chemistry 4 (3+1)

This course covers a range of general topics of inorganic chemistry.It will provide a useful supplement to the advanced courses specified in the department. This course aims to enable the students to achieve the advance knowledge about the key introductory concepts of chemical bonding, acid-base chemistry, and properties of the representative and transition elements, as well as using this knowledge for qualitative and quantitative analysis of inorganic compounds during laboratory work. Learning objectives emphasized in CHEM 5102 involve developing an understanding of basic principles of inorganic chemistry. It develop critical thinking skills enabling students to solve chemistry problems that incorporate their cumulative knowledge. Students learned in class to modern chemistry techniques which give them opportunities to upgrade their knowledge about advanced inorganic concepts. The essence of this course is to develop study skills that students need to succeed in university-level chemistry courses and preparation of students for professional positions in chemistry.

Contents

1. Periodic Table and Periodicity of Properties: Modern Periodic Table
2. Acid Base Equilibria: Acids and bases, relative strengths of acids, pH, pKa, pKb. Hard/soft acid
3. Chemical Bonding: Nature of a bond, hybridization, Valence Bond Theory (VBT), The Concept of Resonance, Molecular Orbital Theory (MOT), Valence Shell Electron Pair Repulsion (VSEPR) theory.
4. Chemistry of p-Block andd-Block Elements, Chemistry of Elements
5. Separation Techniques: General introduction and Applications
6. Introduction to Analytical Techniques in Inorganic Chemistry:
7. Chemical Industries: Metallurgy of Al, Cr and U, fertilizers (Urea and Phosphate fertilizers) Cement and Sugar.

Lab work

1. Qualitative Analysis; four radicals (cations and anions) for salt mixture.
2. Chromatographic separation of cations
3. Determination of total hardness of water using EDTA.Estimation of copper (Iodometrically).
4. Determination of ferricyanide using KI solution.Determination of chloride by Mohr's methods
5. Estimation of chloride ions using adsorption (Fluorescein) indicator.
6. Percentage determination of ferric ions in ferric alum using $KMnO_4$ solution.
7. Determination of purity of commercial potassium oxalate using $KMnO_4$ solution.
8. Estimation of ferrous ions using $K_2Cr_2O_7$ solution.

Recommended Texts

1. Iqbal, M. Z. (2015). *Text Book of Inorganic Chemistry* (Revised Ed.). Lahore: Ilmi Kitab Khana.
2. Lee, J.D. (1996). *Concise Inorganic Chemistry*. 5th Ed. London: Chapman and Hall.

Suggested Readings

1. Graham, H., & Man, H. (2000). *Chemistry in Context* 5th Ed. London: Thomas Nelson Ltd.
2. Vogel, A. I. (1995). *A Text Book of Macro and Semi micro Qualitative Inorganic Analysis.* London*:* Longman Green and Co. NY.

URCE-5102 Language Comprehension & Presentation Skills 3(3+0)

The course aims at developing linguistic competence by focusing on basic language skills in integration to make the use of language in context. It also aims at developing students' skills in reading and reading comprehension of written texts in various contexts. The course also provides assistance in developing students' vocabulary building skills as well as their critical thinking skills. The contents of the course are designed on the basis of these language skills: listening skills, pronunciation skills, comprehension skills and presentation skills. The course provides practice in accurate pronunciation, stress and intonation patterns and critical listening skills for different contexts. The students require a grasp of English language to comprehend texts as organic whole, to interact with reasonable ease in structured situations, and to comprehend and construct academic discourse. The course objectives are to enhance students' language skill management capacity, to comprehend text(s) in context, to respond to language in context, and to write structured response(s).

Contents

1. Listening skills
2. Listening to isolated sentences and speech extracts
3. Managing listening and overcoming barriers to listening
4. Expressing opinions (debating current events) and oral synthesis of thoughts and ideas
5. Pronunciation skills
6. Recognizing phonemes, phonemic symbols and syllables, pronouncing words correctly
7. Understanding and practicing stress patterns and intonation patterns in simple sentences
8. Comprehension skills
9. Reading strategies, summarizing, sequencing, inferencing, comparing and contrasting
10. Drawing conclusions, self-questioning, problem-solving, relating background knowledge
11. Distinguishing between fact and opinion, finding the main idea, and supporting details
12. Text organizational patterns, investigating implied ideas, purpose and tone of the text
13. Critical reading, SQ3R method
14. Presentation skills, features of good presentations, different types of presentations
15. Different patterns of introducing a presentation, organizing arguments in a presentation
16. Tactics of maintaining interest of the audience, dealing with the questions of audience
17. Concluding a presentation, giving suggestions and recommendations

Recommended Texts

1. Mikulecky, B. S., & Jeffries, L. (2007). *Advanced reading power: Extensive reading, vocabulary building, comprehension skills, reading faster*. New York: Pearson.
2. Helgesen, M., & Brown, S. (2004). *Active listening: Building skills for understanding*. Cambridge: Cambridge University Press.

Suggested Readings

1. Roach, C. A., & Wyatt, N. (1988). *Successful listening*. New York: Harper & Row.
2. Horowitz, R., & Samuels, S. J. (1987). *Comprehending oral and written language*. San Diego: Academic Press.

URCI-5105 **Islamic Studies** **2(2+0)**

Islamic Studies engages in the study of Islam as a textual tradition inscribed in the fundamental sources of Islam; Qur'an and Hadith, history and particular cultural contexts. The area seeks to provide an introduction to and a specialization in Islam through a large variety of expressions (literary, poetic, social, and political) and through a variety of methods (literary criticism, hermeneutics, history, sociology, and anthropology). It offers opportunities to get fully introductory foundational bases of Islam in fields that include Qur'anic studies, Hadith and Seerah of Prophet Muhammad (PBUH), Islamic philosophy, and Islamic law, culture and theology through the textual study of Qur'an and Sunnah. Islamic Studies is the academic study of Islam and Islamic culture. The basic sources of the Islamic Studies are the Holy Qur'an and Sunnah or Hadith of the Holy Prophet Muhammadﷺ. The learning of the Qur'an and Sunnah guides the Muslims to live peacefully.

Contents

1. Study of the Qur'an (Introduction to the Qur'an, Selected verses from *Surah Al-Baqarah, Al-Furqan, Al-Ahzab, Al-Mu'minoon, Al-An'am, Al-Hujurat, Al-Saff*)
2. Study of the Hadith (Introduction to Hadith literature, Selected Ahadith (Text and Translation)
3. Introduction to Qur'anic Studies
4. Basic Concepts of Qur'an
5. History of Quran
6. Basic Concepts of Hadith
7. History of Hadith
8. Kinds of Hadith
9. Uloom –ul-Hadith
10. Sunnah & Hadith
11. Seerat ul-Nabi (PBUH), necessity and importance of Seerat, role of Seerah in the development of personality, Pact of Madinah, Khutbah Hajjat al-Wada' and ethical teachings of Prophet (PBUH).
12. Legal Position of Sunnah
13. Islamic Culture & Civilization
14. Characteristics of Islamic Culture & Civilization
15. Historical Development of Islamic Culture & Civilization
16. Comparative Religions and Contemporary Issues
17. Impact of Islamic civilization

Recommended Texts

1. Hassan, A. (1990). *Principles of Islamic jurisprudence*. New Dehli: Adam Publishers.
2. Zia-ul-Haq, M. (2001). *Introduction to al-Sharia al-Islamia*. Lahore: Aziz Publication.

Suggested Readings

1. Hameedullah, M. (1957). *Introduction to Islam*. Lahore: Sh M Ashraf Publisher.
2. Hameedullah, M. (1980). *Emergence of Islam*. New Dehli: Adam Publishers.
3. Hameedullah, M. (1942). *Muslim conduct of state.* Lahore: Sh M Ashraf Publisher.

URCC-5110 Citizenship Education and Community Engagement (0+0)

In recent years, community engagement has become a central dimension of governance as well as policy development and service delivery. However, efforts to directly involve citizens in policy processes have been bedeviled by crude understandings of the issues involved, and by poor selection of techniques for engaging citizens. This course will provide a critical interrogation of the central conceptual issues as well as an examination of how to design a program of effective community engagement. This course begins by asking: Why involve citizens in planning and policymaking? This leads to an examination of the politics of planning, conceptualizations of "community" and, to the tension between local and professional knowledge in policy making. This course will also analyze different types of citizen engagement and examine how to design a program of public participation for policy making. Approaches to evaluating community engagement programs will also be a component of the course.

Contents

1. Introduction to Citizenship Education and Community Engagement: Orientation
2. Introduction to Active Citizenship: Overview of the ideas, Concepts, Philosophy and Skills
3. Identity, Culture and Social Harmony: Concepts and Development of Identity
4. Components of Culture and Social Harmony, Cultural & Religious Diversity
5. Multi-cultural society and inter-cultural dialogue: bridging the differences, promoting harmony
6. Significance of diversity and its impact, Importance and domains of inter-cultural harmony
7. Active Citizen: Locally active, Globally connected
8. Importance of active citizenship at national and global level
9. Understanding community, Identification of resources (human, natural and others)
10. Human rights, Constitutionalism and citizens' responsibilities: Introduction to human rights
11. Universalism vs relativism, Human rights in constitution of Pakistan
12. Public duties and responsibilities
13. Social Issues in Pakistan: Introduction to the concept of social problem, Causes and solutions
14. Social Issues in Pakistan (Poverty, Equal and Equitable access of resources, unemployment)
15. Social Issues in Pakistan (Agricultural problems, terrorism & militancy, governance issues)
16. Social action and project: Introduction and planning of social action project
17. Identification of problem, Ethical considerations related to project
18. Assessment of existing resources

Recommended Texts

1. Kennedy, J. K., & Brunold, A. (2016). *Regional context and citizenship education in Asia and Europe*. New York: Routledge Falmer.
2. Macionis, J. J., & Gerber, M. L. (2010). *Sociology*. New York: Pearson Education

Suggested Texts

1. British Council. (2017). *Active citizen's social action projects guide.* Scotland: British Council
2. Larsen, K. A., Sewpaul, V., & Hole, G. O. (Eds.). (2013). *Participation in community work: International perspectives.* New York: Routledge

BOTN-5103 Cell Biology, Genetics and Evolution 4(3+1)

Cell biology, genetics and evolution are fundamental to an understanding of the processes of life. In this unit, students will be able examine the structure and function of prokaryotic and eukaryotic cells, including a discussion of the energy flow in photosynthesis, respiration and metabolism. A brief introduction to DNA structure and function from molecular to organism levels and current applications of DNA technology will be studied. This will also enlighten and introduce with classical genetic and evolutionary theory as unifying explanations of life. This course is intended for the student interested in understanding and appreciating common biological topics in the study of the smallest units within biology: molecules and cells.Evolution is the process of change in all forms of life over generations, and evolutionary biology is the study of how evolution occurs. Laboratory practicals will investigate enzyme function, cytogenetics and the genetic analysis of populations.

Contents

Cell Biology

1. Structure and Function of Bio-molecules (Carbohydrates, Lipids, Proteins, Nucleic Acids)
2. Cell: Cell theory, cell types, Brief description of structure and function of the following cell organelles, Reproduction in somatic and embryogenic cell, mitosis, meiosis and cell cycle
3. Genetics
4. Introduction, scope and brief history of genetics. Mendelian inheritance
5. Molecular genetics; DNA replication, nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. lac operon), Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and Euploidy. Evolution: Introduction and theories.

Lab work

Cell Biology

1. Study of cell structure using compound microscope and elucidation of ultra structure from electron microphotographs, Measurement of cell size, Study of mitosis and meiosis by smear/squash method and from prepared slides, Study of chromosome morphology and variation in chromosome number.
2. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.
3. Genetics, Genetical problems related to transmission and distribution of genetic material, Identification of chromosomes in plant material. Carmine/orcein staining, Determination of blood groups

Recommended Texts

1. Templeton, N.C. (2015). *Gene and cell therapy* (4th ed.) London: Taylor and Francis Publications,
2. Sybille, M., & Shoshan, M. (2015). *Tumor cell metabolism*. New York**:** Springer Publications**.**

Suggested Readings

1. Verma, P. S., & Agarwal, V. K. (2016). *Cell Biology* (*Cytology, Biomolecules and Molecular Biology*). New Dehli: S. Chand Publishing.
2. Milo, R., & Phillips, R. (2015). *Cell biology by the numbers.*(1st ed.) London: Taylor and Francis publications.

ZOOL 5103 Animal Form and Function-I (A Comparative Perspective) 4(3+1)

This course teaches about animal diversity adapted strategically for performance of their similar functions through modifications in body parts in past and present times. It imparts understanding of diverse structural adaptations in each of the functions of integumentary, skeletal, muscular, nervous, sensory, endocrine, circulatory and respiratory systems for effective survival in their specific conditions. The course mainly aims to teach the students about animal diversity adapted in different ways for their functions through modifications in body parts, about the diversity in integumentary, skeletal, muscular, nervous and sensory, endocrine, circulatory, respiratory, nutritive, excretory, osmoregulatory and reproductive systems according to strategies to survive in their specific conditions. It will also introduce about organ systems, their specialization and coordination with each other and constantly changing internal and external environment, inside and outside the animal's body along with the basic structure of each system that determines its particular function of animal body.

Contents

1. Protection, support, and movement: integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates/vertebrates
2. Communication: neurons, structure and function, sensory reception
3. Communication: endocrine system and chemical messengers: chemical messengers: hormones chemistry, hormones with principal function each of porifera, cnidarians, platyhelminthes, nemerteans, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system
4. Circulation and immunity: internal transport and circulatory systems in invertebrates, characteristics of invertebrate coelomic fluid, hemolymph, and blood cells, transport systems in vertebrates; characteristics of vertebrate blood, blood cells and vessels; hearts and circulatory systems of vertebrates; the human heart: blood pressure and the lymphatic system; immunity: nonspecific defenses, the immune response.

Lab work

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin
2. Study and notes of skeleton of fish (*Labeorohita*), frog (*Hoplobatrachustigerinus*), varanus (*Varanusbengalensis*), fowl (*Gallus domesticus*)and rabbit (*Oryctolaguscuniculus*): adaptations
3. Dissection of representative animals from invertebrate and vertebrate phyla
4. Study of heart, principal arteries and veins in a representative vertebrate (fish/frog dissection)

Recommended Texts

1. Pechenik, J. A. (2013). B*iology of invertebrates* (4thed.). Singapore: McGraw-Hill.
2. Hickman, C. P., Roberts, L. S., & Larson, A. (2004). *Integrated principles of zoology* (11thed.). Singapore: McGraw-Hill.

Suggested Readings

1. Campbell, N. A. (2002). *Biology* 6thed.). California: Benjamin Cummings.
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.

CHEM-5103 Organic Chemistry 4 (3+1)

The students will acquire knowledge about the basic concepts of organic chemistry, chemistry of hydrocarbons, functional groups and the mechanism of organic reactions. It will be useful for the qualitative analysis and synthesis of organic compound. Understanding and knowledge of new and advanced field of organic and also significances the importance of application of advanced techniques. This course is a foundation course for Organic Chemistry major courses of higher semester. The main objectives emphasized in this course involve developing an understanding of basic principles of organic chemistry. It develop critical thinking skills enabling students to solve general chemistry problems that incorporate their cumulative knowledge. Students learned in class to advanced organic chemistry concepts which give them opportunities to upgrade their knowledge about advanced organic concepts. The essence of this course is to develop study skills that students need to succeed in university-level chemistry courses and preparation of students for professional positions in the field of synthesis chemistry.

Contents

1. Basic concepts: atomic, molecular and hybrid orbitals: multiple localized and delocalized bonds, .
2. Introduction to spectroscopy with special reference to the infrared, ultraviolet/visible spectroscopy.
3. Hydrocarbons: classification of hydrocarbons. Nomenclature. Methods of preparation,
4. Stereoisomerism: conformational analysis of ethane and butane. Optical isomerism, optical activity,
5. Alkyl halide: nomenclature, method of preparation and chemical reaction
6. The hydroxyl group and ether: nature of hydroxyl group in phenol and alcohol.
7. Alcohol: classification and nomenclature, preparation method and chemical reaction
8. Ether: preparation and reactions.
9. The carbonyl group: nature and its reactivity, nomenclature of aldehyde and ketone, Carboxylic acid acid anhydrides, acid halides, acid amides, esters including glycerides. Introduction to amino acid.
10. Nitrogen compounds: amines; classification, nomenclature, preparation and chemical reactions, .

Organic Chemistry Lab.

1. Qualitative organic analysis; systematic identification of organic compounds containing group like COOH, OH, NH_2, C=O.
2. Purification techniques viz solvent extraction distillation and recrystallization, etc.
3. Preparation of simple organic compounds viz, Ethyl benzoate, benzoic acid, tribromophenol, aspirin, nitrobenzene.

Recommended Texts

1. Younas, M. (2006). *Organic Spectroscopy*. Lahore: A. H. Publisher.
2. Solomons, T.W.G. (2016).*Fundamentals of Organic Chemistry*. 12th edition, New York: Wiley.

Suggested Readings

1. Kemp, W. (1990). *Organic Spectroscopy*. London. Macmillan.
2. Chughtai, F. A. (1995). *Organic Reactions*, Lahore/Faisalabad: Majid Book Depot..

URCE-5103 Academic Writing 3(3+0)

Academic writing is a formal, structured and sophisticated writing tofulfill the requirements for a particular field of study. The course aims at providing understanding of writer's goal of writing (i.e. clear, organized and effective content)and to use that understanding and awareness for academic reading and writing. The objectives of the course are to make the students acquire and master the academic writing skills. The course would enable the students to develop argumentative writing techniques. The students would be able to the content logically to add specific details on the topics such as facts, examples and statistical or numerical values. The course will also provide insight to convey the knowledge and ideas in objective and persuasive manner. Furthermore, the course will also enhance the students' understanding of ethical considerations in writing academic assignments and topics including citation, plagiarism, formatting and referencing the sources as well as the technical aspects involved in referencing.

Contents

1. Academic vocabulary
2. Quoting, summarizing and paraphrasing texts
3. Process of academic writing
4. Developing argument
5. Rhetoric: persuasion and identification
6. Elements of rhetoric: Text, author, audience, purposes, setting
7. Sentence structure: Accuracy, variation, appropriateness, and conciseness
8. Appropriate use of active and passive voice
9. Paragraph and essay writing
10. Organization and structure of paragraph and essay
11. Logical reasoning
12. Transitional devices (word, phrase and expressions)
13. Development of ideas in writing
14. Styles of documentation (MLA and APA)
15. In-text citations
16. Plagiarism and strategies for avoiding it

Recommended Texts

Swales, J. M., & Feak, C. B. (2012). *Academic writing for graduate students: Essential tasks and skills* (3rd ed.). Ann Arbor: The University of Michigan Press.
Bailey, S. (2011). *Academic writing: A handbook for international students*(3rd ed.). New York: Routledge.

Suggested Readings

1. Craswell, G. (2004). *Writing for academic success*. London: SAGE.
2. Johnson-Sheehan, R. (2019). *Writing today*. Don Mills: Pearson.
3. Silvia, P. J. (2019). *How to write a lot: A practical guide to productive academic writing*. Washington: American Psychological Association.

URCI-5109 Introduction to Information & Communication Technologies 3(2+1)

The course introduces students to information and communication technologies and their current applications in their respective areas. Objectives include basic understanding of computer software, hardware, and associated technologies. They can make use of technology to get maximum benefit related to their study domain. Students can learn how the Information and Communications systems can improve their work ability and productivity. How Internet technologies, E-Commerce applications and Mobile Computing can influence the businesses and workplace. At the end of semester students will get basic understanding of Computer Systems, Storage Devices, Operating systems, E-commerce, Data Networks, Databases, and associated technologies. They will also learn Microsoft Office tools that includes Word, Power Point, Excel. They will also learn Open office being used on other operating systems and platforms. Specific software's related to specialization areas are also part of course. Course will also cover Computer Ethics and related Social media norms and cyber laws.

Contents

1. Introduction, Overview and its types.
2. Hardware: Computer Systems & Components, Storage Devices and Cloud Computing.
3. Software: Operating Systems, Programming and Application Software,
4. Introduction to Programming Language
5. Databases and Information Systems Networks
6. The Hierarchy of Data and Maintaining Data,
7. File Processing Versus Database Management Systems
8. Data Communication and Networks.
9. Physical Transmission Media&Wireless Transmission Media
10. Applications of smart phone and usage
11. The Internet, Browsers and Search Engines.
12. Websites Concepts, Mobile Computing and their applications.
13. Collaborative Computing and Social Networking
14. E-Commerce& Applications.
15. IT Security and other issues
16. Cyber Laws and Ethics of using Social media
17. Use of Microsoft Office tools (Word, Power Point, Excel), mobile apps or other similar tools depending on the operating system.
18. Other IT tools/software specific to field of study of the students if any

Recommended Texts

1. Vermaat, M. E. (2018). *Discovering computers: digital technology, data and devices.*Boston: Course Technology Press.
2. Skoog, D. A., West, D.M., & Holler, F.J. (1994). *Analytical Chemistry* (6th ed.). London: Saunders College Publications.

Suggested Readings

1. Timothy J. O'Leary & Linda I.(2017).*Computing essentials*,(26th ed.).San Francisco: McGraw Hill Higher Education.
2. Schneider, G. M., &Gersting, J. (2018). *Invitation to computer science*. Boston: Cengage Learning.

BOTN-5104 Plant Physiology and Ecology 4(3+1)

Plant physiology is a sub-discipline of botany concerned with the functioning, or physiology, of plants. Closely related fields include plant morphology, plant ecology, photochemistry, cell biology, genetics, biophysics and molecular biology. Plant physiology is the study of how different parts of plants function. It includes many aspects of plant life, including nutrition, movement, and growth. This course is designed to provide students with comprehensive exposure to the subject of plant physiology and ecology and will give know how about physiological adaptation; limiting factors; resources acquisition/allocation; photosynthesis, carbon, energy balance; water use and relations; nutrient relations; linking physiology, stable isotope applications Eco physiology; stress physiology; life history, physiology; evolution of physiological performance; physiology population, community, ecosystem levels. Plant Ecology is the study of the interactions of living things with their environment. It helps to ask questions across four levels of biological organization—organismal, population, community, and ecosystem.

Contents

Plant Physiology

1. Water relations, Absorption and translocation of water. Mineral nutrition: Soil as a source of minerals, role and deficiency symptoms of macronutrients, Photosynthesis and Respiration
2. Ecology
3. Introduction: Aims and applications of ecology. Soil, Light, Temperature, Water, Wind, Population Ecology, Community Ecology, Ecosystem Ecology, Applied Ecology

Lab work

Plant Physiology

1. Preparation of solutions and their standardization, Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations, Measurement of leaf water potential by the dye method, Determination of the temperature at which beet root cells lose their permeability, Determination of the effects of environmental factors on the rate of transpiration,
2. Extraction of chlorophyll from the leaves and separation of component pigments on a paper chromatogram, Study of absorption spectra using spectrophotometer, Estimation of oxygen utilized by a respiring plant by Winkler's method.

Ecology

3. Determination of physical and chemical characteristics of soil, Measurements of various population variables, Measurement of vegetation by Quadrat and line intercept methods, Field trips to ecologically diverse habitats, Measurements of wind velocity, light and temperature, Effect of light and temperature on seed germination.

Recommended Texts

1. Sharma, H.,& Singh,P. K. (2018). *Laboratory manual for bioinstrumentation, biochemistry, microbiology, cell biology and enzyme technology for PG and UG students*. New Delhi, India:
2. Excellent Publishing House.
3. Jugulam, M. (2017). *Biology, physiology and molecular biology of weeds*. New York: CRC Press.

Suggested Readings

1. Keddy, P. A. (2017). *Plant Ecology Origins, Processes, Consequences*. (2nd ed.) Cambridge: Cambridge University Press.
2. Canadell, J. G., Diaz, S., Heldmaier, G., Jackson, R. B., Levia, D.F., Schulze, E. D., , U., & Wardle, D. A. (2019). *Ecological studies*. New York: Springer.

ZOOL-5104 Animal Form and Function-II 4(3+1)

This course will enable students to understand the diversity in animal form and function adapted according to the modified environmental conditions. Students will also be provided understanding about the need of emergence of diversity of forms for the performance of similar function in variable conditions. It also demonstrates that a form is successfully adapted to perform a function successfully according to its own environment. Upon successful completion of course students will have knowledge about nutrition and digestion process among animal groups, temperature regulation strategies adapted by animals and different modes of reproduction in several groups for their successful stay on planet. The practical section will let them to study the excretory system in invertebrate and vertebrate model animals, can study nutritive canal in an invertebrate and a vertebrate animals through dissection and will be able to study the male and female reproductive system of an invertebrate and a vertebrate animal model with familiarity of major differences in them.

Contents

1. Nutrition and Digestion: Evolution; the metabolic fates of nutrients in heterotrophs; diversity in digestive structures of invertebrates,
2. Mammalian digestive system: gastrointestinal motility, digestion; pancreas, liver and gallbladder
3. Temperature and body fluid regulation: homeostasis and temperature regulation in invertebrates
4. Temperature regulation in fishes, amphibians, reptiles, birds and mammals;
5. Control of water and solutes in fishes, amphibians, reptiles, birds and mammals
6. Invertebrate and vertebrate: excretory systems
7. Reproduction and development: asexual and sexual reproduction in invertebrates;
8. Sexual reproduction in various vertebrate classes; human male and female reproductive system,
9. Prenatal development, birth, placenta; milk production and lactation in human.

Lab work

1. Study of excretory system in an invertebrate and a vertebrate representative (Model).
2. Study of digestive system in invertebrate and a vertebrate representative (Dissection).
3. Dissection and study of male and female reproductive system in vertebrates and invertebrates.

Recommended Texts

1. Pechenik, J. A. (2013). *Biology of invertebrates* (4th ed.). Singapore: McGraw-Hill.
2. Hickman, C. P., Roberts, L. S., & Larson, A. (2004). *Integrated principles of zoology* (11th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Campbell, N. A. (2002). *Biology* (6th ed.). California: Benjamin Cummings.
2. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.
3. Hickman, C. P. & Kats, H. L. (2000). *Laboratory studies in integrated principles of zoology*. Singapore: McGraw-Hill.

CHEM-5104 Chemistry Special Topics 4 (3+1)

This course covers a range of specialized topics in chemistry which provide a useful supplement to the advanced courses specified in the department. Student will be able to learn the basic knowledge of biomolecules, simple heterocycles and introductory organic spectroscopy, is helpful in identification of organic compounds. In addition to it, basics of surface chemistry, modern material and detail study of unit operations in chemical industry and metallurgy can be a beneficial for new learners who are ambitious for specialized area of chemistry.The main objectives emphasized in this course involves developing an understanding of basic principles of different branches of chemistry. It develops critical thinking skills enabling students to solve general chemistry problems that incorporate their cumulative knowledge. Students learned in class to advanced chemistry concepts which give them opportunities to upgrade their applicable knowledge. This course is to develop study skills that students need to succeed in university-level advanced chemistry courses and preparation of students for professional positions in this field and their industrial skill.

Contents

1. Bio-molecules and Simple Heterocycles: (carbohydrates, proteins, lipids, nucleic acids, their importance, nomenclature, properties, synthesis and reactions of simple heterocycles).
2. Introduction to Spectroscopy: (IR and UV/Vis).
3. Surface Phenomena and Colloids: (Physisorption and chemisorption, isotherms, types, properties, preparation and applications of colloids).
4. Nuclear Chemistry: (radioactivity; stability of nuclei, nuclear transformation, measurement
5. Modern Materials: (Introduction to liquid crystals, Inorganic polymers, Ceramics, Fiber glass, Thin films, Semiconductors and Composite materials).
6. Chemical Industries: (Metallurgy of Al, Manufacturing of sulphuric acid, nitric acid, fertilizers, cement and glass).

Lab work

1. Percentage determination of barium in barium nitrate by gravimetric method.
2. Estimate the glucose content in the sample by titration method
3. Determination of adsorption parameters using Langmuir adsorption isotherm of acetic acid on charcoal.
4. To determine the wavelength of maximum absorption of compounds using spectrophotometer.
5. To determine the Iodine value of the oil and fat
6. Estimate the glucose content in the sample by titration method
7. Identification Al^{3+}, Cr^{3+} and F^{3+} in samples by TLC
8. Qualitative analysis of lipids, proteins, carbohydrates

Recommended Texts

1. Voet, D. R., and Voet, J. G. (2001). *Biochemistry*. New Jersey: John Wiley and Sons.
2. Solomons, T.W.G. (2016). *Fundamentals of Organic Chemistry*. 12th edition, New York: Wiley.

Suggested Readings

1. Kent, J.A. (1997). *Riegal's Handbook of Industrial Chemistry*. New Delhi: CBS Publishers and Distributors,.
2. Arnikar, H.J. (1998). *Nuclear Chemistry*. New Delhi: Krishna Prakashan Media (P) Ltd.

BOTN-5105 Biodiversity and Conservation 3(2+1)

Over the years, the depletion of biodiversity has been quite active. This is happening as a result of habitat loss, excessive exploitation of resources, climatic changes, diseases, pollution, poaching of animals etc. In order to correct this scenario, biodiversity conservationhas been majorly stressed by governments and social organizations. It must be understood that human beings cherish almost all benefits from the biodiversity. Hence, they should focus on taking proper care associated with the preservation of biodiversity in different forms. It is important because there must be something left for the future generation to look at. We as human beings should curb the degradation as well as the destruction of the habitats, upholding the biodiversity at its prime level. Biodiversity conservation is basically aimed at protection, enhancement and scientific management of the biodiversity. To be precise, manage it at its threshold level and acquire sustainable benefits both for the present and future population. Biodiversity and conservation maintain crucial ecological processes as well as life support systems.

Contents

1. Biodiversity: Definition, types and threats.
2. Threats to Biodiversity; deforestation, over grazing, erosion, desertification, ecosystem degradation, bio invasion, pollution and climate change.
3. Biodiversity of Pakistan.
4. Measuring biodiversity: Alpha, Beta and Gamma diversity; Systematic and functional diversity.
5. Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. utility of bio resources).
6. Sustainable and unsustainable use of biological resources.
7. Biodiversity Hot spots of Pakistan and the world.
8. International treaties/agreements regarding Biodiversity and Conservation; CBD, CITES, Ramsar.
9. Conservation strategies; *in situ, ex situ, in vitro* conservation.
10. Conservation *vs* preservation.
11. IUCN categorized protected areas in Pakistan; red listing, Environmental Impact Assessment.
12. Use of herbarium and Botanical Garden in biodiversity and conservation.
13. Concept of pastures and wild life management.
14. Global Biodiversity Information Facility (GBIF).

Lab work

1. Inventory of plant biodiversity in various habitats.
2. Field survey for baseline studies and Impact Assessment.
3. Identification of wild plant species used by local communities in different ecosystems.

Recommended Texts

1. Walker, T., (2015). *Plant Conservation: Why it Matters and How it Works*. New York, Timber Press.
2. Pellens, P. and P. Grandcolas, (2016). *Biodiversity Conservation and Phylogenetic Systematics*. Swetzerland: SIP AG.

Suggested Readings

1. Boenigk, A., S., Wodniok and E. Glucksman. (2015). *Biodiversity and Earth history*. New York: Springer.
2. Scherson, R.A, (2018). *Phylogenetic Diversity*. New York: Springer.

URCM-5101 Introduction to Mathematics 3(3+0)

This course is built upon the mathematical concepts, principles and techniques that are useful in almost all undergraduate programs. Mathematics includes the study of such topics as quantity, structure, space, and change. It has no generally accepted definition. Mathematicians seek and use patterns to formulate new conjectures; they resolve the truth or falsity of such by mathematical proof. The main objectives of the course are to enhance student's competency in application of mathematical concepts in solving problems and to improve their level of quantitative approach. Upon the successful completion of this course students would be able to develop understanding: Mathematical functions, Building and solving linear and quadratic equations, Matrices and Determinants with application, sequences and series, and basic Financial Mathematics. To prepare the students, not majoring in mathematics, with the essential tools of financial, algebra and geometry to apply the concepts and the techniques in their respective disciplines.

Contents

1. Linear Equations and Quadratic Equations: Formation of Linear equation
2. Solving Linear equation involving one variable
3. Solution of Quadratic equation by factorization method
4. Solution of quadratic equation by square completion methods
5. Solution of quadratic equation by quadratic formula
6. Application of quadratic equation
7. Sequences and Series
8. Matrices and Determinants: Introduction of matrices
9. Types of matrices, Matrix operations
10. Inverse of matrix, The determinants and its properties
11. Solution of system of linear equations by determinants: Cramer's rule, Inverse Matrices Method
12. Mathematics of Finance: Simple interest, Compound interest
13. Annuities, Sets and Sets Operations
14. Permutation and combinations
15. Introduction to mathematical induction and binomial theorem
16. Basic Concepts of Trigonometry, Fundamental Identities of Trigonometry

Recommended Texts

1. Frank, S. B. (1993). *Applied mathematics for business, economics, and the social Sciences* (4th ed.). New York: McGraw-Hill publisher.
2. Nauman, K. (2019). Basic mathematics-I: algebra and trigonometry (2nd ed.). Lahore: Al-Hassan Pub.

Suggested Readings

1. Kaufmann, J. E. (1994). *College algebra and trigonometry* (3th ed.). Boston: PWS-Kent Pub. Co.
2. Swokowski, E. W. (1993). *Fundamentals of algebra and trigonometry* (8th ed.). Boston: PWS-Kent Pub. Co.

BOTN-6106 **Biostatistics** **3(3+0)**

This course is designed for under graduate programs of science and medical disciplines. Biostatistics is the application of statistical methods (summarizing data and drawing valid inferences based on limited information) to biological systems, more particularly, to humans and their health problems. This course deals with statistical concepts and terminology and basic analytic techniques. The purpose of the course is to give students an introduction to the discipline, an appreciation of a statistical perspective on information arising from the health arena and basic critical appraisal skills to assess the quality of research evidence. This course is also explores the importance of risk factors and effective decision making strategies. The course covers several statistical tools for analyzing biological data through statistical methods with practical applications. This course will also focus on the knowledge of statistical softwares such as Minitab, R etc. for the analysis of biological data. This course will help the students to improve their analytical skills and support for further research.

Contents

1. Definition of Biostatistics, and its importance
2. The type of variables and observations in biological, Health and medical sciences
3. Uniqueness in terms of behavior of variables their domain, and units.
4. Categorical. Numerical data, Censored data.
5. Population, Target populations and samples.
6. Role of sampling in biostatistics
7. Size of samples of various types of studies.
8. Proportions, rates and ratios
9. Incidence, prevalence and odds.
10. Measures of central tendency: Mean, Median, Mode
11. Measures of dispersion: Variance, Standard deviation, CV, MD
12. Distributional behavior of biological variables (Binomial, Poisson and Normal).
13. Probit Models
14. Logit transformations and their analysis,
15. Confidence interval
16. Hypothesis testing: Z-test, t-test, F-test and Chi-square test
17. Analysis of variance
18. Regression Analysis

Recommenced Texts

1. Zar, J. (2000). *Biostatistical analysis* (5^{th} ed.). New York: John Wiley and Sons.
2. Shoukri, M.M , & Pause, C.C. (1998). *Statistical Methods for Health Sciences* (2^{nd} ed.). Florida: CRC press.

Suggested Readings

1. Daniel, W.W. (2010). *Biostatistics: A foundation for the health sciences* (6^{th} ed.). New York: John Wiley & Sons.
2. Diggle, P., Diggle, P. J., Heagerty, P., Liang, K. Y., Heagerty, P. J., & Zeger, S. (2002). *Analysis of longitudinal data* (2^{nd} ed.). London: Oxford University
3. Dunn, G. & Everit, B. (1995). *Clinical Biostatistics* (15^{th} ed.). London: Edward Arnold.

BOTN-6107 Bacteriology and Virology 3(2+1)

The aim of the course is to understand the morphology, structure and economic importance of Viruses and Bacteria. Bacteriology is the branch and specialty of biology that studies the morphology, ecology, genetics and biochemistry of bacteria as well as many other aspects related to them. Virology is the study of viruses – submicroscopic, parasitic particles of genetic material contained in a protein coat – and virus-like agents. Bacteriology and Virology is a three credit hour course for BS in Botany. The main objectives of this course are to establish the basic knowledge on microbes, mostly bacteria and viruses, and their relationships with other organisms, mainly plants and animals. The course is divided into two main sections corresponding to the type of microorganism studied. The Bacteriology part includes: the historical accounts of microbiology, the bacterial structure, physiology and metabolism, the diversity and classification of bacteria, the various ways to control microorganisms, microbial ecology, food and industrial microbiology and finally an introduction to descriptive epidemiology.

Contents

1. Viruses: General features of viruses, viral architecture, classification, dissemination and replication of single and double - stranded DNA/RNA viruses. Plant viral taxonomy. Virus biology and virus transmission. Molecular biology of plant virus transmission. Symptomatology of virus-infected plants, Metabolism of virus-infected plants. Resistance to viral infection. Methods in molecular virology.
2. Bacteria: History, characteristics and classification. Evolutionary tendencies in Monera. Morphology, genetic recombination, locomotion and reproduction in bacteria. Bacterial metabolism. Importance of bacteria with special reference to application in various modern Sciences specially agriculture, biotechnology and genetic engineering. Symptoms and control of major bacterial diseases in Pakistan, Plant microbe interaction

Lab work

1. Viruses: Observation of symptoms of some viral infected plant specimens. Bacteria, Actinomycetes and Cyanobacteria. Methods of sterilization of glassware and media etc. Preparation of nutrient medium and inoculation. Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
2. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques).Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Recommended Texts

1. Black J. & Black, L. (2017). *Microbiology - Principles and Exploration (*10th ed.). Arlington: John Wiley and Sons, Inc.
2. Willey, J., Sherwood, L. & Woolverton, C. (2017). *Prescott's microbiology* (10th ed.). Kent State: McGraw-Hill Companies, Inc.

Suggested Readings

1. Mandahar,C. L., (2017). *Plant viruses: structure and replication* (1st ed.). Florida: CRC Press, Taylor & Francis Group Publishers.
2. Arora, A., (2017). *Textbook of microbiology* (5th ed.). India: CBS Publishers and Distributors.

BOTN- 6108 **Phycology and Bryology** **3(2+1)**

This course aims to understand the classification, morphology and economic importance of Algae and Bryophytes. This course provide basic knowledge about the structure and reproduction of algae and bryophytes and their evolutionary tendencies and to introduce the students with different species of algae and bryophytes, their collection methods, mounting and specimen identification and to enable the students to visualize and understand microscopic differences between algae and bryophytes and their importance. An advanced level course encompassing all the details related to evolution, types, ecology and economic importance of algae. The second half of the course will provide detailed information on Introduction and general account of bryophytes, classification, and brief study of Hepaticopsida, Anthoceropsida and Bryopsida. By the completion of the course, students will be able to understand the structural difference between algae and bryophytes and their evolutionary trends. Students will also collect, identify and prepared stain slides for different specimens.

Contents

1. Phycology Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Chlorophyta, Charophyta, Xanthophyta, Bacillariophyta, Phaeophyta and Rhodophyta.
2. Bryology: Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida, Anthoceropsida and Bryopsida.

Lab work

Phycology

1. Collection of fresh water and marine algae.
2. 2.Identification of benthic and planktonic algae
3. Section cutting of thalloid algae
4. Preparation of temporary slides, Use of camera lucida/micrographs.
5. Bryology
6. Study of the following genera:
7. *Pellia, Porella, Anthoceros and Polytrichum*.

Recommended Texts

1. Lee, R. E. (2019). *Phycology* (5th ed.). England: Cambridge University Press.
2. Bellinger, E., (2015). *Freshwater algae*(2nd ed.). New Jersey: John Wiley and Sons Ltd.

Suggested Readings

1. Barsanti, L. & Gualtieri, P. (2014). *Algae: anatomy, biochemistry, and biotechnology* (1st ed.). Florida: CRC Press, Taylor and Francis Group.
2. Hussain, F. (2016) *Phycology: A text book of algae* (1st ed.). Lahore: Pak Book Empire.

BOTN-6109 Mycology and Plant Pathology 3(2+1)

The aim of the course is to introduce the students to Mycology and diseases caused by Fungi, to develop an understanding of the diversity of organisms in the Kingdom Fungi. This course will provide students with basic concepts and identification of fungi, plant pathogens and diseases caused to various important crops. Students will be able to: identify major fungal groups based on morphology (both in the field and in the lab); understand and explain the ecological roles and trophic modes of major fungal groups; use fungal biology resources to understand fungal nomenclature and systematic; demonstrate a broad knowledge of core concepts in Plant Pathology; disease diagnosis and management. Upon completion of the course the student will be able to: describe the concepts of what constitutes disease in plants. Identify major principles of plant pathology; recognize the etiological agents of disease. Employ methods to diagnose and manage a wide range of plant diseases; describe aspects of integrated pest management; explain the impact of plant disease on human affairs.

Contents

1. Mycology: Introduction: General characters of fungi, Thallus, cell structure and ultra structure of fungi. Reproduction: Asexual and sexual reproduction and reproduction structures, life cycle, haploid, heterokaryotic and diploid states.
2. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction
3. Symbiotic relationships of fungi with other organisms (lichens and mycorrhiza) and their significance. Importance of fungi in human affairs with special reference to Industry and Agriculture.
4. Pathology: Introduction and classification of plant diseases. Symptoms, causes and development of plant diseases.
5. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

Lab work

1. Mycology: General characters and morphology of fungi. Study of unicellular and mycelial forms with septate and aseptate hyphae. Distinguishing characters of different phyla: study of suitable examples. Study of asexual and sexual reproductive structures in different groups of fungi. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.
2. Pathology: Identification of major plant pathogens under lab and field conditions, cultural studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogencity. Demonstration of control measures through chemotherapeutants.

Recommended Texts

1. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (2nd ed.). New York: APS Press, The American Phytopathological Society.
2. Burchett, S., & Burchett, S. (2018). *Plant pathology (*1st ed.). New York: Garland Science Published.

Suggested Readings

1. Phillips, M., (2017). *Mycorrhizal planet: how symbiotic fungi work with roots to support plant health and build soil fertility* (1st ed.). New York: Chelsea Green Publishing Company.
2. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (1st ed.). New York: APS Press, The American Phytopathological Society

BOTN-6110 Diversity of Vascular Plants 3(2+1)

This course provides a comparative study of pteridophytes, gymnosperms and angiosperms, integrating form, function and ecology. This course is designed to introduce students to the major lineages of vascular plants, including the ferns, gymnosperms and flowering plants; to enable the students to understand and appreciate the biology and evolution of plant architecture; to examine the evolutionary origins of plants and the impacts humans have had on plant evolution and diversity; to explore the methods of fossilization and its importance in biology; to get a broad overview of Pteridophytes, Gymnosperms and Angiosperms; to have a good overview of the general morphology, sexual reproduction and diversity of the different divisions of vascular plants; to emphasize appropriate science skills, in lab, including experimental observation, and illustration in various groups of vascular plants. Students will be able to: recognize the major groups of vascular plants; differentiate them by their principal characters, and understand their phylogenetic relationships.

Contents

1. Pteridophytes Introduction, origin, history, features and a generalized life cycle. Methods of fossilization, types of fossils, geological time scale and importance of paleobotany. First vascular plant Rhyniophyta e.g. *Cooksonia*. General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilopsida (*Psilotum*), Lycopsida (*Lycopodium, Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Ophioglossum*, *Dryopteris* and *Marsilea*).
2. Origin and Evolution of seed habit.
3. Gymnosperms: Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales, Coniferales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms.
4. Angiosperms: Origin, general characteristics, importance, and life cycle of angiosperms.
5. Palynology: An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration. Basic information about the nomenclature, morphology and classification of living and fossil pollen and spores.

Lab work

1. To study the morphological and reproductive features of available genera.
2. Study trips to different parts of Pakistan for the collection and identification of important pteridophytes, gymnosperms and angiosperms.
3. Study of pollen morphology.

Recommended Texts

1. Maarten J., Christenhusz, M., & Michael F., (2017). Chase, *plants of the world: an illustrated encyclopedia of vascular plants* (1st ed.). United States: Kew publishing.
2. Maarten J., Christenhusz, M., Michael F. & Byng, J.W. (2018). *The global flora: a practical flora to vascular plant species of the world* (1st ed.). Bradford: Plant Gateway Limited.

Suggested Readings

1. Hobohm, C., (2016). *Endomism in vascular plants* (1st ed.). New York: Columbia University Press.
2. Bowcutt, F. & Hamman, S., (2016). *Vascular plants of the south sound prairies* (1st ed.). Washington: Evergreen State College Greener Bookstore .

BOTN-6111 **Plant Systematics** **3(2+1)**

Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. The aim of the course is to know floral composition/system of classification focusing on identification, classification, and description nomenclature and flora writings monographs; an introduction to the goals and methods of plant systematics, and a survey of the diversity of vascular plants, including ferns, conifers, flowering plants, and related groups. Plant systematics is the study of flowering plant diversity. Lectures cover the processes of plant reproduction and evolution, patterns of plant diversity and biogeography, and the methods used to analyze and interpret these patterns and processes. The laboratory presents a survey of the vascular plants with a focus on major plant families, emphasizing prominent groups in natural habitats and in cultivation.

Contents

1. Introduction: Importance and relationship with other sciences, Phases of plant taxonomy. Origin and radiation of angiosperm, their probable ancestors, when, where and how did the angiosperms evolve; the earliest fossil records of angiosperms.
2. Concept of Species: What is a species? Taxonomic species, Biological species, Micro and macro species, Species aggregate. Infra specific categories. Speciation: Mechanism of speciation, Mutation and hybridization, Geographical isolation, Reproductive isolation, Gradual and abrupt. Variation: Types of variation, continuous and discontinuous variation, Clinal variation.
3. Systematics and Gene ecology / Biosystematics: Introduction and importance, Methodology of conducting biosystematics studies, various biosystematics categories such as ecophene, ecotype, ecospecies, coenospecies and comparium.
4. Taxonomic Evidence: Importance and types of taxonomic evidences: anatomical, cytological, chemical, molecular, palynological, geographical and embryological.
5. Nomenclature, Classification: Why classification is necessary? Importance of predictive value. Brief history, Different systems of classification with at least one example of each (Linnaeus, Bentham and Hooker, Engler and Prantle, Bessey, Cronquist, Takhtajan and Dahlgren).
6. Brief introduction of Numerical taxonomy**,** General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the families of angiosperm

Lab work

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan. Field trips shall be undertaken to study and collect plants from different ecological zones of Pakistan.
2. Preparation of indented and bracketed types of keys. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters.
3. Study of variation pattern in different taxa. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination.

Recommended Texts

1. Simpson, M., (2019). *Plant systematics* (3rd ed.). New York: Elsevier.
2. Novikov, A. & Barabasz-Krasny, B., (2015). *Modern plant systematic* (1st ed.).Ukrainian: Liga-Press.

Suggested Readings

1. Hoorn, C., Perrigo, A. & Antonelli, A., (2018). *Mountains, climate and biodiversity* (1st ed.). New Jersey: Wiley-Blackwell.
2. Shipunov, A., (2018). *Introduction to botany* (1st ed.). North Dakota: Minot State University Publications.

BOTN-6112 **Plant Anatomy** **3(2+1)**

The aim of the course is to provide the students understanding about anatomical features of vascular plants. The objectives of the course are: to provide students with skills necessary to section and stain fresh plant material in preparation for study of plant anatomy; to train students in the proper use of the compound light microscope and to give them experience in interpreting images that they see through the microscope in terms of how plant structure is related to function; to provide students with skills in modern microscopic digital image capture. This course explains primary growth, initiation of lateral meristems, and secondary growth in roots using appropriate terminology. This course gives information to identify the parts of a leaf and distinguish between compound and simple leaves. Identify the anatomy and morphology (cells, tissues, and tissue systems) of a given plant leaf and to identify the anatomy.

Contents

1. The plant body and its development: Fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives. Apical meristem: Delimitation, different growth zones, evolution of the concept of apical organization. Shoot and root apices.
2. Leaf: types, origin, internal organization, development of different tissues with special reference to mesophyll, venation, bundle-sheaths and bundle-sheath extensions. Enlargement of epidermal cells.
3. Vascular cambium: Origin, structure, storied and non-storied cell types, types of divisions: additive and multiplicative; cytoplasmic characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth. Origin, structure, development, functional and evolutionary specialization of the tissues,
4. Periderm, Secretory tissues, Anatomy of Reproductive parts: Flower, Seed, Fruit, Economic aspects of applied plant anatomy. Anatomical adaptations, Molecular markers in tree species used for wood identification.

Lab work

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth, Peel and ground sectioning and maceration of fossil material.
3. Comparative study of wood structure of gymnosperms and angiosperms with the help of prepared slides.

Recommended Texts

1. Crang, R., Lyons-Sobaski, S. & Wise, R., (2018). *Plant anatomy: a concept-based approach to the structure of seed plants* (1st ed.). New York: Springer.
2. Schweingruber, F. H. & Borner, A., (2018). *The plant stem: a microscopic aspect*(1st ed.). New York: Springer.

Suggested Readings

1. Hacke, U. G., (2015). *Functional and ecological xylem anatomy* (2nd ed.). New York: Springer International Publishing.
2. Steeves, T.A. & Sawhney, V.K., (2018). *Essentials of developmental plant anatomy* (1st ed.). London: Oxford University Press.

BOTN-6113 **Genetics-I** **3(2+1)**

This course provides the basic biology to understand all of following issues better, tries to clarify some misconceptions, and tries to prepare students for future, more advanced coursework in Genetics. Genetics is the study of how genes bring about characteristics, or traits, in living things and how those characteristics are inherited. The aim of the course is to learn and apply concepts of modern transmission and molecular genetics. The objectives of the are: to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes; to solve transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes; to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes. This course discusses the principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms.

Contents

1. Extensions of Mendelian Analysis, Linkage I: Basic eukaryotic chromosome mapping: The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps
2. Linkage II: Special eukaryotic chromosome mapping techniques: Accurate calculation of large map distances, analysis of single meiosis, mitotic segregation and recombination, mapping human chromosomes.
3. Recombination in Bacteria and their Viruses, The Structure of DNA: DNA: The genetic material, DNA replication in eukaryotes, DNA and the gene. The Nature of Gene, DNA Function.
4. The Extranuclear Genome, Developmental Genetics: Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease. Population Genetics: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Lab work

1. Arrangement of genetic material: Linkage and recombination, Gene mapping in diploid, Recombination in Fungi, Recombination in bacteria, Recombination in viruses. Population Genetics: Gene frequencies and equilibrium, Changes in gene frequencies. Blood group and Rh-factor
2. Drosophila: Culture technique, Salivary gland chromosome. Fungal Genetics: *Saccharomyces* culture techniques and study. Studies on variation in maize ear size and colour variation. Bacterial Genetics: Bacterial cultural techniques, Gram staining (*E. coli, B. Subtilis*), Transformation, Conjugation.

Recommended Texts

1. Klug, W. S., Cummings, M. R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics* (12th ed.). New York: Pearson Publishers.
2. Klug, W. S., Cummings, M. R., Spencer, C. A. & Palladino, M. A., (2016). *Concepts of genetics* (11th ed.). New York: Pearson Publishers.

Suggested Readings

1. Grotewold, E., Chappell, J. & Kellogg, E. A., (2015). *Plant genes, genomes and genetics* (1st ed.). New Jersey: Willey Blackwell.
2. Carey, N., (2016). *The epigenetics revolution* (2nd ed.). London: Publisher Icon *Books* Ltd.

BOTN-6114 Plant Biochemistry-I 3(2+1)

Plant biochemistry is not only an important field of basic science explaining the molecular function of a plant, but is also an applied science that is in the position to contribute to the solution of agricultural and pharmaceutical problems. The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialized knowledge and understanding of selected aspects. This course gives information to understand the fundamental chemical principles that govern complex biological systems. Biochemistry is the study of the chemical processes that drive biological systems. Biochemistry is both life science and a chemical science - it explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. At the end of the course students will be enable to understand; an understanding of fundamental biochemical principles.

Contents

1. Introduction to photosynthetic organisms, Bioenergetics and overview of photosynthesis, Introduction to carbohydrates: Occurrence and classification, sugar structures, synthesis of polysaccharides
2. Introduction to lipids: Occurrence, classification, structure and chemical properties of fatty acids,
3. Introduction to Proteins: Aminoacids and their structure. Electrochemical properties and reactions of amino acids. Classification of proteins, Protein targeting, protein folding and unfolding, Introduction to Nucleic Acids: General introduction. Purine and pyrimidine bases,
4. Introduction to Enzymes: Nature and functions, I.U.E. classification with examples of typical groups, Isoprenoid metabolism, biosynthetic pathways.

Lab work

1. Solutions, acids and bases, electrolytes, non-electrolytes, buffers, pH and chemical bonds.
2. To determine the R_f value of monosaccharide's on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically/spectrophotometrically. To determine the saponification number of fats.
4. To extract and estimate oil from plant material using soxhlet apparatus. Analysis of various lipids by TLC methods. To estimate soluble proteins by Biuret or Lowry or Dye-binding method.
5. To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
6. To determine $R_f$value of amino acids on a paper chromatogram. Extraction of Nucleic acids from plant material and their estimation by UV absorption or colour reactions, To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source, To determine the PKa and isoelectric point of an amino acid.

Recommended Texts

1. Nelson, D. & Cox, M., (2017). *Lehninger: principles of biochemistry* (7^{th} ed). New York: W.H. Freeman.
2. Heldt, H. & Piechulla, B., (2016). *Plant biochemistry* (1^{st} ed.). London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C.W., (2015). *Fundamentals of biochemistry* (5^{th} ed.). New Jersey: John Wiley and Sons.
2. Mitra, G. N., (2015). *Plants: A biochemical and molecular approach* (1^{st} ed.). New Dehli: Springer.

BOTN-6115 **Plant Ecology-I** **3(2+1)**

The aim of the course is to understand the role and interaction of plants with their environment. Plant Ecology is the study of organisms, populations, and communities as they relate to one another and interact in the ecosystems they comprise. In plant ecology, ecosystems are composed of organisms, the communities they comprise, and the non-living aspects of their environment. Ecosystem processes are those that sustain and regulate the environment. Ecological areas of study include topics ranging from the interactions and adaptations of organisms within an ecosystem to the abiotic processes that drive the development of those ecosystems. The course deals with plants life history and functional traits, demography, and interactions between plants, between plants and animals and between plants and the remaining ecosystem. The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving.

Contents

1. Introduction: History and recent developments in ecology.
2. Soil: Nature and properties of soil (physical and chemical), water in the soil-plant-atmosphere continuum, the ionic environment and plant ionic relations, nutrient cycling. Physiology and ecology of N, S, P and K nutrition. Heavy metals (brief description), salt and drought stress and osmoregulation.
3. Light and temperature: Nature of light, factors affecting the variation in light and temperature, responses of plants to light and temperature, adaptation to temperature extremes. Carbon dioxide: Stomatal responses, Ecophysiological effects of changing atmospheric CO_2concentration.
4. Water: Water as an environmental factor, role of water in the growth, adaptation and distribution of plants, water status in soil, water and stomatal regulation, transpiration of leaves and canopies.
5. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, morph-anatomical changes during oxygen deficiency, post-anoxic stress. Wind as an ecological factor. Fire as an ecological factor. Carbon credit

Lab work

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO_2 and O_2 concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem. pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.

Recommended Texts

1. Keddy, P. A., (2017). *Plant ecology origins, processes, consequences* (2nd ed.). Cambridge: Cambridge University Press.
2. Canadell, J. G., Diaz, S. Heldmaier, G., Jackson, R.B., Levia, D.F., Schulze, E.D., Sommer, U. & Wardle, D. A., (2019). *Ecological studies* (1st ed.). New York: Springer.

Suggested Readings

1. Fath, B., (2018). *Encyclopedia of ecology* (2nd ed.). New York: Elsevier.
2. Keddy, P. A., (2018). *Wetland ecology: principles and conservation*, (2nd ed.). Cambridge: Cambridge University Press.

BOTN-6116 **Plant Physiology-I** **3(2+1)**

This course provides an introduction to basic principles of plant functions including physical processes occurring in plants, photosynthesis, respiration, pathway of translocation, gaseous exchange, mechanism of stomatal regulation and growth and development. This course aims to develop understanding of the relationship of complementary metabolic pathways such as photosynthesis and respiration in energy acquisition and use during plant development and to develop understanding of the environmental influences upon carbon metabolism in plants (e.g. with respect to alternative fixation pathways, photoinhibition, and photorespiration). Plant physiology deals with all the internal activities of plants. The subject here to describe plant physiology-I comprises on harvesting of light by plants and its conversion into a chemical energy, mechanism of oxygen evolution by plants, cyclic and non-cyclic electron transport chain. This also gives information about dark reaction, C_3, C_4 cycle, mechanisms of photosynthesis in CAM plants and phloem transport.

Contents

1. Photosynthesis: History of photosynthesis, nature and units of light, determination of oxygenic and an oxygenic photosynthesis
2. Respiration: Synthesis of hexose sugars from reserve carbohydrates, mechanism of respiration-glycolysis, differences between cytosolic and chloroplastidicglycolysis, oxidative decarboxylation, Krebs cycle, regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation, aerobic and anaerobic respiration. Energetics of respiration, pentose phosphate pathway, glyoxylatecycle, cyanide resistant respiration.
3. Translocation of Food: Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading. Leaves and Atmosphere: Gaseous exchange, mechanism of stomata regulation, factors affecting stomatal regulation. Assimilation of Nitrogen, Sulphur and Phosphorus: The nitrogen cycle, nitrogen fixation, pathways of assimilation of nitrate and ammonium ions, assimilation of Sulphur and phosphorus.

Lab work

1. To determine the volume of CO_2 evolved during respiration by plant material. To determine the amount of O_2 used by respiring water plant by Winkler Method. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
2. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties. To categorize C_3 and C_4 plants through their anatomical and physiological characters. To regulate stomatal opening by light of different colours and pH.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7^{th} ed.). London: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6^{th} ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1^{st} ed.). New Dehli: Springer.
2. Buchanan, B., Gruissem, W. & Russell, L., (2015). *Biochemistry and molecular biology of Plants* (2^{nd} ed.). New Jersey: John Wiley & Sons.

BOTN-6117 **Cell Biology** **3(2+1)**

This course aims to understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation. This course gives information about the cell division; how and when it takes place and to know about the cancer, causes types and possible preventive measures. Cell biology is the study of cell structure and function, and it revolves around the concept that the cell is the fundamental unit of life. Focusing on the cell permits a detailed understanding of the tissues and organisms that cells compose. It is the study of cell with respect to its anatomy and physiology. It provides understanding of about cell which acts as fundamental unit of life. It is focusing on cell combine form tissues, organ and organism. Research in cell biology is interconnected to other fields such as genetics, molecular genetics, biochemistry, molecular biology, medical microbiology, immunology, and cytochemistry.

Contents

1. Introduction of prokaryotes and eukaryote cell, Animal and Plant cell structure.
2. Brief description of ultra-structure and functions of plant cell organelles.
3. End membranous systems, Cell cycle and cell division; meiosis in sexual reproduction in plants.
4. Cellular metabolism and enzymes, Cellular respiration and photosynthesis.
5. Biological information flow; transcription and translation.
6. Informational molecules; carbohydrates proteins and nucleic acids.
7. Cytoskeleton in cell cycle and mitosis, Extra cellular matrix; various types of extra cellular matrix proteins; elastic fibronectin, glycoprotein, collagen, dynein and motor proteins.
8. Vesicular trafficking, cell migration, cell adhesion, cancer growth factors, disorders in cell cycle, apoptosis and gap junction.

Lab work

1. Study of mitosis and meiosis in onion root tip and pollen grains
2. Study of cell organelles in plant cell by compound microscope
3. Measurement of cell size
4. Separation of different sized DNA fragments on agarose gel.
5. Study of chromosomes morphology and variation in chromosomes number.
6. Counting of prokaryotic cells (bacteria) and blood cells by using haemocytometer.
7. Extraction and estimation of carbohydrates, proteins and DNA from plant sources.

Recommended Texts

1. Verma, P. S. & Agarwal, V.K., (2016). *Cell biology* (*cytology, biomolecules and molecular biology*) (1st ed.). New Dehli: S. Chand Publishing .
2. Milo, R. & Phillips, R., (2015). *Cell biology by the numbers (*1st ed.). London: Taylor and Francis publications.

Suggested Readings

1. Templeton, N. S., (2015). *Gene and cell therapy* (4th ed.). London: Taylor and Francis publications.
2. Sybille, M. & Maria, S., (2015). *Tumor cell metabolism* (1st ed.). New York: Springer Publications.

BOTN-6118 Molecular Biology 3(2+1)

The aim of the course is to disseminate the knowledge of molecular basis of life. Molecular biology is a specialized branch, the study of the chemistry of molecules which are specifically connected to living processes. Of particular importance to molecular biology are the nucleic acids (DNA & RNA) and the proteins which are constructed using the genetic instructions encoded in those molecules. As a result, molecular biology techniques are at the forefront of most cutting edge scientific research. This course gives information on a number of commonly used molecular biology techniques involving DNA. The molecules which form the basis of life provide scientists with a more predictable and mechanistic tool for scientists to study. Working with whole organisms (or even just whole cells) can be unpredictable, with the outcome of experiments relying on the interaction of thousands of molecular pathways and external factors. Molecular biology provides scientists with a toolkit with which they may "tinker" with the way life works.

Contents

1. Nucleic Acids: DNA-circular and superhelical DNA, renaturation, hybridization, sequencing of nucleic acids, synthesis of DNA, Central Dogma.
2. Proteins: Basic features of protein molecules, folding of polypeptide chain, α-helical and β-secondary structures, protein purification and sequencing.
3. Transcription: Enzymatic synthesis of RNA, transcriptional signals. Translation: The genetic code, the Wobbling, polycistronic and monocistronic RNA, overlapping genes.
4. Gene regulation in Eukaryotes: Differences in genetic organization and prokaryotes and eukaryotes. Regulation of transcription, initiation, regulation of RNA processing, regulation of nucleocytoplasmic mRNA transport, regulation of mRNA stability, regulation of translation, regulation of protein activity.
5. Plant Genomics: Transcriptomics; DNA libraries, their construction, screening and application. Microarray of gene technology and its application in functional genomics.
6. Proteomics: Structural and functional proteomics, methods to study proteomics Metabolomics; methods to study metabolomics; importance and application of metabolomics
7. Bioinformatics and Computational Biology. Levels, scope, potential and industrial application of bioinformatics and computational biology, docking.

Lab work

1. Following techniques will be used for the isolation and analysis of different components:
2. Extraction of RNA, DNA and proteins. Electrophoreses: One and two dimensional. Purification of proteins, RNA and DNA. Amplification using P. Northern, Western and Southern Blotting.

Recommended Texts

1. Nelson, D., & Cox, M., (2017). *Lehninger: principles of biochemistry* (7^{th} ed.). London: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A., (2016). *Molecular cell biology* (8^{th} ed.). London: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B., Sahijram, R. & Murthy, K., (2015). *Plant biology and biotechnology* (1^{st} ed.). Berlin: Springers-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M., (2019). *Molecular biology* (1^{st} ed.). Amsterdam: Elsevier Inc.

BOTN-6119 Plant Biochemistry-II 3(2+1)

This course provides an advanced introduction to the fundamental processes of plant metabolism. This course gives information on how protein structure and function derived from the constituent amino acids, and the features of structural and globular proteins. It describes the basic principles governing the rate of enzyme catalysed reactions and the forms of inhibition of enzyme-catalysed reactions. The course describes the major pathways of carbohydrate, lipid and amino metabolism and gives information on how energy is stored and released through them. The students will be able to demonstrate familiarity and competence with the practical skills and techniques used in biochemical research and analysis. This will include experimental planning, the preparation of reagents and use of basic instrumentation (spectrophotometers, centrifuges, chromatographic apparatus etc), the collection of biochemical data and its presentation, and most importantly, the analysis and interpretation of the outcomes of biochemical investigations.

Contents

1. Bioenergetics: Energy, laws about energy changes, oxidation and reduction in living systems.
2. Metabolism: Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance, biosynthesis of fats. Replication of DNA, reverse transcription, biosynthesis of DNA and RNA. Components of protein synthesis, genetic code, protein synthesis: initiation, elongation and termination.
3. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role.
4. Terpenoids: Classification monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.
5. Vitamins: General properties and role in metabolism.

Lab work

1. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
2. Separation of nucleic acids by gel electrophoresis.
3. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
4. To determine potential alkaloids in plants.
5. To estimate terpenoids in plants.

Recommended Texts

1. Nelson, D., & Cox, M. , (2017). *Lehninger*: *principles of biochemistry* (7^{th} ed.). London: W.H. Freeman.
2. Heldt, H., & Piechulla, B., (2016). *Plant Biochemistry*. London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C. W. (2015). *Fundamentals of biochemistry* (1^{st} ed.). New Jersey: John Wiley and Sons.
2. Heldt, H. W., (2015). *Plant biochemistry* (5^{th} ed.). Cambridge: Academic Press.
3. Buchanan, B. B, Gruissem, W. &. Jones, R.L., (2015). *Biochemistry and molecular biology of plants* (2^{nd} ed.). New Jersey: Wiley.

BOTN-6120 **Plant Ecology-II** **3(2+1)**

The course aims to provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind. The course covers plant ecology on advanced level. The course deals with plants life history and functional traits, demography, and interactions between plants, between plants and animals and between plants and the remaining ecosystem. The main objectives for this course in plant ecology are to provide a broad overview of the field of plant ecology, gives students a fundamental appreciation of the local boreal forest and tundra floras and ecosystems, provide an overview of the Earth's major biomes. Plant ecology course deals with the study of the main environmental factors affecting the Earth's major vegetation types: tropical forests, tropical savannas, arid regions (deserts), Mediterranean ecosystems, temperate forest ecosystems, temperate grasslands, coniferous forests, tundra. Also give brief account about plant adaptations. The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving with respect to plant responses in terms of functional traits, life history, and demography and ecosystem interactions in different ecosystems.

Contents

1. Population Ecology: Population structure and plant demography: Seed dispersal, seed bank, seed dormancy, recruitment and demography. Life history pattern and resource allocation: Density dependent and density independent factors, resource allocation, reproductive effort, seed size versus seed weight, population genetics and evolution
2. Community Ecology: Historical development of community ecology, community concepts and attributes, methods of sampling of plant communities, ecological succession, community soil-relationship, local vegetation, vegetation of Pakistan and major formation types of the world
3. Ecosystem Ecology, biogeochemical cycles: water carbon and nitrogen case studies.

Lab work

1. Determination of seed bank in various populations. Seed dispersal pattern of local populations.
2. Demography and life history of local annual population.
3. Study of community attributes. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanqut, Field trip to study different communities located in different ecological regions of Pakistan, Slide show of the vegetation of Pakistan and major formations of the world.
4. Soil physical and chemical propertie, Correlation of soil properties with vegetation type

Recommended Texts

1. West, P. W., (2015). *Tree and forest measurement* (1st ed.). Switzerland: Springer International Publishing AG.
2. Osborne, P. L., (2017). *Tropical ecosystems and ecological concepts* (2nd ed.). England: Cambridge University Press.

Suggested Readings

1. Perera, A. H., Peterson, U., Pastur, G.M. &Iverson, L. R., (2018). *Ecosystem services from forest landscapes: broadscale considerations* (1st ed.). New York: Springer International Publishing AG.
2. Mabberly, D. J. (2017). *Mabberly's, plant book: a portable dictionary of plants their uses and classification* (1st ed.). Cambridge: Cambridge University Press.

BOTN-6121 **Research Methodology** **2(2+0)**

This course aims to know about research methods, research process, research design, development of skills for writing the research paper and knowledge about the major theoretical and philosophical underpinnings of research. The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course provides information about the basic concepts used in research and to scientific social research methods and their approach. This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

Contents

1. Research Methods: Planning research, various methods, analyzing results, giving reports etc
2. Research Process: Formulating research questions; sampling (probability and no probability.
3. Measurements: Surveys, scaling, qualitative, unobtrusive.
4. Research Design; Experimental and quasi-experimental, data analysis
5. Writing the Research Paper, the major theoretical and philosophical underpinnings of research including; the idea of validity in research, reliability of measures; and ethics.

Recommended Texts

1. Leedy, P. & Ormrod, J.A., (2019). *Practical research: planning and design* (12th ed.). New York: Pearson Publishers.
2. Creswell, J. & Creswell, D., (2018). *Research design: qualitative, quantitative, and mixed methods approaches* (5th ed.). New York: SAGE Publishers.

Suggested Readings

1. Merriam, S. & Tisdell, E., (2015). *Qualitative research: a guide to design and implementation* (4th ed.). New Jersey: John Wiley & Sons Incorporation .
2. Booth, W., Colomb, G., Williams, J. Bizup, J. & Gerald, W.F., (2016). *The Crafts of Research* (4th ed.). Chicago: University of Chicago Press.
3. Flick, U., (2017). *Introducing research methodology: a beginner's guide to doing a research project* (1st ed.). New York: SAGE Publishers.

BOTN-6122 **Genetics-II** **3(2+1)**

The course aims to develop students' problem solving skills and to introduce them recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics. This course introduces students about the concepts of recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics. It also provides information to extend their knowledge about different mechanisms of genetic change and to help them thinking in an analytical way. This course gives information about recombinant DNA technology and elaborates application of recombinant DNA. Recombinant DNA technology has revolutionized our ability to investigate the genomes of diverse species and has led to the modern revolution in genomics. Modern genetic techniques are playing an emerging role in agriculture, health, medicine, foods, disease diagnosis and therapy. Genetic technology is developing faster than the policies, laws, and conventions that govern its use.

Contents

1. Recombinant DNA: Recombinant DNA Technology Introduction, basic techniques, PCR and Rt PCR, Restriction enzymes, Plasmids, Bacteriophages as tools, the formation of recombinant DNA, recombinant DNA technology, site directed mutagenesis, DNA sequencing. Application of Recombinant DNA: Applications of recombinant DNA technology using prokaryotes, recombinant DNA technology in eukaryotes: An overview, transgenic yeast, transgenic plants, transgenic animals, screening for genetic diseases, identifying disease genes, DNA typing, gene therapy, genetically modified organisms and apprehensions.
2. Mechanisms of Genetic Change I: Gene Mutation, Recombination: General homologous recombination, the Holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.
3. Mechanisms of Genetic Change III: Transposable Genetic Elements: Insertion sequences, transposons, rearrangements mediated by transposable elements, review of transposable elements in prokaryotes, controlling elements in maize.
4. Human Genome Project: Strategies and application, achievement and future prospects. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
5. Bioinformatics, Bioethics: Moral, religious and ethical concerns

Lab work

1. Problems relating to the theory: Isolation and separation of DNA and protein on gel electrophoresis. Bacterial chromosome, Plasmid DNA (mini-preps), Plant DNA, Protein, DNA Amplification by PCR

Recommended Texts

1. Stevens, T. & Newman, S., (2019). *Biotech juggernaut: hope, hype, and hidden agendas of entrepreneurial bioscience* (1st ed.). Philadelphia: Routledge.
2. Shukla, P., (2018). *Applied microbiology and engineering: an interdisciplinary approach* (1st ed.). London: Academic Press.

Suggested Readings

1. Se-Kwon, K., (2015). *Handbook of marine biotechnology* (1st ed.). New York: Springer Publications.
2. Venkat, B., Sahijramand, R. & Murthy, K., (2015). *Plant biology and biotechnology* (2nd ed.). New York: Springer Publications.

BOTN-6123 Plant Physiology-II 3(2+1)

The aim of the course is to give comprehensive and advance knowledge about growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism. Plants are immobile in nature; they want to fulfill all their requirements of their life without moving from one place to another place. Plant physiology helps to study a wide range of processes and functions that plants use to live and survive, including respiration, metabolism, transpiration, plant hormones, environmental response and transport processes. It is also very important to know the functions of a living organism or any of its parts. They also have help in agriculture fields, medicine, food production and textiles. This course examines life process of plants such as signal transduction; different types of hormones (old group of hormones and newly discovered hormones) their synthesis, mode of action and beneficial effects. It also gives information about mechanism and different forces involve in uptake of water, role of water potential, minerals nutrition, their physiological role and deficiency symptoms in plants. This course also introduces physiological process of seed germination.

Contents

1. Plant Growth Regulators: Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action and transport.
2. Water Relations: The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components.
3. Modulus of elasticity coefficient. Plant Mineral Nutrition
4. Phytochromes. Control of Flowering. Circadian rhythms. Role of photoperiodism in flowering, biochemical signaling involved in flowering, vernalization and its effect on flowering. Floral meristem and floral organ development, floral organ identity genes and the ABC model.
5. Signal transduction in prokaryotes and eukaryotes. Dormancy. Plant Movements

Lab work

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer. To investigate water potential of a plant tissue by dye method and water potential apparatus. Determination of K uptake by excised roots. Measurement of stomatal index and conductance. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant* physiology (7^{th} ed.). London: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant Metabolism* (6^{th} ed.). London: Longman Group.

Suggested Readings

1. Mitra, G.N., (2015). *Plants*: *a biochemical and molecular approach* (1^{st} ed.). New Dehli: Springer.
2. Buchanan, B., Wilhelm, G. & Russell, L., (2015). *Biochemistry and molecular biology of plants*(1^{st} ed.). New Jersey : John Wiley & Sons.

BOTN-6124 **Environmental Biology** **3(2+1)**

Environmental Biology is a Physical Science at the intersection of environmental science, ecology, evolution, and global change. The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management. Environmental Biology encompasses varied themes such as energy flow biosphere & biomes, carbon trading and other biogeochemical cycling, greenhouse gas emissions, water resource management, land degradation and rehabilitation, flora and fauna, habitat destruction, deforestation, energy and mineral depletion, air and water pollution, soil erosion, and groundwater contamination. This course provides insight of the basic science of environmental biology and ecological theory. Environmental Biology helps in recognition of environmental problems such as climate change, global warming, ozone layer depletion, acid rains as well. This course enables students to develop strong expertise in contemporaneous themes in ecological research, develop critical thinking and to discuss about advanced topics in population, community and ecosystem ecology as well as in biodiversity research.

Contents

1. Environment: Introduction, scope and pressure. Pollution: Definition, classification and impact on habitats. Air pollution: Sources and effect of various pollutants (inorganic, organic).on plants, prevention, control and remediation. Smog, photochemical smog. Acid rain. Water pollution: Major sources of water pollution and its impact on vegetation, prevention, control, remediation, eutrophication and thermal pollution. Sediments pollution: Fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control, remediation, heavy metal pollution, tanneries, hospital waste. Treatments of sewage, sludge, and polluted waters. Noise pollution. Radiation pollution (including nuclear radiation): Measurement, classification and effects, principle of radiation protection, waste disposal
2. Forest. Ozone layer. Greenhouse effect and global warming: Causes and impacts. Human population explosion: Impact on environment. Brief review of major environmental problems of Pakistan and their solutions. Sustainable environmental management. Wetlands and sanctuaries protection: The pressures, problems and solutions. Range management: Types of rangelands, potential threats, sustainable management. Aerobiology: Pollen allergy and dust allergy.

Lab work

1. Examination of industrial waste water and Municipal sewage and sludge for: Total dissolved solids, pH and EC, BOD/COD, Chlorides, carbonate, and Nitrates. Examination of water samples forms different sites for the presence and diversity of organisms.
2. Effect of air pollutants on plants. Visits to environmentally compromised sites and evolution of remediation

Recommended Texts

1. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.
2. Nriagu, J., (2019). *Encyclopedia of environmental health* (2nd ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.

BOTN-6125 **Plant Water Relations** **3(2+1)**

The aim of the course is to overview comprehensively the soil-plant-atmosphere continuum for the maintenance of vital physiological functions and mechanisms in plants and to upgrade the concept about source sink relationships in translocation of solutes in plants. To familiarize graduate students with some of the tools necessary to measure plant water relations parameters in the field. Emphasis will be on water potential measurements with Scholander pressure chambers, leaf gas exchange measurements with potometers and infrared gas analyzers, and xylem sap flux measurements with heat dissipation probes. The term "plant water relations" describes plant water status in a cell, individual organ (leaf, internode, and flower) or whole plant level, furthering our understanding of basic plant growth and development, and plant response to the environment. After completion of this course, the students will be able to understand water and nutrient movement in soil and plant and adaptation of plants to adverse soil water conditions.

Contents

1. The soil -plant -atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants
2. Cell water relations terminology. Hoflerdiagram - analysis of change in turgor, water and osmotic potential with changes in cell volume. Modulus of elasticity coefficient; Hydraulic conductivity.
3. Osmoregulation, methods for measurement of water, osmotic and turgor potentials- pressure chamber, psychrometry, pressure probe and pressure volume curve, stomatal physiology, transpiration flux, anti-transpirants.
4. Source sink relationships in translocation of solutes. Mineral nutrition. Mineral ion uptake passive and active uptake and transport. Nernst equation, Donnan' spotential, role of H^+ATPase as a carrier, co transport.

Lab work

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations. Measurement of leaf water potential by the dye method.
2. Determination of the temperature at which beet root cells lose their permeability. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a potometer/cobalt chloride paper method. To regulate stomatal opening by light of different colors and pH.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). London: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1st ed.).New Dehli: Springer.
2. Buchanan, B., Wilhelm, G. &Russell, L. (2015). *Biochemistry and molecular biology of plants* (1st ed.). New Jersey: John Wiley & Sons.

BOTN-6126 **Plant Micro Techniques** **3(2+1)**

The aim of the course is to elucidate the importance of light microscopy and other special techniques maceration and staining to study plant sections, and to make students able to use microtome and camera Lucida. Microtechnique an important experimental science that has led and continues to lead a great service for each branch of the life sciences: microbiology, genetics, embryology, morphology and science, also plays an important role in the development of medical studies of human anatomy. This includes knowledge of the preparations microscopic plant sample. This course provides information for managing the techniques of microscopic slides making, microscopic measurements and methods of identification of some organic compounds in plant cells. Microteaching is a highly individualized training device. Microteaching is an experiment in the field of teacher education which has been incorporated in the practice teaching schedule. Microteaching is micro in the sense that it scale down the complexities of real teaching.

Contents

1. Light microscopy–optical principle, resolution, magnification, aberration. Phase contrast microscopy Dark field illumination.
2. Electron microscope (TEM &SEM), principle and preparation techniques. Special techniques maceration; squashes, smears, whole mount and clearing techniques.
3. Micro technique steps fixation and fixatives, dehydration, clearing, infiltration, embedding, block making and sectioning.
4. Microtome's types, principles and operating mechanisms, stainsand staining techniques, Camera Lucida types, principles and their uses.
5. Micrometry

Lab work

1. Preparation of hand sections, maceration and clearing
2. Temporary and permanent mounting of whole specimens and Sections using differenttypes of mo untants. Calibration of microscope and micrometry. Microtomy and microtome sectioning
3. Examination of different cell and tissue types with help of techniques
4. Study of structure of (primary and or secondary) leaf, root, stemand floral parts (including fruit).
5. Examination of vascular cambium and study of its activity.
6. Examination of structure and identification of Wood of some common trees such as *Dalbergia sissoo, Acacia arabica.* etc

Recommended Texts

1. Yeung, E. C. T., Stasolla, C., Sumner, M. J.&Huang, B. Q., (2015). *Plant microtechniques and protocols* (1st ed.). New York: Springer.
2. Richard, C., Sobaski, L., Wise, S.& Robert, S., (2018). *Plant anatomy* (1st ed.). New York: Springer.

Suggested Readings

1. Back, C. B., (2010). *An introduction to plant structure and development: plant anatomy for the twenty-first century* (2nd ed.). Cambridge: Cambridge University Press.
2. Maiti, R., (2012). *Crop plant anatomy* (15th ed.). London: CABI.

BOTN-6127 Plant Seed Physiology 3(2+1)

This course comprehensively provides the details of physiology of seed development and maturation. It is science and technology that is applied in the seed industry and includes biotech, crop improvement, as well as courses in seed production and conditioning. This course provides students with core graduate level management and leadership skills enabling them to better serve seed and agricultural biotechnology businesses and regulatory agencies in an increasingly complex industry. This program emphasizes seed production, handling, and use, seed physiology and technology, plant breeding, and plant biotechnology. This course is designed to help students integrate and better understand crop growth, development and yield from a perspective of whole plant physiology. In this course, students will gain an overview of plant seeds physiological processes that are necessary to understand how plants operate, and interact with their environment. The course is useful to understand and interpret agronomic phenomena contributing to crop yield.

Contents

1. Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.
2. Seed germination Types of germination, factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and interconversion pathways.
3. Seed dormancy. Seed viability and longevity, pre-and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.
4. Seed vigour and its concept, vigour test methods, factors affecting seed vigor, physiological basis of seed vigour in relation to crop performance and yield. Seed, invigoration and its physiological and molecular control.

Lab work

1. Proximate analysis of chemical composition of seed;
2. Different types of seed germination and evaluation,
3. Methods for breaking seed dormancy. Seed vigor test. Accelerated aging test
4. Priming and invigoration treatment for improving germination and vigor

Recommended Texts

1. Agrawal, P. K. & Sherry, R. J., (2018).*Techniques in seed science and technology* (3rd ed.). New Delhi: Brillion Publishing.
2. Baskin, C. C., & Baskin, J. M., (2014). *Seeds: ecology, biogeography and evolution of dormancy and germination* (1st ed.).Cambridge: Academic Press.

Suggested Readings

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

BOTN-6128 **Palynology** **3(2+1)**

This course aims to introduce students to neopalynology and paleopalynology and its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration. It also provide the students information about the nomenclature, morphology and classification of living and fossil pollen, and spores. The objective of the course is to disseminate information on palynology samples and preparation techniques that avoid the use of acids. Palynology is a particular study within the realm of ecology that deals with the pollen and spores of plant species. Specifically, palynologists look at such factors as abundance of pollen and its occurrence in preserved samples. The course teaches the practical procedures used and will be taught through instruction within a laboratory environment. This course gives information about spores and pollens of preserved species samples, which in turn can reveal many details about different ecosystems, especially marine environments. With palynology, one can determine such environmental characteristics as water depth, temperature, and salinity.

Contents

1. An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration.
2. Basic information about the nomenclature, morphology and classification of living and fossil pollen, and spores; Morphology and functional significance of spores and pollen,
3. Palynomorphs of the Paleozoic, Palynomorphs of the Mesozoic, mega and microspores.
4. Gymnosperm pollen-major types through time,diagnostic features of angiosperm pollen and the early fossil record,
5. Anita group and Magnolid pollen, monocot pollen, lower Eudicot pollen types, selected Rosid pollen types, selected Asterid pollen types.
6. Applications: forensics, honey, paleo environment, case histories. Fagales, geometrically bizarre and fun pollen types.

Lab work
:

1. Microscopic Study of Spores and Pollen, Herbarium sheets.
2. Acetolysis.
3. Slide preparation, temporary and permanent slides of spores and pollen
4. Photomicrography, HF safety training, maceration and dissolution, gravity separation, counting techniques.

Recommended Texts

1. Slam, H., (2016). *Aerobiology: the toxicology of airborne pathogens and toxins* (1st ed.). London: Royal Society of Chemistry.
2. Burge, H. & Muilenberg, M., (2018). *Aerobiology* (1st ed.). Florida: CRC Press.

Suggested Readings

1. Bhattacharya, K., (2015). *A text book of palynology* (1st ed.). New Delhi: New Century Publication.
2. Beaudoin, A.B. & Head, M.J., (2017).*The palynology and micropalaeontology of boundaries* (1st ed.). London: Geological Society.

BOTN-6129 **Plant Tissue Culture** **3(2+1)**

The aim of the course is to know about concept of cellular totipotency, differentiation and de-differentiation and various tissue culture methods / techniques for the production pathogen-free plants and explicit the role of plant tissue culture in crop improvement. Plant tissue culture broadly refers to the an *in vitro* cultivation of plants, seeds and various parts of the plants (organs, embryos, tissues, single cells, protoplasts).With the advances made in the tissue culture technology, it is now possible to regenerate species of any plant in the laboratory. In this process the growth medium or culture solution is very important as, it is used for growing plant tissue because it contains various plant nutrients in the form of 'jelly' known as agar and plant hormones which are necessary for the growth of plant. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Applications include: The commercial production of plants used as potting, landscape, and florist subjects, which uses meristem and shoot culture to produce large numbers of identical individuals.

Contents

1. Plant Tissue Culture-An introduction
2. Cellular totipotency, differentiation and de-differentiation
3. Selection of a suitable explant material in different plant groups
4. Initiation and maintenance of callus cultures, Organogenesis, Somatic embryogenesis
5. Micropropagation, Role of somaclonal variation in crop improvement
6. Cell suspension cultures, Isolation, purification and culture of plant protoplasts
7. Role of plant protoplasts in crop improvement
8. Production of pathogen-free plants using tissue culture techniques.

Lab work

1. An introduction to a Plant Tissue Culture lab.
2. Laboratory facilities and their use.
3. Aseptic techniques.
4. Preparation and use of Stock solutions.
5. Media composition and preparation protocols.
6. Preparation of selected media, pouring and sterilization.
7. Procurement, preparation and sterilization of explants.
8. Initiation and maintenance of callus cultures and regeneration studies inselected species.
9. Culture initiation and maintenance for Micropropagation of selected species.

Recommended Texts

1. Umesha, S., (2019). *Plant biotechnology* (1st ed.). Philadelphia: Francis and Taylor Group.
2. Dixon, R.A. & Gonzalcs, F.A., (2017). *Plant Cell Cultures. A Practical Approach* (2nd ed.). London: Oxford University Press.

Suggested Readings

1. Loyola-Vargas, V.M. & Ochoa-Alejo, N., (2016). *Somatic embryogenesis: fundamental aspects and applications* (1st ed.). Switzerland: Springer International Publishing.
2. Kumar, S., Mishra, S. & Mishra, A.P., (2016). *Plant tissue culture: theory and techniques* (2nd ed.). London: Scientific Publishers.

BOTN-6130 Plant Biotechnology 3(2+1)

The aim of the course is to introduce students to genetic engineering, cloning strategies, PCR and genetic markers and applications of plant biotechnology, to provide updated knowledge of environmental problems and sustainable environmental management through treatment technologies such as phytoremediation. The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including breeding of healthy plants, plants with improved characteristics and plants for biomolecule production. This course enhances the ability of explanation of concepts, principles and usage of the acquired knowledge in biotechnological, pharmaceutical, medical and agricultural applications. This course explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation. There is an emphasis on the molecular mechanisms directing plant gene expression.

Contents

1. Biotechnology: Definition, history, scope and significance. Principles and applications of genetic recombinant technology in medicine, agriculture, veterinary and food industry. Production of biotechnological products – food SCP (algae, yeast, mushroom). Biofertilizers, biofuel, biopesticides, biogas production, waste and sewage management, effective microorganisms
2. Enzyme biotechnology
3. Amplification of genes by PCR, cDNA and construction of cDNA libraries.
4. Blotting techniques, nonradioactive probe DNAdiagnostics, DNA sequencing.
5. Recombinant DNA technology-gene transfer in plants. Vectors. Gene cloning. Plant tissue culture

Lab work

1. Extraction and estimation of plant DNA. Basic biotechnology techniques: Preparation of different types of standard tissue culture media. Preparation of culture medium (MS, N&N, SH, B5), sterilization and inoculation. Establishment of aseptic cultures following appropriate sterilization procedures using seeds. Demonstration of Agarose gel electrophoresis. Encapsulation of seeds/embryos in calcium alginate.
2. Visits of Biotechnology labs at NIBGI, Faisalabad, AARI, Faisalabad and School of Biological Sciences Lahore, Center of Excellence in Molecular Biology, Lahore: National institute for Genomics and Advance Biotechnology (NIGAB)

Recommended Texts

1. Abdin**,** M.Z., Kiran, U. Kamaluddinand, A. &Ali**,** M.A.(2017). *Plant biotechnology: principles and applications* (1st ed.).New York: Springer.
2. Kumar, S., Kumar, R., & Pandey, A. (2019). *Current developments in biotechnology and bioengineering: waste treatment processes for energy generation* (1st ed.).Amsterdam: Elsevier .
3. Gahlawat**,** S. K., Salar, R.K., Siwach**,** P.,Duhan**,** J. S.,Kumar, S., &Kaur**,** P. (2017). *Plant biotechnology: recent advancements and developments* (1st ed.). New York: Springer.

Suggested Readings

1. Smith, R. H., (2013). *Plant tissue culture: techniques and experiments* (3rd ed.). Cambridge: Academic Press.
2. Stewart, N., (2017). *Plant biotechnology and genetics: Principles, Techniques, and Applications* (2nd ed.). New Jersey: Wiley Online Liberar.

BOTN-6131 Advanced Environmental Biology 3(2+1)

Environmental Biology is a Physical Science at the intersection of environmental science, ecology, evolution, and global change. Environmental biology examines the ways organisms, species, and communities influence, and impacted by, natural and human-altered ecosystems. The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management, to familiarize the students with national conservation strategy and role of natural resources in conservation diversity of nature and importance of biodiversity for survival and proper functioning of ecosystems. This course introduces the student to the fundamentals of environmental biology: the structure and biota of several aquatic and terrestrial ecosystems, including Vermont ecosystems. The student investigates why species occupy specific habitats. Today, it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. Environmental biology incorporates more of the pure sciences for understanding human relationships, perceptions and policies towards the environment.

Contents

1. Environmental problems, their causes, and sustainability & Environmental history.
2. Science Systems, Matter and Energy, Energy Conversions, Thermodynamics, Basic Chemistry (acids, bases, salts), Niches, Interactions, Succession
3. Biogeography: Weather, Climate, Biomes & Biodiversity
4. Population Dynamics, Carrying Capacity, and Conservation Biology and Evolution of a Species
5. The Human Population: Growth, Demography
6. Global Problems, Energy Resources, Human Health
7. Air, Water soil and their pollution
8. Food Resources, Pesticides and Pest Control,
9. Land Management and Diversity, Economics, Politics, and Ethics

Lab work

1. Water Characterization, Alkalinity and Buffering Capacity of Water,
2. Examination of industrial waste water and Municipal sewage and sludge for: Total dissolved solids, pH and EC, BOD/COD, Chlorides, carbonate, and Nitrates,
3. Visits to environmentally compromised sites, disturbed ecosystems, different sanctuaries
4. Survey of different important species for conservation.

Recommended Texts

1. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.
2. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Jorge G. Ibanez., Margarita Hemandez-Esparza,Carmen Doria-Serrano and Arturo Fregoso-Infante (2008). Environmental Chemistry: *Microscale Laboratory Experiments* (1st ed.). NYC: Springer Science.

BOTN-6132 Plant Conservation Management 3(2+1)

The aim of the course is to provide updated knowledge of plant conservation, conservation in practice and conservation techniques for sustainable ecosystem management, to familiarize the students with threats to plant communities and its impact on population dynamics and economic development. The course provides a thorough introduction to the essential aspects of plant conservation including an overview of threats to the world's plant diversity, conservation genetics, conservation assessments and ways to minimize biodiversity loss. It includes an introduction to international legislations, politics and humans' role, both as threats and conservers of plant diversity. This class will review the causes of plant species decline, the biological factors associated with small populations at both the ecological and genetic level, the current practices of population monitoring and management for conservation in both in-situ and ex-situ environments and the possibility of reintroduction.

Contents

1. Plant Conservation: Introduction, philosophy, origin, scope, objectives. Definitions
2. Understanding of Conservation: Biodiversity (types). Species (number), advantages of conservation (food, drugs and medicine
3. Extinction of Plant Species: Natural causes of Extinction. Anthropogenic (man-made) extinction, habitat destruction, Invasive species. Pollution, over harvesting, commercial products and life specimen, introduced species, predator and pest control, threats to species, over exploitation, introduced species, genetic problems in small population, risks reviews and dynamics of small population. Threats to Communities: Chains of extinctions, emergence of new species from old. Functional integrity in relation to fragment size.
4. Conservation in Practice: Endangered species management and biodiversity protection, categorization of plant species, endangered species law. Bunting and fishing laws, the endangered species act, recovery plans, captive breeding and management plans,types of conservation (Ex-situ conservation), protected areas, conservation towards restoration of ecology, healthy approach to save biodiversity, saving rare species in the wild, habitat protection, private land and land critical habitat. Reauthorizing the endangered species. Conservation Techniques, Conservation and Economic Development: Indigenous communities and biosphere reserves, International wildlife preserves. Transboundary peace parks, preserving functional ecosystem and landscapes, landscape dynamics, size and design of nature preserves, wetland conservation.

Lab work

1. Visits to Botanical garden, Governor House, Lahore, Bagh-e-Jinnah Lahore, Soon Valley, Botanical Garden, University of Agriculture, Faisalabad.

Recommended Texts

1. Ortega-Rubio, A., (2018). *Mexican natural resources management and biodiversity conservation* (1st ed.). New York: Springer publication.
2. Blackmore, S., (2018). *Best plant conservation practices to support species survival in the wild* (3rd ed.). Amsterdam: Center for Plant Conservation.

Suggested Readings

1. Walker, T., (2015). *Plant conservation: why it matters and how it works* (5th ed.). Portland: Timber Press.
2. Blackmore, S. & Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens* (1st ed.). London: Cambridge University Press.

BOTN-6133 Conservation Genetics 3(2+1)

The aim of the course is to provide updated knowledge of conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, to familiarize the students with *conservation techniques and* genetic tools, genetic markers for assessing biodiversity. This course will introduce the principles and applications of conservation genetics, from assessing the genetic health of individuals and whole populations to deciding on species and sub-species divisions. The key genetic analyses employed in conservation genetics studies will be described and their technical and theoretical limitations discussed, as will their considerable power to inform key conservation decisions. This course focuses on the application of genetic analyses to management and recovery of endangered species. This course will provide expanded coverage to include application of genetic techniques to general questions in wildlife and fisheries biology and management. This course requires students to have taken introductory biology courses as well as courses in ecology and genetics.

Contents

1. Introduction to plant conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, Hardy-Weinberg principle, genetic drift, effective population size, population subdivision, quantitative genetics, molecular phylogenetics.
2. Genetic tools for conservation, genetic markers, inbreeding coefficients, conservation issue, met population and fragmentation, evolutionary significant units, conservation breeding.
3. Types of conservation: Forest conservation, wild plant conservation, invasive species study and control, medicinal plant conservation,
4. Conservation methods/techniques/management.
5. Natural and human-caused factors that cause plant species to be rare or imperiled and the genetic and ecological implications of rarity in plant species, conservation strategy for a rare or imperiled plant species, and applications of ecological and population genetics principles to evaluate the long-term viability of such a plant species with and without conservation measures.

Lab work

1. Extraction of DNA from plant material by using CTAB method.
2. Molecular markers: SSR, Intron-polymorphisms, CAPS, AFLP, RAPD etc.
3. Analysis of morphological and molecular diversity in different cultivars/varieties of a crop plant.
4. QTL mapping (Theoretical using available data)
5. Field trips to the location of rare or threatened plant populations.

Recommended Texts

1. Frankham, R., Jonathan D. &David, A. Briscoe A. (2017). *Introduction to conservation genetics* (2nd ed.). England: Cambridge University Press.
2. Desalle, R. & Amato, G. (2017). *Conservation genetics, precision conservation, and de-extinction* (1st ed.). New Jersey: Wiley publishers.

Suggested Readings

1. Allendorf, F.W., Luikart, G. H. & Aitken, S. N. (2015). *Conservation and the genetics of populations* (2nd ed.). New Jersey: Wiley and Sons Publications.
2. Frankham, R., Ballou, J. D. & David, A. (2015). *Introduction to conservation genetics* (1st ed.). England: Cambridge University Press.

BOTN-6134 **Basic Ecological Genetics** **3(2+1)**

The aim of this course is to provide the basics of the genetic component in functioning, development and sustainability of ecosystems with the main focus on forests and the associated communities. Sustainable development and biodiversity as well as increased impact of biotechnology became important present-day challenges and the basics of interaction between genetics and environment are needed to solve these problems. This course elucidates the role of genetic techniques, genetic markers to assess the genetic diversity within and among the population. This course also provides an insight into gene flow and mating system and importance of biological and environmental factors on gene flow. After completing the course students should obtain the basics of ecological genetics on one hand and breeding and biotechnology on another hand. This knowledge will allow the students to efficiently cope with the ecological problems connected with genetics to proceed with well-balanced approach to simultaneously maintain the ecological stability and economical benefit.

Contents

1. Ecological genetics: what is ecological genetics? Why study ecological genetics.
2. Markers and sampling in ecological genetics Introduction, methods of data generation, principles of sampling within and among population.
3. Genetic diversity and differentiation. Introduction, factors influencing diversity and differentiation, The Hardy Weinberg Equilibrium, genetic diversity, genetic differentiation, genetic distance, statistical approaches, use of genetic diversity statistics.
4. Gene flow and mating system. Introduction, Factors governing gene flow. Considerations for measuring gene flow, measuring gene flow -indirect estimates, measuring gene flow -direct estimates. The importance of biological and environmental factors on gene flow.
5. Intraspecific phylogenies and phylogeography. Introduction, homology, gene trees and species trees, tree form and building, tree interpretation, organelles versus nuclear intraspecific phylogenies.
6. Speciation and hybridization. Introduction, species, speciation, hybridization, analysis of speciation and hybridization

Lab work

1. Extraction of DNA from plant material.
2. Separation of DNA by gel electrophoreses.
3. Gene amplification through PCR
4. Graphical representation of speciation and hybridization data by UPGMA
5. DNA sequencing.

Recommended Texts

1. Daniel, L., & Cochrane, H. B. (2017). *Genetics: analysis of genes and genomes* (9th ed.). Burlington: Jones & Bartlett Learning.
2. Turnpenny, P. D., & Ellard, S. (2016). *Emery's elements of medical genetics* (15th ed.). Amsterdam: Elsevier.

Suggested Readings

1. Pierce, B.A.(2017).*Genetics: a conceptual approach* (6th ed.).London: W. H. Freeman.
2. Klug, W. S., Michael, R. Cummings, R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics* (1st ed.) New York: Pearson.

BOTN-6135 Medicinal Plants 3(2+1)

The overall objective of this course is to improve students understanding of the uses and effects of medicinal plants, including herbal supplements, on people and their cultures or societies. The course topics will be taught from the perspective of how different cultures utilize medicinal plants. Students will learn how different cultures perceive diseases and then utilize plants to treat them. Currently medicinal plant usage is quite common, but how that use of medicinal plants is perceived depends on the society where they are used. The latter part of the course focuses on how societies in developed countries perceive, use and regulate plant medicines or herbal supplements. Finally, because all plants with bioactive compounds can't always be regulated, throughout the course students will learn how to evaluate claims made of specific plants and herbal supplements and will learn where to find reliable information about those plants and products. This will focus on natural extraction products, assessment of dried botanicals, and quality assessment and sensory analysis of essential oils.

Contents

1. History of Medicinal plants. Traditional Medicinal systems: Ayurvedha, Siddha, Unani and Naturopathy. Cultivation, therapeutically and pharmaceutical uses of selected medicinal plants of Sargodha region. Historical account of medicinal plants in Pakistan. Establishment of medicinal plant gardens.
2. Definition of Drug-Classification of natural drugs: alphabetical, morphological, pharmacological and chemical .traditional and folklore medicine-native medicine drugs from leaves, flower, fruits and seeds, roots, bark (Cinchona) and wood (Ephedra)
3. Pharmacognosy-Definition and scope, drug adulteration, drug evaluation, chemical evaluation and biological evaluation of drugs, phytochemical investigations-quality control of herbal drugs.

Lab work

1. Ethnomedicinal survey of various places
2. Preparation of herbarium sheets of ethnomedicinal plants.
3. Phytochemical analysis of ethnomedicinal plants.
4. HPLC of selected plant extracts

Recommended Texts

1. Akos, M. (2015). *Medicinal and aromatic plants of the world*. United States: Springer publishers.
2. Tránsito, M., Luengo, L., & Manez, C.(2015). *Medicinal plants at home*. New York: Skyhorse Publishers.

Suggested Readings

1. Krochmal, A., Walters, R. S., & Doughty, R.M. (2016). *A guide to medicinal plants of Appalachia.* New York: Amazon publishers.
2. Kumar, A. (2016). *Handbook of medicinal plants*: New York:Amazon publishers,.
3. Da, H., Xiao, J., Pei, G., & Xiao, G. (2015). *Medicinal plants.*1st edition. **Amsterdam:**Elsevier Publsihers**.**

BOTN-6136 **Ethnobotany** **3(2+1)**

Ethnobotany is the scientific study of interactions between human cultures and plants/plant environments (the interrelationships between people and plants). This course examines many different levels and types of interactions between people and plants. The goal of this course is to introduce students to the fascinating world of the relationships between people and plants. The course offers a unique and multidisciplinary approach that includes plant structure and function, plant diversity, the origins of agriculture, and the uses of plants by peoples around the world. As plants are important to people, the course focuses on how plants affect human health, nutrition and well-being, interact with other organisms, and provide critical support to biodiversity. The course provides important examples on the economic importance of plants, and how the study of plants with a focus on medicine, health, and nutrition can shape the future careers of students.

Contents

1. Definition-Scope. History of ethnomedicinal plants. Traditional Medicinal systems:
2. Ayurvedha, Siddha, Unani and Naturopathy.
3. Definition of Drug-Classification of natural drugs, alphabetical, morphological, pharmacological, chemical and chemo taxonomical. Traditional and Folklore medicines. Native medicine. Major tribes of the Sargodha region and their ethnobotanical and ethno-biological heritage.
4. Ethno Medicines. Ethnobotany and conservation of plants with special reference to Pakistan – mythology and conservation of ecosystems, conservation of selected plant species: sacred grove, forestry and unique ecosystems and their ethnobiological values, plants and animals in art, tradition and ethnography: Ethnobotanical field methods.
5. Pharmacognosy:Definition and scope, drug adulteration, drug evaluation;chemical evaluation, physical evaluation and biological evaluation.
6. Phytochemical investigations, standardization and quality control of herbal drugs.
7. Cultivation, collection and preparation of natural drugs. Macroscopic characters: physical and organoleptic characters, therapeutical and pharmaceutical uses of the local ethnomedicinal plans: Commercial value.

Lab work

1. Ethnobotanical survey of various places
2. Preparation of herbarium sheets of ethnobotanicalplants.
3. Phytochemical analysis of ethnobotanicalplants.
4. HPLC of selected plant extracts.

Recommended Texts

1. Rafael, L., Casas, A., & Jose, B. (2016). *Ethnobotany of mexico*. New York: Springer publisher.
2. Albuquerque, A., Paulino, U., Alves, N., & Romeu, R. (2016). *Introduction to ethnobiology*. New York: Springer publishers.

Suggested Readings

1. Rainer, B. (2017). *Ethnobotanyof the Caucasus*. New York: Springer Publisher.
2. Schmidt, B. M., Diana, M., & Cheng, K. (2017). *Ethnobotany: a phytochemical perspective*. New Jersey: Wiley publishers**.**

BOTN-6137 Biodegradation and Bioremediation 3(2+1)

This course will present the basic principles of chemical and biological degradation of toxic chemicals, and familiarize the students with the application of the remedial technologies in natural environments. Topics covered will include: 1) occurrence and ecological significance of toxic organic chemicals, 2) chemistry of contaminants, kinetics and mechanisms of degradation (chemical and biological), and 3) current technologies of bioremediation of contaminated soils and water. Bio/remediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to nonbiological processes. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and polyaromatic hydrocarbons) will be studied in detail. The investigation component of this course consists of learning how to do appropriate laboratory and field experiments to obtain data on microbial degradation of an organic pollutant to be able to calculate bioremediation design parameters such as mass and delivery rate requirements of electron acceptors and nutrients and degradation rates in reactor and non-reactor based systems; and to be aware of limitations of these calculations.

Contents

1. The environment and pollution: Introduction, environmental laws.
2. Treatment technologies:Traditional approaches to pollution control, Bio-treatment technologies for pollution control.
3. Biocatalyst selection and genetic modification: Enrichment and screening strategies, Design of enrichment strategies relating to the environmental source, Microbiological techniques for enrichment and selection, Genetic approach, The carbon cycle and xenobiotic compounds, Biodegradation and microbial technologies by microorganisms, Acclimation, Detoxification, Activation, Sorption, Bioavailability, Sequestering and complexing, Cometabolism, Environmental effects, Effects of metals and radionuclide on environment, Metal and radionuclide microbial treatment, Biotechnology for metal and radionuclide removal and recovery, Recalcitrant molecules

Lab work

1. Isolation of bacteria from oil wastes, polluted water from industries and sewage.
2. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons, Bioremediation from culture by metal resistant bacteria.

Recommended Texts

1. Kaushik, G. (2015). *Applied environmental biotechnology: present scenario and future trends*. Berlin: Springer Verlag.
2. Crawford, R.L. (2009). *Bioremediation principle and applications*. Cambridge University Press, Cambridge: Cambridge University Press
3. Singh, H. (2006). *Mycoremediation: Fungal Bioremediation*. New Jersey: Wiley-Interscience.

Suggested Readings

1. Chang, W. (2017). *Biodegradation and bioremediation*. New York: Syrawood Publishing House.
2. Sangeetha, J., Thangadurai, D., Muniswamy D., & Abdullah, M.A. (2016). *Environmental biotechnology: biodegradation, bioremediation, and bioconversion of xenobiotics for sustainable development*. New York: Apple Academic Press.

BOTN-6138 Water Pollution Management 3(2+1)

This course provides an overview of engineering approaches to protecting water quality with an emphasis on water treatment unit operations. It covers a wide range of topics, including water characterization parameters and designing systems to treat municipal and industrial wastewater, as well as the legislative framework. Water Pollution management and strategies is offered to students to let students know basic knowledge and control technologies of water pollution, so that they can solve problems on water treatment. An understanding of the physical, chemical and biological processes involved during contamination of water is essential if society is going to effectively monitor and control the effects of pollution using modern technology and engineering practices. A huge range of pollutants may be released into the aquatic environment during everyday domestic, leisure, industrial and commercial activities and many of these contaminants are potentially harmful to human health and the environment.

Contents

1. Water pollution: Sources, types and their impacts; Pollution problems of groundwater resources, sources of contamination, management issues; Pollutants, dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys
2. Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation; Waste recycling and utilization in aquaculture; Design and construction of water filtration devices, solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of waste water.

Lab work

1. Determination of DO, BOD and COD of water, Determination of total dissolved solids (TDS) of ground and surface water, Estimation of amount of phosphate, sulphate, nitrate, nitrite, iron and magnesium and calcium in the ground and surface water, Estimation of Ca, Mg, organic matter and phosphates in soil, Collection and preservation of waste water samples; Physicochemical analysis of wastewater total dissolved and suspended solids, colour, odour, DO, BOD, COD, H_2S,NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides.
2. Use of algae for organic waste treatment, Visit to sewage treatment plants, fish processing units and other industries.

Recommended Texts

1. Chakraborty, D., & Mukhopadhyay, K. (2016). *Water pollution and abatement policy in india: a study from an economic perspective*,(1st ed.) New York: Springer.
2. McMillan, S. (2018). *Water pollution: types, causes and management strategies*. New York: Syrawood Publishing House.

Suggested Readings

1. Kneese, A.V. (2015). *Water pollution: economics aspects and research needs*. London, United Kingdom.
2. Rose, M., & Mendoza, O. (2016). *Water pollution and treatment*. Toronto: Arcler Education Inc.

BOTN-6139 Air Pollution Management Strategies 3(2+1)

In this course, students will learn effects of air pollutants on human beings, materials and the environment, what their sources are, and their physical and chemical behaviour in the atmosphere. This will introduce the nature of our atmosphere, its composition and meteorology, air pollutant emissions, air pollution chemistry and climate change / carbon management, together with the practical measures used to limit emissions from sources ranging from power stations to vehicles and the legislative and policy framework used by national and local authorities to enforce air quality objectives. Benefits can include improved public health, energy savings, economic development, agricultural benefits and reduced emissions of greenhouse gases and other short-lived climate pollution. This course provides skills and information on how to monitor air pollution and increase public awareness, how to develop emission inventories and track progress, how to assess the benefits of air quality improvement, how to select control strategies that are most effective and will describe regulatory approaches that have been most effective elsewhere.

Contents

1. Nature and classification of pollutants, sources and effects of pollutants on plant growth, causes, prevention and control of air pollution (vehicular pollution and industrial chimney wastes).
2. Air Pollution, Basic principles of air pollution management, ambient concentrations of air pollutants and trace gases, national environmental policies, implementation of policies and organization of management agencies, national air monitoring programme, effects of air pollution on human health, air quality criteria and case study, emergency preparedness, safety planning and management, vehicular pollution, monitoring and abatement technologies.
3. Air pollution control equipments, objectives and types of control equipments
4. Hazardous air pollutants and their management. Biological abatement of air pollution, scope of green belt development, economical aspect of air pollution abatement technologies.

Lab work

1. Estimation of foliar dust deposition in samples collected from sites exposed to air pollution, Determination of settled particulate matter in air.
2. Biomonitoring of heavy metals in the environment, Mapping of vegetation of selected region by using Remote sensing data, Field visits to industrial areas for on-spot biodiversity assessment and to prepare status report.

Recommended Texts

1. Vallero, D. A. (2014). *Fundamentals of air pollution*. New York: Academic Press.
2. Vallero, D. A. (2019). *Air pollution calculations: quantifying pollutant formation, transport, transformation, fate and risks*. Amsterdam: Elsevier.

Suggested Readings

1. Guardia, M.D.L., &SergioA. (2016). *The quality of air: Volume 73*. London: Oxford Press.
2. Smedley, T. (2019). *Clearing the air: the beginning and the end of air pollution*. New York: Bloomsbury Sigma.

BOTN-6140 **Conservation Ecology** **3(2+1)**

This course will help the students to learn about the work of conservation biologists and study of ecosystems can help with conserving the world's biodiversity. Students will explore the impact of wind farms on populations of seabirds, and understand how the use of advanced techniques can be used to study different populations. It will also enable the students to know that how ecosystems are influenced by human activity and will explore the reasons behind the bee decline across the world, and examine fish species in tropical seas to see at first-hand how climate change damages coral reefs. Conservation ecology is the branch of ecology and evolutionary biology that deals with the preservation and management of biodiversity and natural resources. It is a discipline that is emerging rapidly as a result of the accelerating deterioration of natural systems and the worldwide epidemic of species extinctions. Its goal is to find ways to conserve species, habitats, landscapes, and ecosystems as quickly, as efficiently, and as economically as possible.

Contents

1. Introduction to conservation ecology, history, importance of edaphic factors in conservation. Importance of topographic factors, biotic factors.
2. Ecosystem: Physical conditions and availability of resources.
3. Applied issues in conservation: Role of natural resources in conservation ecology.
4. Types of natural resources (renewable m non-renewable), wildlife management, species preservation, conservation of habitat, introduction of exotic species, natural parks, forests resources, soil and water resources, food and agriculture resources.

Lab work

1. Visits to different disturbed ecosystem
2. Survey of different important species for conservation
3. Visit to different sanctuaries

Recommended Texts

1. Schowalter T. D. (2016). *Plant Ecology: An Ecosystem Approach*. Florida: Academic Press.
2. Ent, A., Repin, R., Sagau, J., & Wong, K. (2015). *Plant Diversity and Ecology of outcrops in Malaysia.* New York: Springer.

Suggested Readings

1. Real, L. (2017). Ecological genetics. Florida: Princeton University Press.
2. Kobori, H., Dicikinson, L. D., Washintani, I., Sakurai, R., & Amano, T. (2016). *A new approach to plant ecology and conservation*. New York: Springer.
3. Baer, H., & Singer, M. (2016). *Global warming and the political ecology of plants health*. London: Rautledge Publishers.

BOTN-6141 Plant Stress Physiology 3(2+1)

This course will provide an understanding of the unique features of plant cells and a general grounding on plant physiology and growth. In addition it will provide a brief introduction to the various physiological, molecular, and biochemical mechanisms plants use to respond to environmental stresses like extreme temperature, drought, salt, and pathogens. Any external factor that negatively influences plant growth, productivity, reproductive capacity, or survival is considered as a stress. In this course the students are expected to; learn the major principles of plant physiology and the crucial processes behind it (e.g. water and nutrient transport, photosynthesis, key regulatory hormones); gain understanding on the interaction between plants and the environment, become familiar with basic methodologies employed in these fields and to develop the skills to read relevant literature, to follow research seminars in these fields and to critically assess the presented information.

Contents

1. The history of stress research, general theory of stress, Stress at plants at sub-cellular, cellular, organ.
2. Stress factors, classification of biotic, abiotic factors, methods of measurement
3. Signal transduction, molecular biological foundations of anti-stress reaction
4. Stress proteins, antioxidants - anti-stress response mechanisms
5. Stress lack / excess of available water (mechanisms to avoid stress)
6. Stress of substrate salinity, osmotic stress, Stress caused by toxic and foreign substances
7. Stress caused by cold, frost, Thermal stress (heat effects of physical, chemical, molecular and biological)
8. Radiation stress (regularly, classification, mechanisms of formation, mechanisms for protection)
9. Acclimation / adaptation to stress in extreme environments. Plant responses to stress at multiple levels of integration - from the molecule to the whole plant. Global issues related to environment and plant stresses. Use of the primary scientific literature as a basis for the in-depth study of plant responses to environmental stress

Lab work

1. Determination of water potential by pressure chamber, Determination of osmotic potential by osmometer, Investigation of osmolytes from plants growing under stress conditions, Estimation of antioxidant activity in plants under stress conditions

Recommended Texts

1. Mitra, G.N. (2015). *Plants: A Biochemical and Molecular* Approach. New Dehli: Springer.
2. Jugulam, M. (2017). *Biology, physiology and molecular biology of weeds*. Florida: CRC Press.

Suggested Readings

1. Taiz, L., & Zeiger, E. (2019). *Plant physiology*.(7thed.) New York: Sinnauers Publ. Co. Inc.
2. Taiz, L., & Zeiger, E. (2018). *Fundamental of plant physiology*. New York: Sinnauers Publ. Co. Inc.
3. Buchanan, B., Gruissem, W., & Russell, L. (2015). *Biochemistry and molecular biology of plants*. Jones. New Jersey: John Wiley & Sons.

BOTN-6142 **Advanced Plant Anatomy** **3(2+1)**

Plant anatomy is the study of the internal structure of plants. It plays a key role in understanding how plants function and is an essential component of much research. This course focuses on plants and provides with comprehensive, updated information about the organization, development, structure and function of plant cells, tissues and organs. It will enable the students to learn about the internal organization of the tissues and their types and when or where these specific types of tissues arise and perform specific function. The following learning outcomes are expected to be achieved through the study of this course i.e. Understand basic concepts and terminology in plant anatomy and various structures of seed plants in relation to their development, function and evolution, Explain how knowledge of plant anatomy is connected to our everyday life and practices in agriculture and forestry etc. The Plant Anatomy course will combine theory and practical so that participants can develop a sound understanding of the structure and function of plants.

Contents

1. The plant body and its development: fundamental parts of the plant body, internal organization, different tissue systems of primary and secondary body.
2. Meristematic tissues, Leaf, Vascular cambium: Origin, structure, storied and non-storied cell types, types of divisions: additive and multiplicative; cytoplasmic characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth.
3. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm, Secretory tissues, Anatomy of reproductive parts: Flower, Seed, Fruit, Economic aspects of applied plant anatomy, Anatomical adaptations, Molecular markers in tree species used for wood identification.

Lab work

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth, Peel and ground sectioning and maceration of fossil material, Comparative study of wood structure of gymnosperms and angiosperms with the help of prepared slides.

Recommended Texts

1. Clive, A., Stace, C.A., & Crawley, M. J. (2015). *Alien* plants. New York: Harper Collins Publishers.
2. Hather, J.G. (2016). *Archaeological Parenchyma*. London: Routledge Publishers.

Suggested Readings

1. Steeves, T. A., & Sawhney, V. K. (2017). *Essentials of developmental plant anatomy*. London: Oxford University Press.
2. Spichiger, R.E. (2019). *Systematic Botany of flowering plants: A new phytogenetic approach of the angiosperms of the temperate and tropical regions*. Florida: CRC Press.

BOTN-6143 Quality Seed Production 3(2+1)

The course is designed to enhance the students' knowledge of seed production and the key roles of bees and other insect pollinators, how to manage seed crops from agronomic, quality control, and genetic integrity standpoints, and how to meet new challenges through seed production research. Seed is the product of fertilized ovule that consists of embryo, seed coat, and cotyledon (s). In terms of seed technology, any part of the plant body which is used for commercial multiplication of crop is called seed. To make the available good quality seeds to the farmers, seed certification is necessary, which is a scientifically designed process. In our country seed certification is linked with notification of kind/variety. Only those varieties are eligible for certification, which are released and notified under Seeds Act. Seed testing is required to achieve the objectives for minimizing the risks of planting low quality seeds and the primary aim of the seed testing is to obtain accurate and reproducible results regarding the quality status of the seed samples submitted to the seed testing laboratories.

Contents

1. Reproductive process in plants. Definition of seed and planting material. Anatomy and chemistry of seed. Introduction to seed industry of Pakistan. Variety development, registration and maintains system.
2. Modern concept of quality and seed management. Production of early generation seed. Seed generation system from pre-basic to basic and certified. Seed quality system, legislation under seed (Amendment). Act-2015, crop inspection, seed testing, seed processing and storage.
3. Production of true to type disease free fruit nursery plant, hybrid seed production, establishment, planning and management of seed business, seed marketing and prices network.
4. Comparative study of various seed management systems in the world.

Lab work

1. Lay out of seed adaptability and demonstration plot.
2. Visit to seed production plot and seed testing Laboratory to know the physical and analytical purity of seed lot,
3. Variety purity identification by using electrophoresis and DNA fingure printing techniques.
4. Assessment of seed viability and planting value by using tetrazolium test and vigor test.
5. Visit to variety breeding institute, seed farm and seed processing plant and seed storage.
6. An assignment/Mini project to assess the profit and loss of seed production entrepreneur.

Recommended Texts

1. Bhutta, A. R. (2010). *Introduction seed pathology*. Islamabad: HEC.
2. Khare, D., & Shale, M. S. (2014). *Seed technology* (2nded.) New York: Scientific Publisher.
3. Singh, S. (2014). *Seed Testing*. Pakistan: Gene Tech Book.

Suggested Readings

1. Hussain, A., & Bhutta, A. R. (2016). *Seed industry in pakistan*. Islamabad: FSC&RD/PSF.
2. Shagufta, S. (2012). *Seed science & seed technology*. New Dehli: APH Publisher.
3. Chakarborty, S. (2013). *Plant Molecular Genetics.* New York: Scientific Publisher.

BOTN-6144 **Seed Pathology** **3(2+1)**

Seed pathology involves the study and management of diseases affecting seed production and utilization, as well as disease management practices applied to seeds. International seed trade has been affected significantly by changing phytosanitary regulations, not always based on science. This course deals with the History, economic importance, dynamic of transmission of plant pathogens, methodology and control measures of seed borne diseases. Seed pathology as a subdisipline of plant pathology is relatively new. Recent developments in the area of seed pathology technology allow for more ecofriendly seed treatments and more reliable seed health testing. Due to economics and new interest in environmental issues, research into the viability of biological seed treatments is becoming more common.

Contents

1. Emergence of seed pathology as an independent discipline and its significance.
2. Morphological and anatomical studies of healthy and infected seed and planting material by using molecular techniques.
3. Effect of seed borne disease on seed viability and planting value. Histopathological study of infected seed, transmission of seed borne pathogens and their establishment in host and then to seed.
4. Mycotoxicological problems induce by seed borne pathogens and their health hazards. Identification of economical important seed borne disease and their post-harvest losses in agriculture and horticulture crops. Seed health technology and seed health certification system for production of disease free seed and inspection of seed consignments during export import and testing of germplasm material.
5. Concept of GMO in management of seed borne disease. Management of commercial scale production of disease free forest nursery and fruit plant certification. Seed and planting material national health standard under the seed (Amendment) Act-2015.Bioterrorism, SPS measures and international obligations.

Lab work

1. Collection of seed samples as per ISTA rules,
2. Isolation of pathogen, identification and preservation of culture, Histopathology of healthy and infected seed.
3. Effect of different chemicals and antagonistic microorganisms on seed borne pathogens and seed germination.
4. Field crop inspection for disease assessment, Visit to seed health testing lab, seed processing plants and seed storage.

Recommended Texts

1. Bhutta, A. R. (2010). *Introductory seed pathology*. Islamabad: HEC.
2. Ahmed, S. (2009). *Plant Disease Management for Sustainable Agriculture*. New Dehli: Daya Publishing House.

Suggested Readings

1. Agarwal,V. K. (2014). *Management of Seed Borne Disease*. New Dehli: Agrobios.
2. Agrios, G. N. (2005). *Plant Pathology*. Florida: Academic Press.

BOTN-6201 **Biostatistics** **3(3+0)**

Biostatistics encompasses the design of biological experiments, the collection and analysis of data from those experiments and the interpretation of the results. This course is designed for graduate programs of sciences. Biostatistics provides an introduction to selected important topics in biostatistical concepts and reasoning. This course represents an introduction to the field and provides a survey of data and data types. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions via sample data; statistical hypothesis testing and its application to group comparisons; issues of power and sample size in study designs; and random sample and other study types. While there are some formulae and computational elements to the course, the emphasis is on interpretation and concepts. Some statistical software will also be part of this course to analyze biostatistical data and improve the analytical skills of the students.

Contents

1. Introduction objectives and scope: i. Definition ii. Characteristics iii. Importance and limit iv. Population and samples
2. Frequency distribution: i. Variable types ii. Formation of frequency table from raw data iii. Summation, notation and statistical inference iv. Data transformation.
3. Measures of central tendencies and dispersion: i. Arithmetic Mean ii. Median iii. Mode iv. Range v. Variance vi. Standard deviation vii. Standard error of the mean viii. Mean deviation.
4. Organizing and describing data (Standard distributions): i. Random sampling and the binomial distribution ii. Probability, Types of Probabilities, Random variables, combining probabilities, Probability distributions Binomial distributions. iii. Poisson and normal distributions, properties and applications.
5. Basic experimental design: i. Concept and design ii. Principles of experiments iii. Observational studies iv. Planning of experiments v. Replication and randomization vi. Field plot technique vii. Layout and analysis of completely randomized design viii. Randomized complete block design ix. Latin square x. Factorial design xi. Treatment comparison
6. Tests of significance: i. T-test: (Basic idea, confidence limits of means, significant difference of means. ii. Chi square test: Basic idea, testing goodness of fit to a ratio, testing association (contingency table). iii. F-test: Introduction and application in analysis of variance. Iv. LSD test, Duncan's New Multiple Range test (for comparison of individual means). Bonferroni test
7. Introduction to comparing of means: Unit organization, Basic one way ANOVA, Types of sums of squares, How ANOVA works, The ANOVA Table. Two-way ANOVA-Factorial designs: (two-way factorial analysis, calculating and analyzing the two-way ANOVA, Linear combination, multiple comparisons.
8. Correlation and Regression.

Recommenced Texts

1. Zar, J. (2000). *Biostatisticalanalysis* (5th ed.). New York: John Wiley & Sons.
2. Shoukri, M.M. & Pause, C.C. (1998). *Statistical methods for health sciences* (2nd ed.). Florida: CRC press.

Suggested Readings

1. Daniel, W.W. (2010). *Biostatistics: A foundation for the health Sciences* (6th ed.). New York: John Wiley & Sons.
2. Dunn, G. & Everit, B. (1995). *Clinical biostatistics*. London: Edward Arnold.

BOTN-6202 Bacteriology and Virology 3(2+1)

Bacteriology involves the identification, classification, and characterization of various bacterial species. It is important in medicine, public health and sanitation work, agriculture, food-processing, and industry. Virology is the study of viruses, complexes of nucleic acids and proteins that have the capacity for replication in animal, plant and bacterial cells. Virology in the field of medical practice is widely used for diagnosis of viral infections, including viral culture, antigen detection, nucleic acid detection, and serology. To understand the morphology, structure and economic importance of Viruses and Bacteria. Bacteriology and Virology covers the basic principles of Bacteriology and Virology. The main objectives of the Microbiology course is to establish the basic knowledge on microbes, mostly bacteria and viruses, and their relationships with other organisms, mainly plants and animals. Also included are the biochemical and molecular techniques and strategies used to study, but also to control, these microorganisms. After this course the students will be able to understand various biological and molecular aspects of viruses.

Contents

1. *Viruses:* General features of viruses, viral architecture, classification, dissemination and replication of single and double - stranded DNA/RNA viruses, Plant viral taxonomy.
2. Virus biology and virus transmission, Molecular biology of plant virus transmission.
3. Symptomatology of virus-infected plants: (external and internal symptoms).
4. Metabolism of virus-infected plants, Resistance to viral infection, Methods in molecular virology.

1. *Bacteria:* History, characteristics and classification, Evolutionary tendencies in Monera (bacteria, actinomycetes and cyanobacteria)
2. Morphology, genetic recombination, locomotion and reproduction in bacteria
3. Bacterial metabolism (respiration, fermentation, photosynthesis and nitrogen fixation)
4. Importance of bacteria with special reference to application in various modern Sciences specially agriculture, biotechnology and genetic engineering.
5. Symptoms and control of major bacterial diseases in Pakistan, Plant microbe interaction

Lab work

1. Viruses: Observation of symptoms of some viral infected plant specimens.
2. Bacteria, Actinomycetes and Cyanobacteria
3. Methods of sterilization of glassware and media etc, Preparation of nutrient medium and inoculation, Preparation of slides for the study of various forms, capsule/slime layer, spores, flagella and Gram-staining.
4. Growth of bacteria, subculturing and identification of bacteria on morphological and biochemical basis (using available techniques), Microscopic study of representative genera of Actinomycetes and Cyanobacteria from fresh collections and prepared slides.

Recommended Texts

1. Black J. & Black, L. (2017). *Microbiology Principles and Exploration (*10th ed.). Arlington: John Wiley and Sons, Inc.
2. Willey, J., Sherwood, L. & Woolverton, C. (2017). *Prescott's microbiology* (10th ed.). Kent State: McGraw-Hill Companies, Inc.

Suggested Readings

1. Mandahar,C. L., (2017). *Plant viruses: structure and replication* (1st ed.). Florida: CRC Press, Taylor & Francis Group Publishers.
2. Pommerville, J., (2018). *Fundamentals of microbiology* (11th ed.). Sudbury: Jones & Bartlet Publishers.

BOTN- 6203 **Phycology and Bryology** **3(2+1)**

This course aims to understand the classification, morphology and economic importance of Algae and Bryophytes. This course provide basic knowledge about the structure and reproduction of algal and bryophytes and their evolutionary tendencies and to introduce the students with different species of algae and bryophytes, their collection methods, mounting and specimen identification and to enable the students to visualize and understand microscopic differences between algae and bryophytes and their importance. The second half of the course will provide detail information on Introduction and general account of bryophytes, classification, and brief study of Hepaticopsida, Anthoceropsida and Bryopsida. By the completion of the course, students will be able to understand the structural difference between algae and bryophytes and their evolutionary trends. Students will also collect, identify and prepared stain slides for different specimens of algae and bryophytes. Students make use of this knowledge for the detailed study of algae, bryophytes and their economic importance.

Contents

1. Phycology Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Chlorophyta, Charophyta, and Xanthophyta.
2. Phycology Introduction, general account, evolution, classification, biochemistry, ecology and economic importance of the following divisions of algae: Bacillariophyta, Phaeophyta and Rhodophyta.
3. Bryology: Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Hepaticopsida,
4. Bryology: Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Anthoceropsida.
5. Bryology: Introduction and general account of bryophytes, classification, theories of origin and evolution. Brief study of the classes: Bryopsida.

Lab work

Phycology:
1. Collection of fresh water and marine algae.
2. Identification of benthic and planktonic algae
3. Section cutting of thalloid algae
4. Preparation of temporary slides
5. Use of camera lucida/micrographs.

Bryology
1. Study of the following genera: *Pellia, Porella, Anthoceros and Polytrichum*.

Recommended Texts

1. Lee, R. E. (2019). *Phycology* (5th ed.). Cambridge: Cambridge University Press.
2. Bellinger, E., (2015). *Freshwater algae* (2nd ed.). New Jersey: John Wiley and Sons Ltd.

Suggested Readings

1. Barsanti, L. & Gualtieri, P. (2014). *Algae: anatomy, biochemistry, and biotechnology* (1st ed.). Florida: CRC Press, Taylor and Francis Group.
2. Hussain, F. (2016) *Phycology: A text book of algae* (1st ed.). Lahore: Pak Book Empire.

BOTN-6204 Mycology and Plant Pathology 3(2+1)

The aim of the course is to introduce the students to Mycology and diseases caused by Fungi, to develop an understanding of the diversity of organisms in the Kingdom Fungi. This course will provide students with basic concepts and identification of fungi, plant pathogens and diseases caused to various important crops. Students will be able to: identify major fungal groups based on morphology (both in the field and in the lab); understand and explain the ecological roles and trophic modes of major fungal groups; use fungal biology resources to understand fungal nomenclature and systematic; demonstrate a broad knowledge of core concepts in Plant Pathology; disease diagnosis and management.Upon completion of the course the student will be able to: describe the concepts of what constitutes disease in plants. Identify major principles of plant pathology; recognize the etiological agents of disease. Employ methods to diagnose and manage a wide range of plant diseases; describe aspects of integrated pest management; explain the impact of plant disease on human affairs.

Contents

Mycology
1. Introduction: General characters of fungi, Thallus, cell structure and ultra structure of fungi.
2. Reproduction, life cycle, haploid, heterokaryotic and diploid states.
3. Fungal Systematics: Classification of fungi into phyla with suitable examples to illustrate somatic structures, life cycle and reproduction.
4. Lichens and mycorrhiza: Symbiotic fungi and their significance.
5. Importance of fungi: Industrial and Agricultural.

Pathology
6. Introduction, classification, Symptoms, causes and development of plant diseases
7. Loss assessment and disease control, Epidemiology and disease forecast
8. Important diseases of crop plants and fruit trees in Pakistan caused by fungi
9. Systemic resistance: Induced systematic resistance (ISR), Acquired Systematic resistance (ASR).

Lab work

1. Mycology: General characters and morphology of fungi. Study of unicellular and mycelial forms with septate and aseptate hyphae. Distinguishing characters of different phyla: study of suitable examples. Study of asexual and sexual reproductive structures in different groups of fungi. Study of some common examples of saprophytic, parasitic and air-borne fungi belonging to different phyla.
2. Pathology: Identification of major plant pathogens under lab and field conditions, cultural studies of some important plant pathogenic fungi, application of Koch's postulates for confirmation of pathogencity. Demonstration of control measures through chemotherapeutants.

Recommended Texts

1. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (2nd ed.). New York: APS Press, The American Phytopathological Society.
2. Burchett, S., & Burchett, S. (2018). *Plant pathology (*1st ed.). New York: Garland Science Published.

Suggested Readings

1. Phillips, M., (2017). *Mycorrhizal planet: how symbiotic fungi work with roots to support plant health and build soil fertility* (1st ed.). New York: Chelsea Green Publishing Company.
2. Piepenbring, M., (2015). *Introduction to mycology in the tropics* (1st ed.). Florida: APS Press, The American Phytopathological Society.

BOTN-6205 Diversity of Vascular Plants 3(2+1)

This course is designed to introduce students to the major lineages of vascular plants, including the ferns, gymnosperms and flowering plants; to enable the students to understand and appreciate the biology and evolution of plant architecture; to examine the evolutionary origins of plants and the impacts humans have had on plant evolution and diversity; to explore the methods of fossilization and its importance in biology; to get a broad overview of Pteridophytes, Gymnosperms and Angiosperms; to have a good overview of the general morphology, sexual reproduction and diversity of the different divisions of vascular plants; to emphasize appropriate science skills, in lab, including experimental observation, and illustration in various groups of vascular plants. Students will be able to: recognize the major groups of vascular plants; differentiate them by their principal characters, and understand their phylogenetic relationships; utilize the knowledge in developing strategies for their higher studies conservation of the plants and sustainable utilization of these natural resources.

Contents

1. Pteridophytes Introduction, origin, history, features and a generalized life cycle. Methods of fossilization, types of fossils, geological time scale and importance of paleobotany. First vascular plant Rhyniophyta e.g. *Cooksonia*. General characters, classification, affinities and comparative account of evolutionary trends of the following phyla: Psilopsida (*Psilotum*), Lycopsida (*Lycopodium, Selaginella*), Sphenopsida (*Equisetum*), Pteropsida (*Ophioglossum, Dryopteris* and *Marsilea*).
2. Origin and Evolution of seed habit.
3. Gymnosperms: Geological history, origin, distribution, morphology, anatomy, classification and affinities of Cycadofillicales, Bennettitales, Ginkgoales, Cycadales, Coniferales and Gnetales. Distribution of gymnosperms in Pakistan. Economic importance of gymnosperms.
4. Angiosperms: Origin, general characteristics, importance, and life cycle of angiosperms.
5. Palynology:An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration.
6. Basic information about the nomenclature, morphology and classification of living and fossil pollen and spores.

Lab work

1. To study the morphological and reproductive features of available genera.
2. Study trips to different parts of Pakistan for the collection and identification of important pteridophytes, gymnosperms and angiosperms.
3. Study of pollen morphology

Recommended Texts

1. Maarten J., Christenhusz, M., & Michael F., (2017). Chase, *plants of the world: an illustrated encyclopedia of vascular plants* (1st ed.). United States: Kew publishing.
2. Maarten J., Christenhusz, M., Michael F. & Byng, J.W. (2018). *The global flora: a practical flora to vascular plant species of the world* (1st ed.). Bradford: Plant Gateway Limited.

Suggested Readings

1. Hobohm, C., (2016). *Endomism in vascular plants* (1st ed.). New York: Columbia University Press.
2. Bowcutt, F. &Hamman, S., (2016). *Vascular plants of the south sound prairies* (1st ed.). Washington: Evergreen State College Greener Bookstore .

BOTN-6206 Plant Systematics 3(2+1)

Plant systematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. The aim of the course is to know floral composition/system of classification focusing on identification, classification, and description nomenclature and flora writings monographs. An introduction to the goals and methods of plant systematics, and a survey of the diversity of vascular plants, including ferns, conifers, flowering plants, and related groups. Plant systematics is the study of flowering plant diversity. Lectures cover the processes of plant reproduction and evolution, patterns of plant diversity and biogeography, and the methods used to analyze and interpret these patterns and processes. The laboratory presents a survey of the vascular plants with a focus on major plant families, emphasizing prominent groups in natural habitats and in cultivation.

Contents

1. Introduction: Importance, origin and relationship with other sciences
2. Concept of Species
3. Speciation: Mechanism of speciation, Mutation and hybridization.
4. Variation: Types of variation, continuous and discontinuous variation, Clinal variation.
5. Systematics and Gene ecology / Biosystematics:
6. Taxonomic Evidence: Importance and types of taxonomic evidences:
7. Nomenclature: Important rules of Botanical nomenclature
8. Classification: Why classification is necessary? Different systems of classification
9. Brief introduction of Numerical taxonomy**.**
10. General characteristics, distribution, evolutionary trends, phyletic relationships and economic importance of the following families of angiosperm:
    Apiaceae (Umbelliferae), Arecaceae (Palmae), Asclepiadaceae, Asteraceae (Compositae), Boraginaceae, Brassicaceae (Cruciferae), Caryophyllaceae, Chenopodiaceous, Convolvulaceae, Cucurbitaceae, Cyperaceae, Euphorbiacea, Fabaceae (Leguminosae), Lamiaceae (Labiatae), Liliaceae, Magnoliaceae, Malvaceae, Myrtaceae, Orchidaceae, Papaveraceae, Ranunculaceae, Rosaceae, Salicaceae, Scrophulariaceae

Lab work

1. Technical description of plants of the local flora and their identification up to species level with the help of a regional/Flora of Pakistan, Preparation of indented and bracketed types of keys
2. Preparation of permanent slides of pollen grains by acetolysis method and study of different pollen characters. Study of variation pattern in different taxa.
3. Submission of properly mounted and fully identified hundred herbarium specimens at the time of examination
4. Field trips shall be undertaken to study and collect plants from different zones of Pakistan.

Recommended Texts

1. Simpson, M., (2019). *Plant systematics* (3rd ed.). New York: Elsevier.
2. Novikov, A. & Barabasz-Krasny, B., (2015). *Modern plant systematic* (1st ed.).Ukrainian:Liga-Press.

Suggested Readings

1. Hoorn, C., Perrigo, A. & Antonelli, A., (2018). *Mountains, climate and biodiversity* (1st ed.). New Jersey: Wiley-Blackwell.
2. Shipunov, A., (2018). *Introduction to botany* (1st ed.). North Dakota: Minot State University Publications.

BOTN-6207 **Plant Anatomy** **3(2+1)**

The aim of the course is to provide the students understanding about anatomical features of vascular plants. To provide students with skills necessary to section and stain fresh plant material in preparation for study of plant anatomy. To train students in the proper use of the compound light microscope and to give them experience in interpreting images that they see through the microscope in terms of how plant structure is related to function. To provide students with skills in modern microscopic digital image capture, processing and analysis techniques useful in plant anatomical studies. To instill in students an appreciation for the complexity of tissue organization that exists within plant bodies that allow plants to develop and live as integrated organisms in diverse environments. Identify the parts of a leaf and distinguish between compound and simple leaves. Identify the anatomy and morphology (cells, tissues, and tissue systems) of a given plant leaf.

Contents

1. The plant body and its development.
2. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
3. Apical meristem: evolution of apical organization. Shoot and root apices.
4. Leaf: types, origin, internal organization and development of different tissues
5. Vascular cambium: Origin, structure, and types of tissues Abnormal secondary growth. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm.
6. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
7. Anatomy of Reproductive parts: Flower, Seed, Fruit, Economic aspects of applied plant anatomy.
8. Anatomical adaptations. Molecular markers in tree species used for wood identification.

Lab work

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures, Study of abnormal/unusual secondary growth. Peel and ground sectioning and maceration of fossil material.
2. Comparative study of wood structure of gymnosperms and angiosperms with the help of prepared slides.

Recommended Texts

1. Crang, R., Lyons-Sobaski, S. & Wise, R., (2018). *Plant anatomy: a concept-based approach to the structure of seed plants* (1st ed.). Switzerland: Springer.
2. Schweingruber, F. H. & Borner, A., (2018). *The plant stem: a microscopic aspect*(1st ed.). Switzerland: Springer.

Suggested Readings

1. Hacke, U. G., (2015). *Functional and ecological xylem anatomy* (2nd ed.). New York: Springer International Publishing.
2. Steeves, T.A. & Sawhney, V.K., (2018). *Essentials of developmental plant anatomy* (1st ed.). London: Oxford University Press.

BOTN-6208 **Genetics-I** **3(2+1)**

This course provides the basic biology to understand all of these issues better, tries to clarify some misconceptions, and tries to prepare students for future, more advanced coursework in Genetics. Genetics is the study of how genes bring about characteristics, or traits, in living things and how those characteristics are inherited. The aim of the course is to learn and apply concepts of modern transmission and molecular genetics. The objectives of the are: to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis, as well as predict the outcomes of these processes; to solve transmission genetics problems, make accurate predictions about inheritance of genetic traits, and map the locations of genes; to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes. This course discusses the principles of genetics with application to the study of biological function at the level of molecules, cells, and multicellular organisms, including humans.

Contents

1. Extensions of Mendelian Analysis: Variations on dominance, multiple alleles, lethal alleles,
2. Linkage I: Basic eukaryotic chromosome mapping : The discovery of linkage, recombination, linkage symbolism, linkage of genes on the X chromosome, linkage maps, three-point testcross.
3. Linkage II: Special eukaryotic chromosome mapping techniques: Accurate calculation of large map distances, Recombination in Bacteria and their Viruses
4. The Structure of DNA, The Nature of Gene: How genes work, gene-protein relationships.
5. DNA Function: Transcription, translation, eukaryotic RNA.
6. The Extranuclear Genome: Variegation in leaves of higher plants, cytoplasmic inheritance in fungi, extranuclear genes in chlamydomonas, mitochrondrialgenes in yeast, extragenomic plasmids in eukaryotes.
7. Developmental Genetics: Gene Regulation and Differentiation, Crown gall disease in plants, cancer as a developmental genetic disease.
8. Population Genetics: Gene frequencies, conservation of gene frequencies, equilibrium, Hardy-Weinberg law, factors affecting gene equilibrium.

Lab work

1. Arrangement of genetic material: Linkage and recombination, Gene mapping in diploid.
2. Recombination in Fungi, bacteria and viruses
3. Population Genetics: Gene frequencies, equilibrium and Changes in gene frequencies,
4. Blood group and Rh-factor, Drosophila, Culture technique, Salivary gland chromosome
5. Fungal Genetics: *Saccharomyces* culture techniques and study.
6. Studies on variation in maize ear size and colour variation
7. Bacterial Genetics, Bacterial cultural techniques, Gram staining (*E. coli, B. Subtilis*), Transformation, Conjugation.

Recommended Texts

1. Klug, W. S., Cummings, M. R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics* (12th ed.). New York: Pearson Publishers.
2. Klug, W. S., Cummings, M. R., Spencer, C. A. & Palladino, M. A., (2016). *Concepts of genetics* (11th ed.). New York: Pearson Publishers.

Suggested Readings

1. Grotewold, E., Chappell, J. & Kellogg, E. A., (2015). *Plant genes, genomes and genetics* (1st ed.). New Jersey: Willey Blackwell.
2. Carey, N., (2016). *The epigenetics revolution* (2nd ed.).London: PublisherIcon*Books* Ltd.

BOTN-6209 Plant Biochemistry -I 3(2+1)

Biochemistry is the study of the chemical processes that drive biological systems. Biochemistry is both life science and a chemical science. It explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. Because the field of biochemistry is continually evolving and touches many areas of cell biology, this course also includes an elementary introduction to the study of molecular biology. Biochemistry is both life science and a chemical science - it explores the chemistry of living organisms and the molecular basis for the changes occurring in living cells. It uses the methods of chemistry, "Biochemistry has become the foundation for understanding all biological processes. The course aims to provide an advanced understanding of the core principles and topics of Biochemistry and their experimental basis, and to enable students to acquire a specialized knowledge and understanding of selected aspects.

Contents

1. Introduction to photosynthetic organisms, and Photosynthesis
2. Introduction to carbohydrates: occurrence, classification, structures, synthesis, transport in plants.
3. Introduction to lipids: occurrence, classification, structure and chemical properties of fatty acids, fatty acid biosynthesis in plants
4. Introduction to proteins: occurrence, classification, properties, Amino acids: structure. Electrochemical properties and reactions of amino acids.
5. Protein purification, protein sequencing, biological role, plant defense proteins. Synthesis and functions of non-ribosomal peptides
6. Introduction to Nucleic Acids: Structure and properties of DNA and RNA, types and functions of RNA, nucleic acid metabolism.
7. Introduction to Enzymes: Nature, functions, I.U.E. classification, mechanism of action and biosynthesis pathway.

Lab work

1. Solutions, acids and bases, electrolytes, non-electrolytes, buffers, pH and chemical bonds.
2. To determine the R_f value of monosaccharide's on a paper Chromatogram.
3. To estimate the amount of reducing and non-reducing sugars in plant material titrimetrically/spectrophotometrically.
4. To determine the saponification number of fats, To extract and estimate oil from plant material using soxhlet apparatus, Analysis of various lipids by TLC methods.
5. To estimate soluble proteins by Biuret or Lowry or Dye-binding method, To estimate the amount of total Nitrogen in plant material by Kjeldahl's method.
6. To determine R_f value of amino acids on a paper chromatogram, Extraction of Nucleic acids from plant material and their estimation by UV absorption or color reactions, To estimate the catalytic property of enzyme catalase or peroxidase extracted from a plant source.

Recommended Texts

1. Nelson, D. & Cox, M., (2017). *Lehninger: principles of biochemistry* (7^{th} ed). New York: W.H. Freeman.
2. Heldt, H. & Piechulla, B., (2016). *Plant biochemistry* (1^{st} ed.). London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C.W., (2015). *Fundamentals of biochemistry* (5^{th} ed.). New Jersey: John Wiley and Sons.
2. Mitra, G. N., (2015). *Plants: A biochemical and molecular approach*. New Dehli: Springer.

BOTN-6210 **Plant Ecology-I** **3(2+1)**

Plant Ecology is the study of organisms, populations, and communities as they relate to one another and interact in the ecosystems they comprise. In plant ecology, ecosystems are composed of organisms, the communities they comprise, and the non-living aspects of their environment. The four main levels of study in plant ecology are the organism, population, community, and ecosystem. Ecosystem processes are those that sustain and regulate the environment. Ecological areas of study include topics ranging from the interactions and adaptations of organisms within an ecosystem to the abiotic processes that drive the development of those ecosystems. The course covers plant ecology on advanced level. The course deals with plants life history and functional traits, demography, and interactions between plants, between plants and animals and between plants and the remaining ecosystem.The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving.

Contents

1. Introduction: History and recent developments in ecology.
2. Soil: Nature and properties of soil, water in the soil-plant-atmosphere continuum, the ionic environment and plant ionic relations, nutrient cycling. Physiology and ecology of N, S, P and K nutrition. Heavy metals (brief description), salt and drought stress and osmoregulation.
3. Light and temperature: Nature of light, factors affecting the variation in light and temperature, responses of plants to light and temperature, adaptation to temperature extremes,
4. Carbon dioxide: Stomatal responses, water loss and CO_2 assimilation rates of plants in contrasting environments. Ecophysiological effects of changing atmospheric CO_2concentration. Functional significance of different pathways of CO_2 fixation. Productivity: response of photosynthesis to environmental factors, C and N balance.
5. Water: Water as an environmental factor, role of water in the growth, adaptation and distribution of plants, water status in soil, water and stomatal regulation, transpiration of leaves and canopies.
6. Oxygen deficiency: Energy metabolism of plants under oxygen deficiency, morph-anatomical changes during oxygen deficiency, post-anoxic stress
7. Wind and fire as an ecological factor, Carbon credit

Lab work

1. Determination of physico-chemical properties of soil and water.
2. Measurements of light and temperature under different ecological conditions.
3. Measurements of wind velocity.
4. Measurement of CO_2 and O_2 concentration of air and water.
5. Effect of light, temperature, moisture, salinity and soil type on germination and growth of plants.
6. Measurement of ions, stomatal conductance, osmotic potential, water potential, xylem. pressure potential, leaf area and rate of CO_2 exchange in plants in relation to various environmental conditions.

Recommended Texts

1. Keddy, P. A., (2017). *Plant ecology origins, processes, consequences* (2nd ed.). Cambridge: Cambridge University Press.
2. Canadell, J. G., Diaz, S. Heldmaier, G., Jackson, R.B., Levia, D.F., Schulze, E.D., Sommer, U. & Wardle, D. A., (2019). *Ecological studies* (1st ed.). New York: Springer.

Suggested Readings

1. Fath, B., (2018). *Encyclopedia of ecology* (2nd ed.). New York: Elsevier.
2. Keddy, P. A., (2018). *Wetland ecology: principles and conservation*. Cambridge: Cambridge University Press.

BOTN-6211 Plant Physiology-I 3(2+1)

This course provides an introduction to basic principles of plant functions including physical processes occurring in plants, Photosynthesis, Respiration, Pathway of translocation, Gaseous exchange, Mechanism of stomatal regulation and growth and development. This course aims to develop understanding of the relationship of complementary metabolic pathways such as photosynthesis and respiration in energy acquistion and use during plant development and to develop understanding of the environmental influences upon carbon metabolism in plants (e.g. with respect to alternative fixation pathways, photoinhibition, and photorespiration). Plant physiology deals with all the internal activities of plants. The subject here to describe plant physiology-I comprises on harvesting of light by plants and its conversion into a chemical energy, mechanism of oxygen evolution by plants, cyclic and non-cyclic electron transport chain. This also gives information about dark reaction, C3, C4 cycle, mechanisms of photosynthesis in CAM plants and phloem transport.

Contents

1. Photosynthesis: light and dark reactions. C_3, C_4 and CAM pathways.
2. Respiration: Synthesis of hexose sugars from reserve carbohydrates, mechanism of respiration-glycolysis, differences between cytosolic and chloroplastidic glycolysis, oxidative decarboxylation, Krebs cycle, regulation of glycolysis and Krebs cycle, Electron transport and oxidative phosphorylation, aerobic and anaerobic respiration. Energetics of respiration, pentose phosphate pathway, glyoxylate cycle, cyanide resistant respiration.
3. Translocation of Food: Pathway of translocation, source and sink interaction, materials translocated, mechanism of phloem transport, loading and unloading.
4. Leaves and Atmosphere: Gaseous exchange, mechanism of stomata regulation, factors affecting stomatal regulation.
5. Assimilation of Nitrogen, Sulphur and Phosphorus: The nitrogen cycle, nitrogen fixation, pathways of assimilation of nitrate and ammonium ions, assimilation of Sulphur and phosphorus.

Lab work

1. To determine the volume of CO_2 evolved during respiration by plant material.
2. To determine the amount of O_2 used by respiring water plant by Winkler Method.
3. Separation of chloroplast pigments on column chromatogram and their quantification by spectrophotometer.
4. To extract and separate anthocyanins and other phenolic pigments from plant material and study their light absorption properties.
5. To categorize C_3 and C_4 plants through their anatomical and physiological characters.
6. To regulate stomatal opening by light of different colors and pH.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). London: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1st ed.). New Dehli: Springer.
2. Buchanan, B., Gruissem, W. & Russell, L., (2015). *Biochemistry and molecular biology of Plants* (2nd ed.). New Jersey: John Wiley & Sons.

BOTN-6212 **Cell Biology** **3(2+1)**

This course aims to understand the structures and purposes of basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles. These can include responses to environmental or physiological changes, or alterations of cell function brought about by mutation. To know about the cell division; how and when it takes place. To know about the cancer, causes types and possible preventive measures. Cell biology is the study of cell structure and function, and it revolves around the concept that the cell is the fundamental unit of life. Focusing on the cell permits a detailed understanding of the tissues and organisms that cells compose. It is the study of cell with respect to its anatomy and physiology. It provide understanding of about cell which act as fundamental unit of life. It focusing on cell combine form tissues, organ and organism. Research in cell biology is interconnected to other fields such as genetics, molecular genetics, biochemistry, molecular biology, medical microbiology, immunology, and cytochemistry.

Contents

1. Introduction of prokaryotes and eukaryote cell, Animal and Plant cell structure.
2. Brief description of ultra-structure and functions of plant cell organelles.
3. End membranous systems.
4. Cell cycle and cell division; meiosis in sexual reproduction in plants.
5. Cellular metabolism and enzymes.
6. Cellular respiration and photosynthesis.
7. Biological information flow; transcription and translation.
8. Informational molecules; carbohydrates proteins and nucleic acids.
9. Cytoskeleton in cell cycle and mitosis.
10. Extra cellular matrix; various types of extra cellular matrix proteins; elastic fibronectin, glycoprotein, collagen, dynein and motor proteins.
11. Vesicular trafficking, cell migration, cell adhesion, cancer growth factors, disorders in cell cycle, apoptosis and gap junction.

Lab work

1. Study of mitosis and meiosis in onion root tip and pollen grains
2. Study of cell organelles in plant cell by compound microscope
3. Measurement of cell size
4. Separation of different sized DNA fragments on agarose gel.
5. Study of chromosomes morphology and variation in chromosomes number.
6. Counting of prokaryotic cells (bacteria) and blood cells by using haemocytometer.
7. Extraction and estimation of carbohydrates, proteins and DNA from plant sources.

Recommended Texts

1. Verma, P. S. & Agarwal, V.K., (2016). *Cell biology* (*cytology, biomolecules and molecular biology*) (1st ed.). New Dehli: S. Chand Publishing .
2. Milo, R. & Phillips, R., (2015). *Cell biology by the numbers (*1st ed.). London: Taylor and Francis publications.

Suggested Readings

1. Templeton, N. S., (2015). *Gene and cell therapy* (4th ed.). London: Taylor and Francis.
2. Sybille, M. & Maria, S., (2015). *Tumor cell metabolism* (1st ed.). New York: Springer Publications.

URCC-5110 Citizenship Education and Community Engagement 0 (0-0)

In recent years, community engagement has become a central dimension of governance as well as policy development and service delivery. However, efforts to directly involve citizens in policy processes have been bedeviled by crude understandings of the issues involved, and by poor selection of techniques for engaging citizens. This course will provide a critical interrogation of the central conceptual issues as well as an examination of how to design a program of effective community engagement. This course begins by asking: Why involve citizens in planning and policymaking? This leads to an examination of the politics of planning, conceptualizations of "community" and, to the tension between local and professional knowledge in policy making. This course will also analyze different types of citizen engagement and examine how to design a program of public participation for policy making. Approaches to evaluating community engagement programs will also be a component of the course.

Contents

1. Introduction to Citizenship Education and Community Engagement: Orientation
2. Introduction to Active Citizenship: Overview of the ideas, Concepts, Philosophy and Skills
3. Identity, Culture and Social Harmony: Concepts and Development of Identity
4. Components of Culture and Social Harmony, Cultural & Religious Diversity
5. Multi-cultural society and inter-cultural dialogue: bridging the differences, promoting harmony
6. Significance of diversity and its impact, Importance and domains of inter-cultural harmony
7. Active Citizen: Locally active, Globally connected
8. Importance of active citizenship at national and global level
9. Understanding community, Identification of resources (human, natural and others)
10. Human rights, Constitutionalism and citizens' responsibilities: Introduction to human rights
11. Universalism vs relativism, Human rights in constitution of Pakistan
12. Public duties and responsibilities
13. Social Issues in Pakistan: Introduction to the concept of social problem, Causes and solutions
14. Social Issues in Pakistan (Poverty, Equal and Equitable access of resources, unemployment)
15. Social Issues in Pakistan (Agricultural problems, terrorism & militancy, governance issues)
16. Social action and project: Introduction and planning of social action project
17. Identification of problem, Ethical considerations related to project
18. Assessment of existing resources

Recommended Texts

1. Kennedy, J. K., & Brunold, A. (2016). *Regional context and citizenship education in Asia and Europe*. New York: Routledge Falmer.
2. Macionis, J. J., & Gerber, M. L. (2010). *Sociology*. New York: Pearson Education

Suggested Readings

1. British Council. (2017). *Active citizen's social action projects guide.* Scotland: British Council
2. Larsen, K. A., Sewpaul, V., & Hole, G. O. (Eds.). (2013). *Participation in community work: International perspectives.* New York: Routledge

BOTN-6213 Molecular Biology 3(2+1)

Molecular biology is the branch of biology that concerns the molecular basis of biological activity in and between cells, including molecular synthesis, modification, mechanisms and interactions. Molecular biology is a specialized branch, the study of the chemistry of biological molecules which are specifically connected to living processes of particular importance to molecular biology are the nucleic acids (DNA and RNA) and the proteins which are constructed using the genetic instructions encoded in those molecules. As a result, molecular biology techniques are at the forefront of most cutting edge scientific research. Molecular biology provides scientists with a toolkit with which they may "tinker" with the way life works. They may use them to determine the function of single genes or proteins, and find out what would happen if that gene or protein was absent or faulty. Molecular biology is used to examine when and why certain genes are switched "on" or "off".

Contents

1. Nucleic Acids: DNA-circular and super helical DNA, renaturation, hybridization, sequencing of nucleic acids, synthesis of DNA, Central Dogma
2. Proteins: Basic features of protein molecules, folding of polypeptide chain, α-helical and β-secondary structures, protein purification and sequencing.
3. Transcription: Enzymatic synthesis of RNA, transcriptional signals. Translation: The genetic code, the Wobbling, polycistronic and monocistronic RNA, overlapping genes.
4. Gene regulation in Eukaryotes: Differences in genetic organization and prokaryotes and eukaryotes. Regulation of transcription, initiation, regulation of RNA processing, regulation of nucleocytoplasmic mRNA transport, regulation of mRNA stability, regulation of translation, regulation of protein activity.
5. Plant Genomics: Transcriptomics; DNA libraries, their construction, screening and application. Microarray of gene technology and its application in functional genomics.
6. Proteomics: Structural and functional proteomics, methods to study proteomics Metabolomics; methods to study metabolomics; importance and application of metabolomics
7. Bioinformatics and Computational Biology. Levels, scope, potential and industrial application of bioinformatics and computational biology, docking.

Lab work

Following techniques will be used for the isolation and analysis of different components:
1. Extraction of RNA, DNA and proteins.
2. Electrophoreses: One and two dimensional
3. Purification of proteins, RNA and DNA.
4. Amplification using PCR, Northern, Western and Southern Blotting.

Recommended Texts

1. Nelson, D., & Cox, M., (2017). *Lehninger: principles of biochemistry* (7th ed.). London: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A., (2016). *Molecular cell biology* (8th ed.). London: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B.,Sahijram, R.& Murthy, K., (2015). *Plant biology and biotechnology* (1st ed.). Berlin: Springers-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M., (2019). *Molecular biology* (1st ed.). Amsterdam: Elsevier Inc.

BOTN-6214 Plant Biochemistry-II 3(2+1)

This course provides an advanced introduction to the fundamental processes of plant metabolism. Topics will include protein structure and function, mechanisms and control of enzyme action, the biochemistry of carbohydrate, fat and protein metabolism, energy generation and ruminant specific biochemistry. Explain how protein structure and function is derived from the constituent amino acids, and compare the features of structural and globular proteins. Describe the basic principles governing the rate of enzyme catalysed reactions and the forms of inhibition of enzyme-catalysed reactions. Describe the major pathways of carbohydrate, lipid and amino metabolism and demonstrate how energy is stored and released through them. Demonstrate familiarity and competence with the practical skills and techniques used in biochemical research and analysis. This will include experimental planning, the preparation of reagents and use of basic instrumentation (spectrophotometers, centrifuges, chromatographic apparatus etc), the collection of biochemical data and its presentation, and most importantly, the analysis and interpretation of the outcomes of biochemical investigations.

Contents

1. Bioenergetics: Energy, laws about energy changes, oxidation and reduction in living systems.
2. Metabolism: Biosynthesis, degradation and regulation of sucrose and starch. Breakdown of fats with special reference to beta-oxidation and its energy balance, biosynthesis of fats. Replication of DNA, reverse transcription, biosynthesis of DNA and RNA. Components of protein synthesis, genetic code, protein synthesis: initiation, elongation and termination.
3. Alkaloids: Occurrence, physiological effects, chemical nature with special reference to solanine, nicotine, morphine, theine and caffeine. Aflatoxins, their nature and role.
6. Terpenoids: Classification monoterpenes, sesquiterpenes, diterpenes, triterpenes, tetraterpenes, polyterpenes and their chemical constitution and biosynthesis.
7. Vitamins: General properties and role in metabolism.

Lab work

1. Separation of soluble proteins by polyacrylamide gel (PAGE) electrophoresis.
2. Separation of nucleic acids by gel electrophoresis.
3. To estimate the amount of vitamin C in a plant organ (orange, apple juice).
4. To determine potential alkaloids in plants.
5. To estimate terpenoids in plants.

Recommended Texts

1. Nelson, D., & Cox, M. , (2017). *Lehninger*: *principles of biochemistry* (7^{th} ed.). London:W.H. Freeman.
2. Heldt, H., & Piechulla, B., (2016). *Plant Biochemistry*. London: Academic Press.

Suggested Readings

1. Voet, D., Voet, J. G. & Pratt, C. W. (2015). *Fundamentals of biochemistry* (1^{st} ed.). New Jersey: John Wiley and Sons.
2. Heldt, H. W., (2015). *Plant biochemistry* (5^{th} ed.). Cambridge: Academic Press.

BOTN-6215 **Plant Ecology-II** **3(2+1)**

Plant ecology examines the relationships between plants and their physical and biotic environment. Plants are mostly sessile and photosynthetic organisms, and must attain their light, water, and nutrient resources directly from the immediate environment. The course aims to provide comprehensive knowledge of population, community, ecosystem ecology and its relevance to mankind. The course covers plant ecology on advanced level. The main objectives for this course in plant ecology are to provide a broad overview of the field of plant ecology. Plant ecology course deals with the study of the main environmental factors affecting the Earth's major vegetation types: tropical forests, tropical savannas, arid regions (deserts), Mediterranean ecosystems, temperate forest ecosystems, temperate grasslands, coniferous forests, tundra. The student can analyze the current theories, methods and interpretations within the field plant ecology, and work independently with practical and theoretical problem solving with respect to plant responses in terms of functional traits, life history, demography and ecosystem interactions in different ecosystems.

Contents

1. Population Ecology, Population structure and plant demography: Seed dispersal, seed bank, seed dormancy, recruitment and demography
2. Life history pattern and resource allocation: Density dependent and density independent factors, resource allocation, reproductive effort, seed size versus seed weight, population genetics and evolution
3. Community Ecology: Historical development of community ecology, community concepts and attributes, methods of sampling of plant communities, ecological succession, community soil-relationship, local vegetation, vegetation of Pakistan and major formation types of the world
4. Ecosystem Ecology: Ecological concepts of ecosystem, boundaries of ecosystem. Compartmentalization and system concepts, energy flow in ecosystem, biogeochemical cycles: water carbon and nitrogen case studies.

Lab work

1. Determination of seed bank in various populations, Seed dispersal pattern of local populations.
2. Demography and life history of local annual population.
3. Study of community attributes. Sampling of vegetation including Quadrat, plotless, transect and Braun-Blanqut.
4. Field trip to study different communities located in different ecological regions of Pakistan.
5. Slide show of the vegetation of Pakistan, the major formations of the world
6. Soil physical and chemical properties, Correlation of soil properties with vegetation type

Recommended Texts

1. West, P. W., (2015). *Tree and forest measurement* (1st ed.). Switzerland: Springer International Publishing AG.
2. Osborne, P. L., (2017). *Tropical ecosystems and ecological concepts* (2nd ed.). England: Cambridge University Press.

Suggested Readings

1. Perera, A. H., Peterson, U., Pastur, G.M. &Iverson, L. R., (2018). *Ecosystem services from forest landscapes: broadscale considerations* (1st ed.). New York: Springer International Publishing AG.
2. Mabberly, D. J. (2017). *Mabberly's, plant book: a portable dictionary of plants their uses and classification* (1st ed.). Cambridge: Cambridge University Press.

BOTN-6216 **Research Methodology** **2(2+0)**

This course aims to know about research methods, research process, research design, development of skills for writing the research paper and knowledge about the major theoretical and philosophical underpinnings of research. The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course aims at introducing them to the basic concepts used in research and to scientific social research methods and their approach. This course will provide an opportunity for participants to establish or advance their understanding of research through critical exploration of research language, ethics, and approaches. The course introduces the language of research, ethical principles and challenges, and the elements of the research process within quantitative, qualitative, and mixed methods approaches. Participants will use these theoretical underpinnings to begin to critically review literature relevant to their field or interests and determine how research findings are useful in forming their understanding of their work, social, local and global environment.

Contents

1. Research Methods.
2. Planning research, various methods. analyzing results, giving reports etc
3. Research Process.
4. Formulating research questions; sampling (probability and no probability).
5. Measurements, Surveys
6. Scaling, Qualitative Measurements
7. Unobtrusive, Research Design
8. Experimental Design
9. Quasi-experimental
10. Data analysis
11. Writing the Research Paper
12. The major theoretical and philosophical underpinnings of research
13. The idea of validity in research,
14. The reliability of measures
15. Ethics in research.

Recommended Texts

1. Leedy, P. & Ormrod, J.A., (2019). *Practical research: planning and design* (12th ed.). New York: Pearson Publishers.
2. Creswell, J. & Creswell, D., (2018). *Research design: qualitative, quantitative, and mixed methods approaches* (5th ed.). New York: SAGE Publishers.

Suggested Readings

1. Merriam, S. & Tisdell, E., (2015). *Qualitative research: a guide to design and implementation* (4th ed.). New Jersey: John Wiley & Sons Incorporation .
2. Booth, W., Colomb, G., Williams, J. Bizup, J. & Gerald, W.F., (2016). *The Crafts of Research* (4th ed.). Chicago: University of Chicago Press.

BOTN-6218 **Plant Physiology-II** **3(2+1)**

The aim of the course is to give comprehensive and advance knowledge about growth regulators, mechanism of water uptake and role of essential nutrients in plant metabolism.Plants are immobile in nature, they want to fulfill all their requirements of their life without moving from one place to another place. Plant physiology helps to study a wide range of processes and functions that plants use to live and survive, including respiration, metabolism, transpiration, plant hormones, environmental response and transport processes. It is also very important to know the functions of a living organism or any of its parts. They also have help in agriculture fields, medicine, food production and textiles. This course examines life process of plants such as signal transduction; different types of hormones (old group of hormones and newly discovered hormones) their synthesis, mode of action and beneficial effects.

Contents

1. Plant Growth Regulators: Major natural hormones and their synthetic analogues. Bioassay, structure, biosynthesis, receptors, signal transduction and mode of action and transport.
2. Water Relations: The soil-plant-atmosphere continuum - an overview. Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants.
3. Plant Mineral Nutrition: Inorganic composition of plant and soil. Absorption of mineral nutrients through roots. Effect of soil pH on nutrient availability. Passive and active (primary and secondary) transports and their energetics. Essential and beneficial elements. Fertilizers.
4. Phytochromes: Discovery of phytochromes and cryptochromes, physical and chemical properties of phytochromes, distribution of phytochromes among species, cells and tissues and their role in biological processes. Phytochromes and gene expression.
5. Photoperiodism:. Classification of plants according to photoperiodic reaction, Role of photoperiodism in flowering, biochemical signaling involved in flowering, vernalization and its effect on flowering. Floral meristem and floral organ development, floral organ identity genes and the ABC model.
6. Signal transduction in prokaryotes and eukaryotes.
7. Dormancy; definition and causes of seed dormancy; methods of breaking seed dormancy; types and physiological process of seed germination, Plant Movements

Lab work

1. To investigate the preferential absorption of ions by corn seedlings and potato slices.
2. To determine osmotic potential of massive tissue by freezing point depression method or by an osmometer.
3. To investigate water potential of a plant tissue by dye method and water potential apparatus.
4. Determination of K uptake by excised roots, Measurement of stomatal index and conductance.
5. Qualitative determination of K content in Guard cells by Sodium cobalt nitrite method.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant* physiology (7^{th} ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant Metabolism* (6^{th} ed.). London: Longman Group.

Suggested Readings

1. Mitra, G.N., (2015). *Plants*: *a biochemical and molecular approach* (1^{st} ed.). India: Springer.
2. Buchanan, B., Wilhelm, G. & Russell, L., (2015). *Biochemistry and molecular biology of plants*(1^{st} ed.). New Jersey: Wiley & Sons.

BOTN-6219 **Genetics-II** **3(2+1)**

Genetics is a branch of biology concerned with the study of genes, genetic variation, and heredity in organisms. Recombinant DNA technology has revolutionized our ability to investigate the genomes of diverse species and has led to the modern revolution in genomics. Modern genetic techniques are playing an emerging role in agriculture, health, medicine, foods, disease diagnosis and therapy. Genetic technology is developing faster than the policies, laws, and conventions that govern its use. The course aims to develop students' problem solving skills and to introduce them recombination of genetic material at molecular levels with emphasis on introduction to biotechnology and genomics. It also provides information to extend their knowledge about different Mechanisms of Genetic Change and to help them thinking in an analytical way. The objectives of learning of this course includes: to introduce recombinant DNA technology and to elaborate application of recombinant DNA.

Contents

1. Recombinant DNA: Introduction, basic techniques, site directed mutagenesis, DNA sequencing.
2. Application of Recombinant DNA by using prokaryotes, transgenic yeast, plants and animals, screening for genetic diseases, gene therapy, genetically modified organisms and apprehensions.
3. Mechanisms of Genetic Change I: Gene mutation and its types biological repair mechanisms.
4. Mechanisms of Genetic Change II: Recombination: General homologous recombination, the Holiday model, enzymatic mechanism of recombination, site-specific recombination, recombination and chromosomal rearrangements.
5. Mechanisms of Genetic Change III: Transposable Genetic Elements, review of transposable elements in prokaryotes, controlling elements in maize.
6. Human Genome Project: Strategies and application, achievement and future prospects.
7. Plant Genome Projects: Arabidopsis, achievement and future prospects. Other plant genome projects
8. Bioinformatics: Application of computational tests to the analysis of genome and their gene products, Bioethics: Moral, religious and ethical concerns

Lab work

Problems relating to the theory
1. Isolation and separation of DNA and protein on gel electrophoresis: Bacterial chromosome, Plasmid DNA(mini-preps), Plant DNA, Protein.
2. DNA Amplification by PCR

Recommended Texts

1. Stevens, T. & Newman, S., (2019). *Biotech juggernaut: hope, hype, and hidden agendas of entrepreneurial bioscience* (1st ed.). Philadelphia: Routledge.
2. Shukla, P., (2018). *Applied microbiology and engineering: an interdisciplinary approach* (1st ed.). London: Academic Press.

Suggested Readings

1. Se-Kwon, K., (2015). *Handbook of marine biotechnology* (1st ed.). New York: Springer Publications.
2. Venkat, B., Sahijramand, R. & Murthy, K., (2015). *Plant biology and biotechnology* (2nd ed.). New York: Springer Publications.

BOTN-6220 Environmental Biology 3(2+1)

The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management. Environmental Biology encompasses varied themes such as energy flow biosphere & biomes, carbon trading and other biogeochemical cycling, greenhouse gas emissions, water resource management, land degradation and rehabilitation, flora and fauna, habitat destruction, deforestation, energy and mineral depletion, air and water pollution, soil erosion, and groundwater contamination. This course provides insight into of the basic science of environmental biology and ecological theory. Environmental Biology helps in recognition of environmental problems such as climate change, global warming, ozone layer depletion, acid rains as well. This course enables students to develop strong expertise in contemporaneous themes in ecological research, develop critical thinking and to discuss about advanced topics in population, community and ecosystem ecology as well as in biodiversity research.

Contents

1. Environment: Introduction, scope and pressure
2. Pollution: Definition, classification and impact on habitats.
3. Air pollution: Sources and effect of various pollutants (inorganic, organic).on plants, prevention, control and remediation. Smog, photochemical smog. Acid rain: Theory of acid rain, adverse effects of acid rains. Chlorofluorocarbons and its effects.
4. Water pollution: Major sources of water pollution and its impact on vegetation, prevention, control, remediation, eutrophication and thermal pollution.
5. Sediments pollution: Fungicide, pesticides, herbicide, major sources of soil pollution and its impact. Prevention, control, remediation, heavy metal pollution. tanneries, hospital waste. Treatments of sewage, sludge, and polluted waters.
6. Noise pollution, Radiation pollution (including nuclear radiation): Measurement, classification and effects, principle of radiation protection, waste disposal
7. Forest: Importance, deforestation, desertification and conservation.
8. Ozone layer: Formation, Mechanism of depletion, Effects of ozone depletion
9. Greenhouse effect and global warming: Causes and impacts.
10. Human population explosion: Impact on environment.
11. Environment impact assessment: Industrial urban, civil developments.

Lab work

1. Examination of industrial waste water and Municipal sewage and sludge for: Total dissolved solids, pH and EC, BOD/COD, Chlorides, carbonate, and Nitrates.
2. Examination of water samples forms different sites for the presence and diversity of organisms.
3. Effect of air pollutants on plants, Visits to environmentally compromised sites and evolution of remediation

Recommended Texts

1. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.
2. Nriagu, J., (2019). *Encyclopedia of environmental health* (2nd ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.

BOTN-6221 Biodiversity and Conservation 3(2+1)

Over the years, the depletion of biodiversity has been quite active. This is happening as a result of habitat loss, excessive exploitation of resources, climatic changes, diseases, pollution, poaching of animals etc. In order to correct this scenario, biodiversity conservation has been majorly stressed by governments and social organizations. It must be understood that human beings cherish almost all benefits from the biodiversity. Hence, they should focus on taking proper care associated with the preservation of biodiversity in different forms. It is important because there must be something left for the future generation to look at. We as human beings should curb the degradation as well as the destruction of the habitats, upholding the biodiversity at its prime level. Biodiversity conservation is basically aimed at protection, enhancement and scientific management of the biodiversity. To be precise, manage it at its threshold level and acquire sustainable benefits both for the present and future population. Biodiversity and conservation maintain crucial ecological processes as well as life support systems.

Contents

1. Biodiversity: Definition, types and threats.
2. Threats to Biodiversity; deforestation, over grazing, erosion, desertification, ecosystem degradation, bio invasion, pollution and climate change, Biodiversity of Pakistan.
3. Measuring biodiversity: Alpha, Beta and Gamma diversity; Systematic and functional diversity.
4. Ecological services, indirect value of ecosystem by virtue of their ecological functions, direct value of ecosystem (i.e. utility of bio resources).
5. Sustainable and unsustainable use of biological resources.
6. Biodiversity Hot spots of Pakistan and the world.
7. International treaties/agreements regarding Biodiversity and Conservation; CBD, CITES, Ramsar.
8. Conservation strategies; *in situ, ex situ, in vitro* conservation, Conservation *vs* preservation.
9. IUCN categorized protected areas in Pakistan; red listing.
10. Environmental Impact Assessment
11. Use of herbarium and Botanical Garden in biodiversity and conservation.
12. Concept of pastures and wild life management.
13. Global Biodiversity Information Facility (GBIF).

Lab work

1. Inventory of plant biodiversity in various habitats.
2. Field survey for baseline studies and Impact Assessment.
3. Identification of wild plant species used by local communities in different ecosystems.

Recommended Texts

1. Walker, T., (2015). *Plant Conservation: Why it Matters and How it Works*. Timber Press.
2. Pellens, P. and P. Grandcolas, (2016). *Biodiversity Conservation and Phylogenetic Systematics*. SIP AG Swetzerland.

Suggested Readings

1. Boenigk, A., S., Wodniok and E. Glucksman. (2015). *Biodiversity and Earth history*. Berlin: Springer.
2. Scherson, R.A, (2018). *Phylogenetic Diversity*. Berlin: Springer.

BOTN-6222 **Plant Water Relations** **3(2+1)**

Plant–water relations concern how plants control the hydration of their cells, including the collection of water from the soil, its transport within the plant and its loss by evaporation from the leaves. The aim of the course is to overview comprehensively the soil-plant-atmosphere continuum for the maintenance of vital physiological functions and mechanisms in plants and to upgrade the concept about source sink relationships in translocation of solutes in plants. To familiarize students with some of the tools necessary to measure plant water relations parameters in the field. Water is the major component of living cells and constitutes more than 90% of protoplasm by volume and weight. Mechanisms of water and nutrient movement in soils and plants, and their relationships with plant growth are discussed. After completion of this course, the students will be able to understand water and nutrient movement in soil and plant and adaptation of plants to diverse soil water conditions.

Contents

1. The soil-plant-atmosphere continuum - an overview, Structure of water. Physico-chemical properties of water. Water in the soil and its potentials. Water in cell components. Absorption of water in plants (pathways and driving forces, aquaporins, their structure and types).
2. Cell water relations terminology. Hoflerdiagram - analysis of change in turgor, water and osmotic potential with changes in cell volume, Modulus of elasticity coefficient; Hydraulic conductivity.
3. Osmoregulation, methods for measurement of water, osmotic and turgor potentials- pressure chamber, psychrometry, pressure probe and pressure volume curve, stomatal physiology, transpiration flux, anti-transpirants.
4. Source sink relationships in translocation of solutes. Mineral nutrition: Hydroponics prospects and problems,
5. Nutrient solutions, chelating agents. Mineral ion uptake passive and active uptake and transport
6. Nernst equation, Donnan's potential, role of H^+ ATPase as a carrier, co transport.

Lab work

1. Preparation of solutions of specific normality of acids/bases, salts, sugars, molal and molar solutions and their standardization.
2. Determination of uptake of water by swelling seeds when placed in sodium chloride solution of different concentrations.
3. Measurement of leaf water potential by the dye method, Determination of the temperature at which beet root cells lose their permeability.
4. Determination of the effects of environmental factors on the rate of transpiration of a leafy shoot by means of a potometer/cobalt chloride paper method, To regulate stomatal opening by light of different colors and pH.

Recommended Texts

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7^{th} ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D. T., Turpin, D. H., Lefebvre, D. D. & Layzell, D. B., (2016). *Plant metabolism* (6^{th} ed.). London: Longman Group.

Suggested Readings

1. Mitra, G. N., (2015). *Plants: a biochemical and molecular approach* (1^{st} ed.).India: Springer.
2. Buchanan, B., Wilhelm, G. &Russell, L. (2015). *Biochemistry and molecular biology of plants* (1^{st} ed.). New Jersey: John Wiley & Sons.

BOTN-6223 **Plant Micro Techniques** **3(2+1)**

The aim of the course is to elucidate the importance of light microscopy and other special techniques maceration and staining to study plant sections, and to make students able to use microtome and camera Lucida. Micro technique an important experimental science that has led and continues to lead a great service for each branch of the life sciences: microbiology, genetics, embryology, morphology and science, also plays an important role in the development of medical studies of human anatomy. This includes knowledge of the preparations microscopic plant sample. This course provides information for managing the techniques of microscopic slides making, microscopic measurements and methods of identification of some organic compounds in plant cells. Microteaching is a highly individualized training device. Microteaching is an experiment in the field of teacher education which has been incorporated in the practice teaching schedule. Microteaching is micro in the sense that it scale down the complexities of real teaching.

Contents

1. Light microscopy–optical principle, resolution, magnification, aberration. Phase contrast microscopy Dark field illumination.
2. Electron microscope (TEM & SEM), principle and preparation techniques. Special techniques maceration; squashes, smears, whole mount and clearing techniques.
3. Micro technique steps fixation and fixatives, dehydration, clearing, infiltration, embedding, block making and sectioning.
4. Microtome's types, principles and operating mechanisms, stainsand staining techniques, Camera Lucida types, principles and their uses.
5. Micrometry

Lab work

1. Preparation of hand sections, maceration and clearing
2. Temporary and permanent mounting of whole specimens and Sections using different types of mountants.
3. Calibration of microscope and micrometry
4. Microtomy and microtome sectioning
5. Examination of different cell and tissue types with help of techniques
6. Study of structure of (primary and or secondary) leaf, root, stem and floral parts (including fruit).
7. Examination of vascular cambium and study of its activity.
8. Examination of structure and identification of Wood of some common trees such as *Dalbergia sissoo, Acacia arabica.* etc

Recommended Texts

1. Yeung, E. C. T., Stasolla, C., Sumner, M. J.&Huang, B. Q., (2015). *Plant microtechniques and protocols* (1st ed.). New York: Springer.
2. Richard, C., Sobaski, L., Wise, S.& Robert, S., (2018). *Plant anatomy* (1st ed.). New York: Springer.

Suggested Readings

1. Back, C. B., (2010). *An introduction to plant structure and development: plant anatomy for the twenty-first century* (2nd ed.). England: Cambridge University Press.
2. Maiti, R., (2012). *Crop plant anatomy* (15th ed.). England: CABI.

BOTN-6224 Plant Seed Physiology 3(2+1)

This course comprehensively provides the details of physiology of seed development and maturation. It is science and technology that is applied in the seed industry and includes biotech, crop improvement, as well as courses in seed production and conditioning. This course provides students with core graduate level management and leadership skills enabling them to better serve seed and agricultural biotechnology businesses and regulatory agencies in an increasingly complex industry. This course is designed to help students integrate and better understand crop growth, development and yield from a perspective of whole plant physiology. In this course, students will gain an overview of plant seeds physiological processes that are necessary to understand how plants operate, and interact with their environment. The course is useful to understand and interpret agronomic phenomena contributing to crop yield. It also offers an opportunity to survey contemporary aspects of crop physiology with emphasis on recent research progress in related fields.

Contents

1. Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.
2. Seed germination Types of germination, factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and interconversion pathways.
3. Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.
4. Seed viability and longevity, pre-and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.
5. Seed vigour and its concept, vigour test methods, factors affecting seed vigor, physiological basis of seed vigour in relation to crop performance and yield. Seed, invigoration and its physiological and molecular control.

Lab work

1. Proximate analysis of chemical composition of seed;
2. Different types of seed germination and evaluation,
3. Methods for breaking seed dormancy, Seed vigor test, Accelerated aging test
4. Priming and invigoration treatment for improving germination and vigor

Recommended Texts

1. Agrawal, P. K. & Sherry, R. J., (2018).*Techniques in seed science and technology* (3rd ed.). New Delhi: Brillion Publishing.
2. Baskin, C. C., & Baskin, J. M., (2014). *Seeds: ecology, biogeography and evolution of dormancy and germination* (1st ed.).Cambridge: Academic Press.

Suggested Readings

1. Taiz, L. & Zeiger, E., (2019). *Plant physiology* (7th ed.). England: Sinnauers Publ. Co. Inc.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B., (2016). *Plant metabolism* (6th ed.). London: Longman Group.

BOTN-6225 Palynology 3(2+1)

This course aims to introduce students to neopalynology and paleopalynology and its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration. It also provide the students information about the nomenclature, morphology and classification of living and fossil pollen, and spores. The objective of the course is to disseminate information on palynology samples and preparation techniques that avoid the use of acids. Palynology is a particular study within the realm of ecology that deals with the pollen and spores of plant species. Specifically, palynologists look at such factors as abundance of pollen and its occurrence in preserved samples. In the research of plants and their origins, palynologists have an important foothold in the study of past environmental systems, or paleoenvironments. The course teaches the practical procedures used and will be taught through instruction within a laboratory environment. This course gives information about spores and pollens of preserved species samples, which in turn can reveal many details about different ecosystems, especially marine environments.

Contents

1. An introduction to Neopalynology and Paleopalynology, its applications in botany, geology, archaeology, criminology, medicines, honey, oil and gas exploration.
2. Basic information about the nomenclature, morphology and classification of living and fossil pollen, and spores; Morphology and functional significance of spores and pollen,
3. Palynomorphs of the Paleozoic, Palynomorphs of the Mesozoic, mega and microspores.
4. Gymnosperm pollen-major types through time, diagnostic features of angiosperm pollen and the early fossil record,
5. Anita group and Magnolid pollen, monocot pollen, lower Eudicot pollen types, selected Rosid pollen types, selected Asterid pollen types.
6. Applications: forensics, honey, paleo environment, case histories. Fagales, geometrically bizarre and fun pollen types.

Lab work

1. Microscopic Study of Spores and Pollen, Herbarium sheets.
2. Acetolysis.
3. Slide preparation, temporary and permanent slides of spores and pollen
4. Photomicrography, HF safety training, maceration and dissolution, gravity separation, counting techniques.

Recommended Texts

1. Slam, H., (2016). *Aerobiology: the toxicology of airborne pathogens and toxins* (1st ed.). London: Royal Society of Chemistry.
2. Burge, H. & Muilenberg, M., (2018). *Aerobiology* (1st ed.). Florida: CRC Press.

Suggested Readings

1. Bhattacharya, K., (2015). *A text book of palynology* (1st ed.). New Delhi: New Century Publication.
2. Beaudoin, A.B. & Head, M.J., (2017).*The palynology and micropalaeontology of boundaries* (1st ed.).London: Geological Society.

BOTN-6226 **Plant Tissue Culture** **3(2+1)**

The aim of the course is to know about concept of cellular totipotency, differentiation and de-differentiation and various tissue culture methods / techniques for the production pathogen-free plants and explicit the role of plant tissue culture in crop improvement. Plant tissue culture broadly refers to the an *in vitro* cultivation of plants, seeds and various parts of the plants (organs, embryos, tissues, single cells, protoplasts).With the advances made in the tissue culture technology, it is now possible to regenerate species of any plant in the laboratory. In this process the growth medium or culture solution is very important as, it is used for growing plant tissue because it contains various plant nutrients in the form of 'jelly' known as agar and plant hormones which are necessary for the growth of plant. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Applications include: The commercial production of plants used as potting, landscape, and florist subjects, which uses meristem and shoot culture to produce large numbers of identical individuals.

Contents

1. Plant Tissue Culture-An introduction
2. Cellular totipotency, differentiation and de-differentiation
3. Selection of a suitable explant material in different plant groups
4. Initiation and maintenance of callus cultures
5. Organogenesis
6. Somatic embryogenesis
7. Micropropagation
8. Role of somaclonal variation in crop improvement
9. Cell suspension cultures
10. Isolation, purification and culture of plant protoplasts
11. Role of plant protoplasts in crop improvement
12. Production of pathogen-free plants using tissue culture techniques.

Lab work

1. An introduction to a Plant Tissue Culture lab.
2. Laboratory facilities and their use.
3. Aseptic techniques.
4. Preparation and use of Stock solutions.
5. Media composition and preparation protocols.
6. Preparation of selected media, pouring and sterilization.
7. Procurement, preparation and sterilization of explants.
8. Initiation and maintenance of callus cultures and regeneration studies in selected species.
9. Culture initiation and maintenance for Micropropagation of selected species.

Recommended Texts

1. Umesha, S., (2019). *Plant biotechnology* (1st ed.). Philadelphia: Francis and Taylor Group.
2. Dixon, R.A. & Gonzalcs, F.A., (2017). *Plant Cell Cultures. A Practical Approach* (2nd ed.). England: Oxford University Press.

Suggested Readings

1. Loyola-Vargas, V.M. & Ochoa-Alejo, N., (2016). *Somatic embryogenesis: fundamental aspects and applications* (1st ed.). Switzerland: Springer International Publishing.
2. Kumar, S., Mishra, S. & Mishra, A.P., (2016). *Plant tissue culture: theory and techniques* (2nd ed.).England: Scientific Publishers.

BOTN-6227 **Plant Biotechnology** **3(2+1)**

Plant biotechnology is a set of techniques used to adapt plants for specific needs or opportunities. The aim of the course is to introduce students to genetic engineering, cloning strategies, PCR and genetic markers and applications of plant biotechnology, to provide updated knowledge of environmental problems and sustainable environmental management through treatment technologies such as phytoremediation. The objective of the course is to give students new knowledge and widening of the knowledge acquired in other course by handling of classical and modern plant biotechnology processes, including breeding of healthy plants, plants with improved characteristics and plants for biomolecule production. This course also explores the use of biotechnology to both generate genetic variation in plants and to understand how factors at the cellular level contribute to the expression of genotypes and hence to phenotypic variation.

Contents

1. Biotechnology: Definition, history, scope/application and significance.
2. Biofertilizers, biofuel, biopesticides, biogas production, waste and sewage management.
3. Enzyme biotechnology: Sources and production of commercially important enzymes. cellulase, amylase, pectinases, proteinases. Immobilization of enzymes and its applications.
4. Amplification of genes by PCR, cDNA and construction of cDNA libraries.
5. Blotting techniques (Southern, northern and western blotting) nonradioactive probe DNA diagnostics (RFLP, AFLP and RAPD). DNA sequencing.
6. Recombinant DNA technology-gene transfer in plants. Vectors – types, plasmids (PBR 322, PBR 327), cosmid insertion vectors, replacement vectors, shuttle vectors and high expression vectors.
7. Strategies for development of transgenic plants, identification of recombinants, insertional inactivation.
8. Plant tissue culture: Concept of totipotency, Sterilization methods, different techniques in tissue culture.

Lab work

1. Extraction and estimation of plant DNA
2. Basic biotechnology techniques, Preparation of different types of standard tissue culture media.
3. Establishment of aseptic cultures following appropriate sterilization procedures using seeds, Preparation of culture medium (MS, N & N, SH, B5), sterilization and inoculation.
4. Demonstration of Agarose gel electrophoresis, Encapsulation of seeds/embryos in calcium alginate.
5. Visits of Biotechnology labs at NIBGI, AARI, Faisalabad and SBS, Lahore,CAMB, Lahore: National institute for Genomics and Advance Biotechnology (NIGAB)

Recommended Texts

1. Abdin**,** M.Z., Kiran, U. Kamaluddinand, A. &Ali**,** M.A.(2017). *Plant biotechnology: principles and applications* (1st ed.).New York: Springer.
2. Kumar, S., Kumar, R., & Pandey, A. (2019). *Current developments in biotechnology and bioengineering: waste treatment processes for energy generation* (1st ed.).Amsterdam: Elsevier .

Suggested Readings

1. Smith, R. H., (2013). *Plant tissue culture: techniques and experiments* (3rd ed.). Cambridge: Academic Press.
2. Stewart, N., (2017). *Plant biotechnology and genetics: Principles, Techniques, and Applications* (2nd ed.). New Jersey: Wiley Online Liberar.

BOTN-6228 Advanced Environmental Biology 3(2+1)

Environmental Biology is a Physical Science at the intersection of environmental science, ecology, evolution, and global change. Environmental biology examines the ways organisms, species, and communities influence, and is impacted by, natural and human-altered ecosystems. The aim of the course is to provide updated knowledge of environmental problems and sustainable environmental management, to familiarize the students with national conservation strategy and role of natural resources in conservation diversity of nature and importance of biodiversity for survival and proper functioning of ecosystems. This course introduces the student to the fundamentals of environmental biology: the structure and biota of several aquatic and terrestrial ecosystems, including Vermont ecosystems. The student investigates why species occupy specific habitats.Today, it provides an integrated, quantitative, and interdisciplinary approach to the study of environmental systems. Environmental biology incorporates more of the pure sciences for understanding human relationships, perceptions and policies towards the environment.

Contents

1. Environmental problems, their causes, and sustainability & Environmental history.
2. Science Systems, Matter and Energy, Energy Conversions, Thermodynamics, Basic Chemistry (acids, bases, salts), Niches, Interactions, Succession
3. Biogeography: Weather, Climate, Biomes & Biodiversity
4. Population Dynamics, Carrying Capacity, and Conservation Biology and Evolution of a Species
5. The Human Population: Growth, Demography
6. Global Problems, Energy Resources, Human Health
7. Air, Water soil and their pollution
8. Food Resources, Pesticides and Pest Control,
9. Land Management and Diversity
10. Economics, Politics, and Ethics

Lab work

1. Water Characterization, Alkalinity and Buffering Capacity of Water,
2. Examination of industrial waste water and Municipal sewage and sludge for: Total dissolved solids, pH and EC, BOD/COD, Chlorides, carbonate, and Nitrates,
3. Visits to environmentally compromised sites, disturbed ecosystems, different sanctuaries
4. Survey of different important species for conservation.

Recommended Texts

1. Fisher, M., (2018). *Environmental biology* (1st ed.). Medford: Open Oregon Press Book Publishing Company.
2. Ren, H. & Zhang, X., (2019). *High-risk pollutants in wastewater* (1st ed.). Amsterdam: Elsevier Publishing Company.

Suggested Readings

1. Sivasubramanian, V., (2016). *Environmental sustainability using green technologies* (1st ed.). Florida: CRC Press Taylor and Francis Group.
2. Jorge G. Ibanez., Margarita Hemandez-Esparza,Carmen Doria-Serrano and Arturo Fregoso-Infante(2008). Environmental Chemistry: *Microscale Laboratory Experiments* (1st ed.). NYC: Springer Science.

BOTN-6229 Plant Conservation Management 3(2+1)

The aim of the course is to provide updated knowledge of plant conservation, conservation in practice and conservation techniques for sustainable ecosystem management, to familiarize the students with threats to plant communities and its impact on population dynamics and economic development. The course provides a thorough introduction to the essential aspects of plant conservation including an overview of threats to the world's plant diversity, conservation genetics, conservation assessments and ways to minimize biodiversity loss. It includes an introduction to international legislations, politics and humans' role, both as threats and conservers of plant diversity. This class will review the causes of plant species decline, the biological factors associated with small populations at both the ecological and genetic level, the current practices of population monitoring and management for conservation in both in-situ and ex-situ environments and the possibility of reintroduction.

Contents

1. Plant Conservation: Introduction, origin, scope, objectives.
2. Understanding of Conservation: Biodiversity (types). Species (number), advantages of conservation (food, drugs and medicine
3. Extinction of Plant Species and its causes
4. Threats to Communities: Chains of extinctions, emergence of new species from old. Functional integrity in relation to fragment size
5. Conservation in Practice: Endangered species management and biodiversity protection, categorization of plant species, endangered species law. Bunting and fishing laws, the endangered species act, recovery plans, captive breeding and management plans, types of conservation (Ex-situ conservation), protected areas, conservation towards restoration of ecology, healthy approach to save biodiversity, saving rare species in the wild, habitat protection, private land and land critical habitat. Reauthorizing the endangered species.
6. Conservation Techniques: Parks and natural preserves, trouble in our parks and management. New parks establishment. Wildlife in parks, wilderness areas, wildlife refuges, refuge management, world conservation strategy.
7. Conservation and Economic Development: Indigenous communities and biosphere reserves, International wildlife preserves. Transboundary peace parks, preserving functional ecosystem and landscapes, landscape dynamics, size and design of nature preserves, wetland conservation.

Lab work

1. Visit to Botanical garden. Governor House, Bagh-e-Jinnah, Lahore
2. Visit to Soon Valley, Pakistan
3. Visit to Botanical Garden, University of Agriculture. Faisalabad

Recommended Texts

1. Ortega-Rubio, A., (2018). *Mexican natural resources management and biodiversity conservation* (1st ed.). New York: Springer publication.
2. Blackmore, S., (2018). *Best plant conservation practices to support species survival in the wild* (3rd ed.). Amsterdam: Center for Plant Conservation.

Suggested Readings

1. Walker, T., (2015). *Plant conservation: why it matters and how it works* (5th ed.). Portland: Timber Press.
2. Blackmore, S. & Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens* (1st ed.). England: Cambridge University Press.

BOTN-6230 Conservation Genetics 3(2+1)

The aim of the course is to provide updated knowledge of conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, to familiarize the students with *conservation techniques and* genetic tools, genetic markers for assessing biodiversity. This course will introduce the principles and applications of conservation genetics, from assessing the genetic health of individuals and whole populations to deciding on species and sub-species divisions. The key genetic analyses employed in conservation genetics studies will be described and their technical and theoretical limitations discussed, as will their considerable power to inform key conservation decisions. It is becoming increasingly apparent that measures of genetic diversity should be included in our assessment of species health and future viability, to make the best decisions for their protection and management. As genetic techniques become more sophisticated and reliable, our use of them to support species conservation has similarly increased.

Contents

1. Introduction to plant conservation genetics, scope of conservation genetics, values of biodiversity and loss of biodiversity, Hardy-Weinberg principle, genetic drift, effective population size, population subdivision, quantitative genetics, molecular phylogenetics
2. Genetic tools for conservation, genetic markers, inbreeding coefficients, conservation issue, met population and fragmentation, evolutionary significant units, conservation breeding
3. Types of conservation: Forest conservation, wild plant conservation, invasive species study and control, medicinal plant conservation
4. Conservation methods/techniques/management
5. Natural and human-caused factors that cause plant species to be rare or imperiled and the genetic and ecological implications of rarity in plant species, conservation strategy for a rare or imperiled plant species, and applications of ecological and population genetics principles to evaluate the long-term viability of such a plant species with and without conservation measures

Lab work

6. Extraction of DNA from plant material by using CTAB method.
7. Molecular markers: SSR, Intron-polymorphisms, CAPS, AFLP, RAPD etc.
8. Analysis of morphological and molecular diversity in different cultivars/varieties of a crop plant.
9. QTL mapping (Theoretical using available data)
10. Field trips to the location of rare or threatened plant populations.

Recommended Texts

1. Ortega-Rubio, A., (2018). *Mexican natural resources management and biodiversity conservation* (1st ed.). New York: Springer publication.
2. Blackmore, S., (2018). *Best plant conservation practices to support species survival in the wild* (3rd ed.). Amsterdam: Center for Plant Conservation.

Suggested Readings

1. Walker, T., (2015). *Plant conservation: why it matters and how it works* (5th ed.). Portland: Timber Press.
2. Blackmore, S. & Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens* (1st ed.). England: Cambridge University Press.

BOTN-6231 Basic Ecological Genetics 3(2+1)

This course elucidates the role of genetic techniques, genetic markers to assess the genetic diversity within and among the population. This course also provides an insight into gene flow and mating system and importance of biological and environmental factors on gene flow. The aim of this course is to provide the basics of the genetic component in functioning, development and sustainability of ecosystems with the main focus on forests and the associated communities. Sustainable development and biodiversity as well as increased impact of biotechnology became important present-day challenges and the basics of interaction between genetics and environment are needed to solve these problems. After completing the course students should obtain the basics of ecological genetics on one hand and breeding and biotechnology on another hand. This knowledge will allow the students to efficiently cope with the ecological problems connected with genetics to proceed with well-balanced approach to simultaneously maintain the ecological stability and economic benefit.

Contents

1. Ecological genetics What is ecological genetics? Why study ecological genetics.
2. Markers and sampling in ecological genetics Introduction, methods of data generation, principles of sampling within and among population.
3. Genetic diversity and differentiation. Introduction, factors influencing diversity and differentiation, The Hardy Weinberg Equilibrium, genetic diversity, genetic differentiation, genetic distance, statistical approaches, use of genetic diversity statistics.
4. Gene flow and mating system. Introduction, Factors governing gene flow. Considerations for measuring gene flow, measuring gene flow -indirect estimates, measuring gene flow -direct estimates. The importance of biological and environmental factors on gene flow.
5. Intraspecific phylogenies and phylogeography. Introduction, homology, gene trees and species trees, tree form and building, tree interpretation, organelles versus nuclear intraspecific phylogenies.
6. Speciation and hybridization. Introduction, species, speciation, hybridization, analysis of speciation and hybridization

Lab work

1. Extraction of DNA from plant material.
2. Separation of DNA by gel electrophoreses.
3. Gene amplification through PCR
4. Graphical representation of speciation and hybridization data by UPGMA
5. DNA sequencing.

Recommended Texts

1. Daniel, L., & Cochrane, H. B. (2017). *Genetics: analysis of genes and genomes 9thEdition.* USA: Jones & Bartlett Learning.
2. Turnpenny, P. D., & Ellard, S. (2016). *Emery's elements of medical genetics*. Amsterdam: Elsevier.

Suggested Readings

1. Pierce, B.A. (2017). *Genetics: a conceptual approach.* 6th Edition. USA: W. H. Freeman.
2. Klug, W. S., Michael, R. Cummings, R. Spencer, C. A. Palladino, M. A. & Killian, D. (2018). *Concepts of genetics*. UK: Pearson.

BOTN-6232 Medicinal Plants 3(2+1)

The overall objective of this course is to improve students understanding of the uses and effects of medicinal plants, including herbal supplements, on people and their cultures or societies. The course topics will be taught from the perspective of how different cultures utilize medicinal plants. Students will learn how different cultures perceive diseases and then utilize plants to treat them. Currently medicinal plant usage is quite common, but how that use of medicinal plants is perceived depends on the society where they are used. The latter part of the course focuses on how societies in developed countries perceive, use and regulate plant medicines or herbal supplements. Finally, because all plants with bioactive compounds can't always be regulated, throughout the course students will learn how to evaluate claims made of specific plants and herbal supplements and will learn where to find reliable information about those plants and products.

Contents

1. History of Medicinal plants. Traditional Medicinal systems: Ayurvedha, Siddha, Unani and Naturopathy. Cultivation, therapeutically and pharmaceutical uses of selected medicinal plants of Sargodha region. Historical account of medicinal plants in Pakistan. Establishment of medicinal plant gardens.
2. Definition of Drug-Classification of natural drugs: alphabetical, morphological, pharmacological and chemical .traditional and folklore medicine-native medicine drugs from leaves, flower, fruits and seeds, roots, bark (Cinchona) and wood (Ephedra)
3. Pharmacognosy-Definition and scope, drug adulteration, drug evaluation, chemical evaluation and biological evaluation of drugs, phytochemical investigations-quality control of herbal drugs.

Lab work

1. Ethnomedicinal survey of various places
2. Preparation of herbarium sheets of ethnomedicinal plants.
3. Phytochemical analysis of ethnomedicinal plants.
4. HPLC of selected plant extracts

Recommended Texts

1. Akos, M. (2015). *Medicinal and Aromatic Plants of the World*: USA: Springer publishers.
2. Tránsito, M., L. Luengo and C. Máñez (2015). *Medicinal plants at home*: NYC: Skyhorse Publishers.

Suggested Readings

1. Krochmal, A., R.S. Walters and R.M. Doughty(2016). *A guide to medicinal plants of Appalachia:* NYC: Amazon publishers.
2. Kumar, A. (2016). *Handbook of medicinal plants*. NYC: Amazon publishers.
3. Da, H., J. Xiao, G. Pei and G. Xiao (2015). *Medicinal plants.* (1st ed.) Amsterdam: Elsevier Publsihers.

BOTN-6233 Ethnobotany 3(2+1)

Ethnobotany is the scientific study of interactions between human cultures and plants/plant environments (the interrelationships between people and plants). This course examines many different levels and types of interactions between people and plants. The goal of this course is to introduce students to the fascinating world of the relationships between people and plants. The course offers a unique and multidisciplinary approach that includes plant structure and function, plant diversity, the origins of agriculture, and the uses of plants by peoples around the world. As plants are important to people, the course focuses on how plants affect human health, nutrition and well-being, interact with other organisms, and provide critical support to biodiversity. The course also offers important views on how people damage plants and their habitats, and how the reversion of this trend is important to secure the future of humankind. The course offers exciting insights into groups of economically important plants such as grasses, legumes, and staples, and how plants serve as a source of useful natural products.

Contents

1. Definition-Scope. History of ethnomedicinal plants. Traditional Medicinal systems:
2. Ayurvedha, Siddha, Unani and Naturopathy.
3. Definition of Drug-Classification of natural drugs, alphabetical, morphological, pharmacological, chemical and chemo taxonomical.
4. Traditional and Folklore medicines. Native medicine. Major tribes of the Sargodha region and their ethnobotanical and ethno-biological heritage.
5. Ethno Medicines. Ethnobotany and conservation of plants with special reference to Pakistan – mythology and conservation of ecosystems, conservation of selected plant species: sacred grove, forestry and unique ecosystems and their ethnobiological values, plants and animals in art, tradition and ethnography: Ethnobotanical field methods.
6. Pharmacognosy: Definition and scope,drug adulteration,drug evaluation;chemical evaluation, physical evaluation and biological evaluation.
7. Phytochemical investigations, standardization and quality control of herbal drugs.
8. Cultivation, collection and preparation of natural drugs. Macroscopic characters: physical andorga noleptic characters, therapeutical and pharmaceutical uses of the local ethnomedicinal plans: Commercial value.

Lab work

1. Ethnobotanical survey of various places, Preparation of herbarium sheets of ethnobotanical plants.
2. Phytochemical analysis of ethnobotanical plants, HPLC of selected plant extracts.

Recommended Texts

1. Rafael, L., Casas, A., & Jose, B. (2016). *Ethnobotany of mexico*. USA: Springer publisher.
2. Albuquerque, A., Paulino, U., Alves, N., & Romeu, R. (2016). *Introduction to ethnobiology*. USA: Springer publishers.

Suggested Readings

1. Rainer, B. (2017). *Ethnobotany of the Caucasus*. USA: Springer Publisher.
2. Schmidt, B. M., Diana, M., & Cheng, K. (2017). *Ethnobotany: a phytochemical perspective*. New Jersey: Wiley publishers.

BOTN-6234 Biodegradation and Bioremediation 3(2+1)

This course will present the basic principles of chemical and biological degradation of toxic chemicals, and familiarize the students with the application of the remedial technologies in natural environments. Topics covered will include: 1) occurrence and ecological significance of toxic organic chemicals, 2) chemistry of contaminants, kinetics and mechanisms of degradation (chemical and biological), and 3) current technologies of bioremediation of contaminated soils and water. Bio/remediation as an option to treat contaminated soils and ground water. Advantages and disadvantages of bioremediation compared to non-biological processes. Biodegradation of specific contaminants (e.g. diesel fuel, polychlorinated biphenyls, dyestuffs, aromatic and poly-aromatic hydrocarbons) will be studied in detail. The investigation component of this course consists of learning how to do appropriate laboratory and field experiments to obtain data on microbial degradation of an organic pollutant to be able to calculate bioremediation design parameters such as mass and delivery rate requirements of electron acceptors and nutrients and degradation rates in reactor and non-reactor based systems; and to be aware of limitations of these calculations.

Contents

1. The environment and pollution: Introduction, environmental laws.
2. Treatment technologies: Traditional approaches to pollution control, Bio-treatment technologies for pollution control.
3. Biocatalyst selection and genetic modification: Enrichment and screening strategies, Design of enrichment strategies relating to the environmental source, Microbiological techniques for enrichment and selection, Genetic approach, The carbon cycle and xenobiotic compounds, Biodegradation and microbial technologies by microorganisms, Acclimation, Detoxification, Activation, Sorption, Bioavailability, Sequestering and complexing, co-metabolism, Environmental effects, Effects of metals and radionuclide on environment, Metal and radionuclide microbial treatment, Biotechnology for metal and radionuclide removal and recovery, Recalcitrant molecules

Lab work

1. Isolation of bacteria from oil wastes, polluted water from industries and sewage.
2. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons.
3. Bioremediation from culture by metal resistant bacteria.

Recommended Texts

1. Kaushik, G. (2015). *Applied environmental biotechnology: present scenario and future trends*. Singapore: Springer Verlag.
2. Crawford, R.L. (2009). *Bioremediation principle and applications*. UK: Cambridge University Press.

Suggested Readings

1. Chang, W. (2017). *Biodegradation and bioremediation*. USA: Syrawood Publishing House.
2. Sangeetha, J., Thangadurai, D., Muniswamy D., & Abdullah, M.A. (2016). *Environmental biotechnology: biodegradation, bioremediation, and bioconversion of xenobiotics for sustainable development*. USA: Apple Academic Press.

BOTN-6235 Water Pollution Management 3(2+1)

This course provides an overview of engineering approaches to protecting water quality with an emphasis on water treatment unit operations. It covers a wide range of topics, including water characterization parameters and designing systems to treat municipal and industrial wastewater, as well as the legislative framework. Water Pollution management and strategies is offered to students to let students know basic knowledge and control technologies of water pollution, so that they can solve problems on water treatment. An understanding of the physical, chemical and biological processes involved during contamination of water is essential if society is going to effectively monitor and control the effects of pollution using modern technology and engineering practices. In this course, we will focus on the origins, pathways and consequences of anthropogenic pollutants in the environment as well as discussing the various approaches to pollution control and remediation. At the end students will learn about the causes and harms of water pollution and their possible methods to remove the pollutants and contaminants.

Contents

1. Water pollution: Sources, types and their impacts; Pollution problems of groundwater resources, sources of contamination, management issues; Pollutants - sewage, pesticides, oils, metals, radioactive wastes, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys; Waste disposal and water quality criteria used in different parts of world national and international standards; ISO-14000 (EMS), EIA, Management strategies'
2. Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation; Waste recycling and utilization in aquaculture; Design and construction of water filtration devices; aerobic and anaerobic treatment of wastewater; Wastes from fish processing units and their treatment; solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of waste water.

Lab work

1. Determination of DO, BOD, COD and total dissolved solids (TDS)of water.
2. Estimation of amount of phosphate, sulphate, nitrate, nitrite, iron and magnesium and calcium in the ground and surface water, Estimation of Ca, Mg, organic matter and phosphates in soil.
3. Collection and preservation of waste water samples; Physicochemical analysis of wastewater total dissolved and suspended solids, color, odor, DO, BOD, COD, H_2S, NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides, Use of algae for organic waste treatment.
4. Visit to sewage treatment plants, fish processing units and other industries.

Recommended Texts

1. Chakraborty, D., & Mukhopadhyay, K. (2016). *Water pollution and abatement policy in india: a study from an economic perspective*,(1st ed.) USA: Springer.
2. McMillan, S. (2018). *Water pollution: types, causes and management strategies*. USA: Syrawood Publishing House.

Suggested Readings

1. Kneese, A.V. (2015). *Water pollution: economics aspects and research needs*. London, United Kingdom.
2. Rose, M., & Mendoza, O. (2016). *Water pollution and treatment*. Canada: Arcler Education Inc.

BOTN-6236 Air Pollution Management Strategies 3(2+1)

In this course, students will learn effects of air pollutants on human beings, materials and the environment, what their sources are, and their physical and chemical behaviour in the atmosphere. This will introduce the nature of our atmosphere, its composition and meteorology, air pollutant emissions, air pollution chemistry and climate change / carbon management, together with the practical measures used to limit emissions from sources ranging from power stations to vehicles and the legislative and policy framework used by national and local authorities to enforce air quality objectives. Benefits can include improved public health, energy savings, economic development, agricultural benefits and reduced emissions of greenhouse gases and other short-lived climate pollution. This course provides skills and information on how to monitor air pollution and increase public awareness, how to develop emission inventories and track progress, how to assess the benefits of air quality improvement, how to select control strategies that are most effective and will describe regulatory approaches that have been most effective elsewhere.

Contents

1. Nature and classification of pollutants, sources and effects of pollutants on plant growth
2. Air Pollution Sources: Origin, dispersion and impact on human, crops and forest of Particulates,
3. Basic principles of air pollution management, ambient concentrations of air pollutants and trace gases
4. Air pollution control equipments, objectives and types of control equipments, efficiency of separating devices, control of particulate emission settlers, cyclones, filters, scrubbers and esps. Control of sulphur dioxide from lean and rich waste gases (recovery of sulphur and sulphuric acid).Control of NOx through absorption and other newer methods; control of vehicular emission (catalytic conversion devices); Indoor air pollution and its control.
5. Hazardous air pollutants and their management. Biological abatement of air pollution, scope of green belt development, economical aspect of air pollution abatement technologies.

Lab work

1. Estimation of foliar dust deposition in samples collected from sites exposed to air pollution.
2. Determination of settled particulate matter in air.
3. Biomonitoring of heavy metals in the environment.
4. Mapping of vegetation of selected region by using Remote sensing data.
5. Field visits to industrial areas for on-spot biodiversity assessment and to prepare status report.

Recommended Texts

1. Vallero, D. A. (2014). *Fundamentals of air pollution*. Cambridge: Academic Press.
2. Vallero, D. A. (2019). *Air pollution calculations: quantifying pollutant formation, transport, transformation, fate and risks*. USA: Elsevier.

Suggested Readings

1. Guardia, M.D.L., &SergioA. (2016). *The quality of air: Volume 73*. United Kingdom: Oxford Press.
2. Smedley, T. (2019). *Clearing the air: the beginning and the end of air pollution*. UK: Bloomsbury Sigma.

BOTN-6237 Conservation Ecology 3(2+1)

This course will help the students to learn about the work of conservation biologists and study of ecosystems can help with conserving the world's biodiversity. Students will explore the impact of wind farms on populations of seabirds, and understand how the use of advanced techniques can be used to study different populations. It will also enable the students to know that how ecosystems are influenced by human activity and will explore the reasons behind the bee decline across the world, and examine fish species in tropical seas to see at first-hand how climate change damages coral reefs. Conservation ecology is the branch of ecology and evolutionary biology that deals with the preservation and management of biodiversity and natural resources. It is a discipline that is emerging rapidly as a result of the accelerating deterioration of natural systems and the worldwide epidemic of species extinctions. Biological diversity or biodiversity includes its ecosystems, species, populations, and genes.

Contents

1. Introduction to conservation ecology, history
2. Importance of edaphic factors in conservation.
3. Importance of topographic factors, biotic factors.
4. Ecosystem: Physical conditions and availability of resources.
5. Applied issues in conservation: Role of natural resources in conservation ecology.
6. Types of natural resources (renewable m non-renewable), wildlife management, species preservation, conservation of habitat, introduction of exotic species, natural parks, forests resources, soil and water resources, food and agriculture resources.

Lab work

1. Visits to different disturbed ecosystem
2. Survey of different important species for conservation
3. Visit to different sanctuaries

Recommended Texts

1. Schowalter T. D. (2016). *Plant Ecology: An Ecosystem Approach*. United States: Academic Press.
2. Ent, A., Repin, R., Sagau, J., & Wong, K. (2015). *Plant Diversity and Ecology of outcrops in Malaysia*. United States: Springer.

Suggested Readings

1. Real, L. (2017). Ecological genetics. United States: Princeton University Press.
2. Kobori, H., Dicikinson, L. D., Washintani, I., Sakurai, R., & Amano, T. (2016). *A new approach to plant ecology and conservation*. United States: Springer.

BOTN-6238 Plant Stress Physiology 3(2+1)

This course will provide an understanding of the unique features of plant cells and a general grounding on plant physiology and growth. In addition it will provide a brief introduction to the various physiological, molecular, and biochemical mechanisms plants use to respond to environmental stresses like extreme temperature, drought, salt, and pathogens. Any external factor that negatively influences plant growth, productivity, reproductive capacity, or survival is considered as a stress. Plants have to face different type of stresses and develop possible mechanism to compensate the effect of stress. In this course the students are expected to; learn the major principles of plant physiology and the crucial processes behind it (e.g. water and nutrient transport, photosynthesis, key regulatory hormones); gain understanding on the interaction between plants and the environment, become familiar with basic methodologies employed in these fields and to develop the skills to read relevant literature, to follow research seminars in these fields and to critically assess the presented information.

Contents

1. The history of stress research, general theory of stress.
2. Stress at plants at sub-cellular, cellular, organ, Stress factors, classification of biotic, abiotic factors, methods of measurement
3. Signal transduction, molecular biological foundations of anti-stress reaction
4. Stress proteins, antioxidants - anti-stress response mechanisms, Stress lack / excess of available water (mechanisms to avoid stress)
5. Stress of substrate salinity, osmotic stress, Stress caused by toxic and foreign substances
6. Stress caused by cold, frost
7. Thermal stress (heat effects of physical, chemical, molecular and biological)
8. Radiation stress (regularly, classification, mechanisms of formation, mechanisms for protection)
9. Acclimation / adaptation to stress in extreme environments Plant responses to stress at multiple levels of integration - from the molecule to the whole plant. Global issues related to environment and plant stresses. Use of the primary scientific literature as a basis for the in-depth study of plant responses to environmental stress

Lab work

1. Determination of water potential by pressure chamber
2. Determination of osmotic potential by osmometer
3. Investigation of osmolytes from plants growing under stress conditions
4. Estimation of antioxidant activity in plants under stress conditions

Recommended Texts

1. Mitra, G.N. (2015). *Plants: A Biochemical and Molecular* Approach. India: Springer.
2. Jugulam, M. (2017). *Biology, physiology and molecular biology of weeds*. United States: CRC Press.

Suggested Readings

1. Taiz, L., & Zeiger, E. (2019). *Plant physiology.*7th Edition. Unites States: Sinnauers Publ. Co. Inc.
2. Taiz, L., & Zeiger, E. (2018). *Fundamental of plant physiology*. Unites States: Sinnauers Publ. Co. Inc.

BOTN-6239 Advanced Plant Anatomy 3(2+1)

Plant anatomy is the study of the internal structure of plants. It plays a key role in understanding how plants function and is an essential component of much research. This course focuses on plants and provides with comprehensive, updated information about the organization, development, structure and function of plant cells, tissues and organs. It will enable the students to learn about the internal organization of the tissues and their types and when or where these specific types of tissues arise and perform specific function. The following learning outcomes are expected to be achieved through the study of this course i.e. Understand basic concepts and terminology in plant anatomy and various structures of seed plants in relation to their development, function and evolution, Explain how knowledge of plant anatomy is connected to our everyday life and practices in agriculture and forestry etc. The Plant Anatomy course will combine theory and practical so that participants can develop a sound understanding of the structure and function of plants.

Contents

1. The plant body and its development: fundamental parts of the plant body,
2. Meristematic tissues: classification, cytohistological characteristics, initials and their derivatives.
3. Apical meristem and its types
4. Leaf: types, origin, internal organization, development of different tissues
5. Vascular cambium: Origin, structure, characteristics, seasonal activity and its role in the secondary growth of root and stem. Abnormal secondary growth.
6. Origin, structure, development, functional and evolutionary specialization of the following tissues: Epidermis and epidermal emergences, Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem with special emphasis on different types of woods, Periderm.
7. Secretory tissues: Laticifers (classification, distribution, development, structural characteristics, functions) and Resin Canals.
8. Anatomy of reproductive parts: Flower, Seed, Fruit
9. Economic aspects of applied plant anatomy, Anatomical adaptations
10. Molecular markers in tree species used for wood identification.

Lab work

1. Study of organization of shoot and root meristem, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands and other secondary structures.
2. Study of abnormal/unusual secondary growth, Peel and ground sectioning and maceration of fossil material, Comparative study of wood structure of gymnosperms and angiosperms with the help of prepared slides.

Recommended Texts

1. Clive, A., Stace, C.A., & Crawley, M. J. (2015). *Alien* plants. New York: Harper Collins Publishers.
2. Hather, J.G. (2016). *Archaeological Parenchyma*. London: Routledge Publishers.

Suggested Readings

1. Steeves, T. A., & Sawhney, V. K. (2017). *Essentials of developmental plant anatomy*. London: Oxford University Press.
2. Spichiger, R.E. (2019). *Systematic Botany of flowering plants: A new phytogenetic approach of the angiosperms of the temperate and tropical regions*. Florida: CRC Press.

BOTN-6240 Seed Production Technology 3(2+1)

The course is designed to enhance the students' knowledge of seed production and the key roles of bees and other insect pollinators, how to manage seed crops from agronomic, quality control, and genetic integrity standpoints, and how to meet new challenges through seed production research. Seed is the product of fertilized ovule that consists of embryo, seed coat, and cotyledon (s). In terms of seed technology, any part of the plant body which is used for commercial multiplication of crop is called seed. To make the available good quality seeds to the farmers, seed certification is necessary, which is a scientifically designed process. In our country seed certification is linked with notification of kind/variety. Only those varieties are eligible for certification, which are released and notified under Seeds Act. Seed testing is required to achieve the objectives for minimizing the risks of planting low quality seeds and the primary aim of the seed testing is to obtain accurate and reproducible results regarding the quality status of the seed samples submitted to the seed testing laboratories.

Contents

1. Reproductive process in plants. Definition of seed and planting material. Anatomy and chemistry of seed. Introduction to seed industry of Pakistan. Variety development, registration and maintains system.
2. Modern concept of quality and seed management. Production of early generation seed. Seed generation system from pre-basic to basic and certified. Seed quality system, legislation under seed (Amendment). Act-2015, crop inspection, seed testing, seed processing and storage.
3. Production of true to type disease free fruit nursery plant, hybrid seed production, establishment, planning and management of seed business, seed marketing and prices network.
4. Comparative study of various seed management systems in the world.

Lab work

1. Lay out of seed adaptability and demonstration plot.
2. Visit to seed production plot and seed testing Laboratory to know the physical and analytical purity of seed lot,
3. Variety purity identification by using electrophoresis and DNA fingure printing techniques.
4. Assessment of seed viability and planting value by using tetrazolium test and vigor test.
5. Visit to variety breeding institute, seed farm and seed processing plant and seed storage.
6. An assignment/Mini project to assess the profit and loss of seed production entrepreneur.

Recommended Texts

1. Bhutta, A. R. (2010). *Introduction seed pathology*. Pakistan: HSC.
2. Khare, D., & Shale, M. S. (2014). *Seed technology* (2nd ed.) USA: Scientific Publisher.
3. Singh, S. (2014). *Seed Testing*. Lahore: Gene Tech Book.

Suggested Readings

1. Hussain, A., & Bhutta, A. R. (2016). *Seed industry in pakistan*. Islamabad: FSC & RD/PSF..
2. Shagufta, S. (2012). *Seed science & seed technology*. India: APH Publisher.

BOTN-6241 Seed Pathology 3(2+1)

Seed pathology involves the study and management of diseases affecting seed production and utilization, as well as disease management practices applied to seeds. International seed trade has been affected significantly by changing phytosanitary regulations, not always based on science. This course deals with the History, economic importance, dynamic of transmission of plant pathogens, methodology and control measures of seed borne diseases. Seed pathology as a sub-discipline of plant pathology is relatively new. Due to economics and new interest in environmental issues, research into the viability of biological seed treatments is becoming more common. The use of sophisticated DNA amplification technologies allows for the detection of seed borne pathogens that might go undetected using more conventional means. For the farmers seeds are not produced and collected in appropriate scientific technology rather these are the portions of grain cash crop harvested for their consumptions.

Contents

1. Emergence of seed pathology as an independent discipline and its significance.
2. Morphological and anatomical studies of healthy and infected seed and planting material by using molecular techniques.
3. Effect of seed borne disease on seed viability and planting value. Histopathological study of infected seed, transmission of seed borne pathogens and their establishment in host and then to seed.
4. Mycotoxicological problems induce by seed borne pathogens and their health hazards. Identification of economical important seed borne disease and their post-harvest losses in agriculture and horticulture crops. Seed health technology and seed health certification system for production of disease free seed and inspection of seed consignments during export import and testing of germplasm material.
5. Concept of GMO in management of seed borne disease. Management of commercial scale production of disease free forest nursery and fruit plant certification. Seed and planting material national health standard under the seed (Amendment) Act-2015.Bioterrorism, SPS measures and international obligations.

Lab work

1. Collection of seed samples as per ISTA rules,
2. Isolation of pathogen, identification and preservation of culture.
3. Histopathology of healthy and infected seed.
4. Effect of different chemicals and antagonistic microorganisms on seed borne pathogens and seed germination.
5. Field crop inspection for disease assessment.
6. Visit to seed health testing lab, seed processing plants and seed storage.

Recommended Texts

1. Bhutta, A. R. (2010). *Introductory seed pathology*. Pakistan: HEC.
2. Ahmed, S. (2009). *Plant Disease Management for Sustainable Agriculture*. India: Daya Publishing House.

Suggested Readings

1. Agarwal,V. K. (2014). *Management of Seed Borne Disease*. India: Agrobios.
2. Agrios, G. N. (2005). *Plant Pathology*. United States: Academic Press.

MPhil
BOTANY

BOTN-7101 Advanced Techniques in Molecular Biology 3(2+1)

This course introduces students to recombination of genetic material at molecular levels with emphasis on recombinant DNA technology, genomics; cloning strategies nucleic acid hybridization transgenic proteins, organisms and gene therapies. It will provide an insight into analysis of gene structure and expression in prokaryotes and eukaryotes, human genome project. gene identification, databases, sequence analysis, gene annotation, detecting open reading frames, software programs for finding genes, using homology to finding genes, phylogenetic trees and genome evaluation. It covers the applications of recombinant DNA technology which include production of transgenic proteins, transgenic organisms and gene therapies and genetic markers such as random amplified polymorphic DNA (RAPD), microsatellite /SSR, restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP).Students will be able to know about molecular basis of gene genetic and physical mapping of gene, deactivating the function of specific genes in prokaryotes (*E. coli*), eukaryotes (*Arabidopsis thaliana* and yeast).

Contents

1. Introduction, prokaryotic, eukaryotic and organellar genomes, genome sizes, introns and exons, methods of preparing genomic DNA.
2. Outline of DNA cloning methods, cloning vectors including plasmids, bacteriophages, cosmids and expression vectors, gene splicing, chromosome walking, development of gene libraries, gene sequencing, potentials of recombinant DNA technology
3. Introduction to DNA amplification and polymerase chain reaction (PCR). Gel electrophoresis of DNA, pulse-field agarose gel electrophoresis, southern blotting, northern and western blotting, *in situ* hybridization, DNA microarray.
4. Molecular definition of a gene, Analysis of gene structure and expression, genetic and physical mapping of gene, deactivating the function of specific genes in eukaryotes, prokaryotes (*E. coli*), eukaryotes (*Arabidopsis thaliana* and yeast) and Human genome project. Gene identification, databases, sequence analysis, gene annotation, detecting open reading frames, software programs for finding genes, using homology to finding genes, human genome project, genome evaluation.
5. Transgenic Proteins, Organisms and Gene Therapies.
6. Production of transgenic proteins, transgenic organisms and gene therapies, random amplified polymorphic DNA (RAPD), microsatellite /SSR, restriction fragment length polymorphism (RFLP), amplified fragment length polymorphism (AFLP).

Lab work

1. Centrifugation techniques, Plasmid DNA isolation from bacterial cells
2. Isolation of genomic DNA from plant tissues, DNA amplification (PCR), agarose gel electrophoresis of isolated DNA, Restriction enzyme digestion of plasmid DNA

Recommended Texts

1. David, N. & Cox, M. (2017). *Lehninger: principles of biochemistry.* New York: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A. (2016).*Molecular cell biology.* (8th ed.).New York: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B., Sahijram, R. &Murthy, K. (2015).*Plant biology and biotechnology*. Berlin: Springer-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019).*Molecular biology*. Amsterdam: Elsevier.

BOTN-7102 Advanced Plant Ecology 3(2+1)

This course of advanced plant ecology provides comprehensive knowledge on greenhouse effect, global warming, acid rains, water pollution, nuclear radiation, mining, ozone depletion, noise pollution. Students will able to understand about environmental pressures and plant responses to environmental pressures, energy metabolism of plants under oxygen deficiency, morpho-anatomical changes during oxygen deficiency, post-anoxic stress and bioremediation a solution to environmental pollution. Significance of water, wind and fire as important ecological factors, particularly field capacity and soil water holding capacity, xerophytes and hydrophytes, effect of precipitation on distribution of plants. It also explicates role of anthropogenic activities on our environment, use of nitrate pesticides, agriculture pollution, and intensive livestock, population explosion, heavy metal pollution and their adverse effects on plants and role of forests in sustainable ecosystem management. Students will also get familiarize with population ecology, seed dispersal and seed bank.

Contents

1. Introduction: Scope and discipline of ecology. Brief description of history of ecology.
2. Applied Ecology: Atmospheric pollution, carbon dioxide a major atmosphere pollutant, greenhouse effect,
3. Water: Field capacity and soil water holding capacity.
4. Characteristics of xerophytes and hydrophytes. Effect of precipitation on distribution of plants.
5. Wind as an ecological factor and its importance.
6. Population Ecology, A brief description of seed dispersal and seed bank. Oxygen deficiency.
7. Energy metabolism of plants under oxygen deficiency, morpho-anatomical changes during oxygen deficiency, post-anoxic stress. Fire as an ecological factor, Agriculture pollution. Intensive livestock. Plant competition in changing world. Plant responses to environmental pressures.
8. Management: Nitrate pesticides, population explosion, heavy metal pollution and their adverse effects on plants, bioremediation a solution to environmental pollution,
9. Radiation: Impact on vegetation and environment, role of forests in our environment, community succession, plant as indicators of pollution, ozone depletion, its causes and effects,

Lab work

1. Field trips to different regions of Pakistan to study vegetation of Pakistan.
2. Elimination of industrial waste water and municipal sewage and slug for:
3. Examination of water samples forms different sites for the presence and diversity of organisms.
4. Visits to environmentally compromised sites, Effect of air pollutants on plants
5. Different methods to study plant populations including quadrate method.

Recommended Texts

1. Keddy, P.A. (2017).*Plant ecology origins, processes, consequences.* Cambridge: Cambridge University Press.
2. Canadell, J.G., Diaz, S., Heldmaier, G., Jackson, R.B., Levia, D.F., Schulze, E.D. & Sommer, U. (2019).*Ecological studies*. Basel: Springer.

Suggested Readings

1. Fath, B. (2018). *Encyclopedia of Ecology*. Amsterdam: Elsevier.
2. Ajith, H., Urmas, P., Pastur, G.M. & Iverson, L.R. (2018).*Ecosystem services from forest landscapes: broadscale considerations*. (1st ed.). Basel, Switzerland: Springer International Publishing AG.

BOTN-7103 Advanced Plant Physiology and Biochemistry 3(2+1)

Plant physiology is a subdiscipline of botany concerned with the functioning, or physiology, of plants. Closely related fields include plant morphology, plant ecology, phytochemistry, cell biology, genetics, biophysics and molecular biology. Plants are immobile in nature; they want to fulfill all their requirements of their life without moving from one place to another place. This course examines life process of plants such as signal transduction; different types of hormones their synthesis, mode of action and beneficial effects. It also gives information about mechanism and different forces involve in uptake of water, role of water potential, minerals nutrition, their physiological role and deficiency symptoms in plants. Students will study photoperiodism, vernalization and assimilation of nutrients. The course elucidates the structure and role of primary and secondary metabolites in plants. Students will have insight into stress physiology, plant responses and stress tolerance mechanisms towards extreme conditions such as water deficit and drought, salinity, metal toxicity, freezing and heat stress and oxidative stress.

Contents

1. Plant Metabolism: Amino Acid Metabolism: Amino acid biosynthesis, shikimic acid pathway, degradation of amino acids.
2. Regulation of carbohydrate metabolism. Regulatory enzymes and metabolites in different pathways like respiration.
3. Metabolism of secondary metabolites of plants,their biosynthesis, distribution and functions
4. Coumarins and lignins: Structure and chemistry, distribution and function.
5. Signal transduction: specific signaling mechanisms, e.g. two-component sensor-regulator system in bacteria and plants, sucrose-sensing mechanism.
6. Stress physiology: Plant responses to biotic and abiotic stress, mechanisms of biotic and abiotic stress tolerance, HR and SAR, water deficit and drought resistance, salinity stress, metal toxicity, freezing and heat stress, oxidative stress.
7. Cell Walls Structure, Biogenesis and Expansion: The cell wall polysaccharides: Structure and biosynthesis. Biosynthesis of non-starch storage polysaccharides.
8. Plant Growth Regulators – A brief idea about discovery, role and possible mechanism of action of Triacontanol, Brassins, Salicylic acid, Jasmonates and Polyamines.

Lab work

1. Separation of Photosynthetic pigments using paper and column chromatography
2. Estimation of chlorophyll by OMSO Method, Calculation of iodine number, acid value, saponification value, Estimation of total carotene and xanthophylls.
3. Separation of Anthocyanin pigment by paper and thin layer chromatography.
4. Estimation of total nitrogen by kjeldahl Method, Separation of different phenolic compounds
5. Effect of A A on elongation growth of maize coleoptile.

Recommended Texts

1. Taiz, L. & Zeiger, E. (2019).*Plant physiology.*7th Edition. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.
2. Taiz, L. & Zeiger, E. (2018). *Fundamental of plant physiology*. Sunderland Massachusetts: Sinnauers Publ. Co. Inc.

Suggested Readings

1. Nelson D. & Cox, M. (2017). *Lehningers principle of biochemisry.* (7th ed.). New York: W.H Freeman.
2. Dennis, D.T., Turpin, D.H., Lefebvre, D.D. & Layzell, D.B. (2016). *Plant metabolism.* (6thed.). London: Longman Group.

BOTN-7104 Plant Nutrition Management 3(2+1)

This course explores sources of plant nutrition, micro and macronutrients, plant nutrient balance, inducible repressible nutrient transport. Photosynthesis, regulation of photosynthesis by sink activity. Students will get familiarize with methods of plant nutrition such as solution culture techniques, chelating agents, radiotracer techniques, role of rhizosphere bacteria to help plants to tolerate abiotic stress, ammonium and nitrate nutrition of plants and role of mineral nutrition in bioactive compounds, antioxidant phenolics, carotenoids, flavonoids in vegetables and fruits. This course also explains role of soil microorganisms in improving phosphorous nutrition of plants and interaction between plant nutrients, antagonism between potassium and magnesium and calcium. Students will successfully learn about management of different fertilizers in soil and hydroponic conditions for better growth and development of crops, they will also know about leaching substances of plants, biocher effect on nutrient leaching in plants.

Contents

1. Plant nutrients, micro and macronutrients. Sources of plant nutrition and plant nutrient balance
2. Effect of mineral nutrition in bioactive compounds in vegetables and fruits (antioxidant phenolics, carotenoids, flavonoids).
3. Photosynthesis, regulation of photosynthesis by sink activity, mineral nutrition inducible repressible nutrient transport.
4. Methods of studying plant nutrition, solution culture techniques, chelating agents, radiotracer techniques,
5. Role of rhizosphere bacteria to help plants to tolerate abiotic stress, ammonium and nitrate nutrition of plants.
6. Leaching substances of plants, biocher effect on nutrient leaching. Nuclear techniques used in soil fertility and plant nutrition. Uptake of mineral nutrition and foliar absorption of mineral nutrients.
7. Role of soil micro-organism in improving phosphorous nutrition of plants, Interaction between plant nutrients, antagonism between potassium and magnesium and calcium

Lab work

1. Experiments of plant growth under different nutrient supplies.
2. Experiments of plant growth with application of different fertilizers in soil and hydroponic conditions.

Recommended Texts

1. Naeem, M., Ansari, A.A. & Gill, S.S. (2017). *Essential plant nutrients: uptake, use efficiency, and management*. Switzerland, Basel: Springer.
2. Jones, J.B. (2012).*Plant nutrition and soil fertility manual* (2nd ed.). Florida: CRC Press.

Suggested Readings

1. Hossain, M.A., Kamiya, T., Burritt, D., Tran, L.P. and Fujiwara, T. (2017).*Plant macronutrient use efficiency*: *molecular and genomic perspectives in crop plants.* Massachusetts: Academic Press.

2. Mitra, G.N. (2015).*Regulation of nutrient uptake by plants: a biochemical and molecular approach*. Switzerland, Basel: Springer.

BOTN-7105 Environmental Toxicology and Impact Assessment 3(2+1)

This course provide updated information on introduction and history of environmental toxicology, types of environmental toxicology and effects of toxins to environment, ecological risk assessment and sustainable environmental management by utilization of algae and plants, treatment technologies which include traditional and modern microbial techniques especially biodegradation and phytoremediation. Students will come to know how plants become helpful to remove toxic contaminants from polluted soils by using their organs, plant roots absorb the contaminants along with other nutrients and water. This method is used primarily for wastes containing metals, the metals are stored in the plants aerial shoots, which are harvested or disposed of as a hazardous waste. Rhizofiltration is similar to phytoextraction, plants used for cleanup are raised in greenhouses with their roots in water, and roots saturated with contaminants are harvested and disposed of. This course also covers toxic effects of metals and other toxins on health of human and plants.

Contents

1. Introduction and history of environmental toxicology.
2. Types and effects of chemical toxins to environment (PCDDs, PCDFs, TEFs and related compounds).
3. Toxic effects of metals.
4. Ecological risk assessment.
5. Biotechnology and bioremediation, possible mechanisms.
6. Role of transgenic plants/ organisms in the bioremediation.
7. Contaminants in the environment.
8. Utilization of algae and plants assay for ecotoxicological assessment of environmental samples.
9. Biodegradation of toxic and environmental pollutants.
10. Bioanalytical techniques used in environmental risk assessment.
11. Environmental toxicology effects on plant and human health.
12. Chelate assisted phytoremediation.
13. Enhanced phytoextraction and rhizofiltration,
14. Control of toxicology.

Lab work

1. Field survey:
2. Hydroponics systems for heavy metal studies, water sampling techniques, soil sampling, heavy metal estimation methods, sample preparation and digestion.
3. Principle of atomic absorption, spectrophotometer

Recommended Texts

1. Dong, M.H. (2018). *An introduction to environmental toxicology.* (4th ed.).Carolina: Create Space Independent Publishing Platform.
2. Laws, E.A. (2013). *Environmental toxicology*. Switzerland, Basel: Springer.

Suggested Readings

1. Sing, A. & Ward, O.P. (2004). *Applied bioremediation and phytoremediation*. Switzerland, Basel: Springer.
2. Rattner, B.A., Burton, G.A. & Cairns, J. (2002). *Handbook of ecotoxicology*. Florida: CRC Press.

BOTN- 7106 Recombinant DNA Technology 3(2+1)

Recombinant DNA technology introduces students to recombination of genetic material at molecular levels with emphasis on recombinant DNA technology and genomics; cloning strategies and nucleic acid hybridization. Students will learn about DNA modifying enzymes and their uses in molecular biology, use of thermostable DNA polymerases in PCR, plasmids as cloning vehicles, basic properties of plasmid, desirable properties of plasmid cloning vehicles, usefulness of natural plasmids as cloning vehicles. There is special focus on DNA sequencing; principle of chemical and enzymatic methods, automated DNA sequencing, high through put pyrosequencing, next generation sequencing, deep sequencing. Site-directed mutagenesis and protein engineering will also be discussed along biotechnological applications of rDNA technology including synthesis and purification of proteins from cloned genes- native and fusion proteins, yeast expression system and production of enzymes. In this regards students will get familiar with therapeutic products of rDNA technology for use in human health care like insulin, growth hormones, TPA, alpha interferon, hepatitis B vaccine and factor VIII.

Contents

1. Introduction: DNA modifying enzymes and their uses in molecular biology Thermostable DNA polymerases used in PCR. Plasmids as cloning vehicles, basic properties of plasmid, desirable properties of plasmid cloning vehicles, usefulness of natural plasmids as cloning vehicles,
2. Cloning strategies, genomic DNA libraries, chromosome walking, cDNA cloning.
3. Recombinant selection and screening: Genetic methods, immunochemical methods, nucleic acid hybridization methods. Expression *in E. coli* of cloned DNA molecules. The effect of plasmid copy number and plasmid stability.
4. Applications of recombinant DNA technology.
5. DNA sequencing; Principle of chemical and enzymatic methods, Automated DNA sequencing, high throughput. Pyrosequencing, next generation sequencing, deep sequencing.
6. Site-directed mutagenesis and protein engineering. DNA foot printing, chromosome jumping, chromosome walking.
7. Biotechnological applications of rDNA technology; Synthesis and purification of proteins from cloned genes- native and fusion proteins. Yeast expression system. Production of enzymes. Therapeutic products for use in human health care- insulin, growth hormones, TPA, alpha interferon, hepatitis B vaccine and factor VIII.

Lab work

1. E coli culture and growth curve.
2. Transformation of plasmid DNA to *E. coli*
3. Conjugation
4. Extraction of plasmid DNA
5. Gel electrophoresis for isolation of protein

Recommended Texts

1. Nelson, D. & Cox, M. (2017). *Lehninger: principles of biochemistry.* New York: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser,C., Krieger, M. & Bretscher, A. (2016).*Molecular cell biology.*(8th ed.). New York: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B., Sahijram, R. &Murthy, K. (2015). *Plant biology and biotechnology*. Berlin: Springer-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019). *Molecular biology*. Amsterdam: Elsevier Inc.

BOTN- 7107 Applications of Plant Biotechnology 3(2+1)

This course is designed to provide students with knowledge about current technological developments in research with trends in the aims and needs of today's biotechnology industries, commercial production of important amino acids, commercial production of antibiotics. Selected topics include the latest scientific achievements in the field of plant biotechnology: application of biotechnology in botany, identification and screening of recombinant DNA molecules, gene regulation, tools of biotechnology, enzymes for DNA manipulation, cloning and expression vectors, fermentation biotechnology, conventional methods of crop improvement, plant tissue culture and role of secondary metabolites in plants. This course elucidates structural and functional aspects of secondary metabolites, their biosynthetic pathways, techniques used in biosynthesis, role of secondary metabolites in plant defense, communication in insets, plants, animals, chemical ecology, interaction between organism using secondary metabolites and production of bioactive secondary metabolites by plant tissue culture.

Contents

1. Introduction to plant biotechnology, gene regulation, tools of biotechnology, enzymes for DNA manipulation, cloning and expression vectors.
2. Fermentation Biotechnology.
3. Conventional methods of crop improvement.
4. Plant tissue culture.
5. Secondary metabolites: Basic biosynthetic pathways, techniques used in biosynthesis, use of isotopes.
6. Role of secondary metabolites: Defense, communication in insets, plants, animals, chemical ecology, interaction between organism using secondary metabolites, production of bioactive secondary metabolites by plant tissue culture.
7. Commercial production of important amino acids commercial production of antibiotics. Application of biotechnology in botany. Identification and screening of recombinant DNA molecules.

Lab work

1. Extraction and estimation of plant DNA.
2. Basic biotechnology techniques
3. Visits of Biotechnology labs at NIBGE, Faisalabad, AARI, Faisalabad and School of Biological Sciences, Lahore, Center of Excellence in Molecular Biology, Lahore: National Institute for Genomics and Advance Biotechnology (NIGAB)

Recommended Texts

1. Nelson, D. & Cox, M. (2017). *Lehninger: principles of biochemistry.* W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A. (2016).*Molecular cell biology.* (8th ed.). New York: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B., Sahijram, R. &Murthy, K. (2015). *Plant biology and biotechnology*. Singapore: Springer-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019). *Molecular biology*: Amsterdam: Elsevier Inc.

BOTN-7108 Plant-Microbe Interactions 3(2+1)

Microbes and plants have developed intriguing strategies to encourage, resist or profit from their coexistence. This course is focused on to study comprehensively the plant microbe interaction for the maintenance of vital physiological functions and mechanisms in plants and to enumerate the symbiotic role of microbes, bacteria, fungi and others to improve mineral uptake and resistance against diseases in plants. Several of the mutualistic or antagonistic interactions illustrate broader principles and contribute to our fundamental understanding of biological processes. These interactions have a strong impact on agricultural ecosystems, and are also of applied importance. Establishment of a relationship between a plant and a microbe may involve colonization, infection, nodulation, or systemic spread of a microbe in or on a plant. In the microbe, our focus will be on the mechanisms of host detection, colonization, virulence, and maintenance of the infection. We will explore plant fungal interaction.

Contents

1. Plant fungal interaction and types of mycorrhizae.
2. Bacterial metabolism in rhizosphere, Role of plasmids in plant bacteria interaction.
3. Plant immunity:-The MTI-ETI Model and beyond (effector trigger immunity, microbe trigger immunity).
4. Plant nematode interaction assisted by microbes in rhizosphere, Bacteria –plant interactions.
5. Microbe interaction leading to plant defense, plant innate, immunity systemic acquired resistance and plant and host range specificity.
6. Symbiosis: plant symbiotic gene, hormonal regulation of plant microbe symbiosis.
7. Mycorrhizae and carbon, nitrogen, phosphorus dynamics,
8. Vesicular arbuscular mycorrhizae and environmental stresses.
9. Viruses: RNA/DNA viruses, Bacterial Toxins; enzymatic degradation; genetic transformation
10. Challenges related to plant microbe interaction to improve plant resistance against diseases.
11. Methods of conforming nitrogen fixation by plant prebiotic bacteria
12. Quantitative assay for nitrogen fixation of endophytic bacteria, Plant growth promoting bacteria.

Lab work

1. Study of VA mycorrhizal associations, Clearing and staining of mycorrhizal roots.
2. Sample storage and slide preparation, Estimation of root length and colonization by mycorrhizal fungi, Bioassay measurements of mycorrhizal inoculums in soil.
3. Isolation and identification of glomalean fungi from field and other soils.
4. Synthesis of mycorrhizae from spore inoculums and from root inoculums.
5. Assessment of plant growth response by mycorrhizal infection in some seasonal crops.

Recommended Texts

1. Schikora, A. (2018).*Plant microbe interaction in the rhizosphere*. Massachusetts : Academic press.
2. Akhtar, M.S. (2017). Salt *stress, microbes, and plant interactions: mechanisms and molecular approaches*. Singapore: Springer Verlag.

Suggested Readings

1. Wolpert, T.,Shiraishi, T., Collmer,_A., Akimitsu, K. & Glazebrook, J. (2017).*Genome-enabled analysis of plant-pathogen interactions*. USA, Minnesota: APS Publications.

BOTN-7109 **Phytochemistry** **3(2+1)**

Phytochemistry is the study of phytochemicals, which are chemicals derived from plants. Those studying phytochemistry strive to describe the structures of the large number of secondary metabolic compounds found in plants, the functions of these compounds in human and plant biology, and the biosynthesis of these compounds. Plants synthesize phytochemicals for many reasons, including to protect themselves against insect attacks and plant diseases. Phytochemicals in food plants are often active in human biology, and in many cases have health benefits The compounds found in plants are of many kinds, but most are in four major biochemical classes, the alkaloids, glycosides, polyphenols, and terpenes. Phytochemistry can be considered a sub-field of botany or chemistry. Activities can be led in botanical gardens or in the wild with the aid of ethnobotany. The applications of the discipline can be for pharmacognosy or the discovery of new drugs, or as an aid for plant physiology studies.

Contents

1. Introduction: Phytochemistry, role of phytochemistry in herbal medicine.
2. Secondary metabolites: Alkaloids, steroids, phenols, flavonoids, terpenoids, tannins, saponins, glycosidases etc. Micronutrients and macronutrients, antioxidants, phytohormones, carbohydrates, protiens and lipids, enzymes and vitamins.
3. Plant pigments, chemical nature of plant based latex and mucilages.
4. Saponins with biological and pharmacological activity: Saponins, steroids, alkaloids and di-terpene from Euphorabiaceae. Mono,di- and sesquiterpenes with pharmacological and therapeutic activity
5. Natural products leads to new drugs: Approaches to discovery and developments of natural products as potential new drugs
6. Selection and optimization of lead compounds for further development with suitable examples from CNS
7. Antibiotics, anticancer and cardiovascular drugs

Lab work

1. Separation of photosynthetic pigments using paper and column chromatography
2. Estimation of total carotene and xanthophylls
3. Separation of anthocyanin pigment by paper and thin layer chromatography
4. Separation of different Phenolic compounds
5. Determination potential alkaloids in plants.
6. Estimation of terpenoids in plants.

Recommended Texts

1. Sarker, S. &Nahar, L. (2018).*Computational phytochemistry*. (1st ed.). Amsterdam: Elsevier Science Publishing Company.
2. Schmidt, B.M., Diana, M. & Cheng, K. *Ethnobotany: a phytochemical perspective*. Hoboken, New Jersey: Wiley.

Suggested Readings

1. Akhtar, M.S. (2019). *Natural bio-active compounds*: production and applications. Singapore: Springer Verlag,.
2. Egbuna, C., Chinenye, J., Kumar, S. and Sharif, N. (2018). *Phytochemistry*. (1st ed.). Cambridge: Apple Academic Press.

OPTIONAL COURSES

BOTN-7110 Biosystematics 3(2+1)

Plant biosystematics is a science that includes and encompasses traditional taxonomy; however, its primary goal is to reconstruct the evolutionary history of plant life. It divides plants into taxonomic groups, using morphological, anatomical, embryological, chromosomal and chemical data. However, the science differs from straight taxonomy in that it expects the plants to evolve, and documents that evolution. Determining phylogeny - the evolutionary history of a particular group - is the primary goal of systematics. Approaches to classifying plants include cladistics, phenetics, and phyletics. Cladistics relies on the evolutionary history behind a plant to classify it into a taxonomic group. Cladogramsare used to represent the evolutionary pattern of descent. The map will note a common ancestor in the past, and outline which species have developed from the common one over time. This course is aimed to know about the concept of biological systematics; phylogeny: the evolutionary history of plant life and study taxonomy, taxonomic hierarchy, taxonomic keys and their significance and use of taxonomic literature in taxonomic publications.

Contents

1. Introduction to biological systematics; Phylogeny: The evolutionary history of life; Evolution and diversity of plants (nonvascular, vascular, seed and flowering plants).
2. Taxonomy: Description, identification, nomenclature and classification.
3. Character and character analysis; Cladograms construction, species and different types of species, speciation.
4. International rules of nomenclature; Historical and contemporary situation.
5. Taxonomic hierarchy. Taxonomic keys and their significance, use of taxonomic literature in taxonomy and taxonomic publications.
6. Advanced analytical methods in systematics.

Lab work

1. Field trips to different Eco-zones of Pakistan
2. Study of different adaptations in diverse environments (study of ecotypes)

Recommended Texts

1. Singh, G. (2016). *Plant systematics: an integrated approach*. (3rded.) Boca Raton, Florida: CRC Press
2. Williams, D., Schmitt, M., & Wheeler, Q. (2016). *The future of phylogenetic systematics: the legacy of Willi Hennig*. England, Cambridge: Cambridge University Press.

Suggested Readings

1. Briggs, D. & Walters, S.M. (2016). *Plant variation and evolution*. UK, Cambridge: Cambridge University Press.
2. Pontarotti, P. (2018).*Origin and evolution of biodiversity*. Switzerland, Basel: Springer.

BOTN-7111 Phytoremediation 3(2+1)

Phytoremediation is a bioremediation process that involves use of plants to remove, transfer, stabilize, or destroy contaminants in the soil and groundwater. There are several different types of phytoremediation . These are: rhizosphere biodegradation, in this process, the plant releases natural substances through its roots, supplying nutrients to microorganisms in the soil. The microorganisms enhance biological degradation while in Phyto-stabilization process, chemical compounds produced by the plant immobilize contaminants. Phyto-accumulation process, plant roots absorb the contaminants along with other nutrients and water. This method is used primarily for wastes containing metals, the metals are stored in the plants aerial shoots, which are harvested or are disposed of as a hazardous waste, readily bioavailable metals for plant uptake include cadmium, nickel, zinc, arsenic, selenium, and copper. Moderately bioavailable metals are cobalt, manganese, and iron. Lead, chromium, and uranium are not very bioavailable. Lead can be made much more bioavailable by the addition of chelating agents to soils.

Contents

1. Introduction to phytoremediation types of contaminants, sources, risks, and the soil environment
2. The scope and applicability of phytoremediation
3. The various mechanisms that can be involved in phytoremediation, phytoextraction, phytostabilization etc.
4. Remediation Technologies: Physical - chemical and biological.
5. Bioremediation; Factors affecting bioremediation in soil systems, optimization of bio-remediation, biological enhancement in bioremediation.
6. Mechanisms of phytoremediation, phytoextraction, phytostabilization, phytovolatilization, phytodegradation, rhizofilteration and phytofilteration.
7. Organics that can be phytoremdiated, plants exudates in organic phytoremediation, uptake rates for organics in phytoremediation
8. soil environment, fate of metals in soils, phyto- availability and bioavailability of metal, methods to assess and measure bioavailability
9. The Genetics of Metal Tolerance: Phytovolatilization of metals, phytoextraction of metals, phytostabilization of metals, phytofilteration of metals.
10. The role of bacteria in the phytoremediation of heavy metals, use of bioactivation and bioaugmentation technologies for treating acidic metal rich drainage.

Lab work

1. Comparison of two potential lead bioremediating plants.
2. Use of plants to remove pesticides from storm water runoff
3. Phytoremediation of lead using *Brassica nigra* or sun flower(*Helianthus annuus*)

*Recommended Text*s

1. Ravishankar, G.A. & Ambati, R.R. (2019).*Handbook of algal technologies and phytochemicals.* Boca Raton, Florida: CRC Press

2. Terry, N. & Banuelos, G.S. (2019). *Phytoremediation of contaminated soil and water*. Florida: CRC Press.

Suggested Readings

1. David, W.M. (2018). *Recent advances towards improved phytoremediation of heavy metal pollution*. UAE, Sharjah: Bentham Science Publishers.
2. Matichenkov, V. (2018). *Phytoremediation: methods, management and assessment.* Hauppauge, New York: Nova Science Publishers.

BOTN-7112 Economic Botany 3(2+1)

Economic botany is the study of the relationship between people and plants. It encompasses the fields of botany, systematic, evolution, anatomy and anthropology. It explores the countless ways humans employ plants for food, medicine, textiles, shelter and more. Without plants, life will be impossible on our planet earth & without plant products humans would be naked, miserable and hungry. Plants and plant products exist in almost every aspect of our lives, yet most of us are plant blind. This course is designed to correct our vision. Botany and medicine were once one and the same. Now most pre-medical students avoid botany, and thus avoid the "roots" of their future profession. Many plants are important because of their interactions with humans. Plants have shaped human history, language and culture. This course will add a new dimension to education. It will simply show how indispensable plants are for human survival. This course deals with man's relationship to plants, introducing students to economic botany, its role in food security and health aspects.

Contents

1. Introduction to economic botany, role in food security and health aspects
2. Plants as sources of food, feed, fiber, timber, vegetable, phytochemicals and medicine; Conventional and alternative sources
3. Study of different groups of plants with their economic uses
4. Basis of utilization; Macronutrients as carbohydrates, proteins, fats and fibers; Micronutrients as vitamins and minerals
5. Medicinal plants and their basis of utilization; Growth habit and ecology of important indigenous medicinal plants
6. Conventional and advanced approaches to improve economic plants for better yield of economic products
7. History and strategies for the domestication and preservation of economic plants
8. Diversity, geographic distribution, taxonomy and nomenclature of economically important plants

Lab work

1. Exploration of natural areas (field visits); Collection, identification and preservation of economically important plants with particular reference to nutritional and medicinal plants.
2. Study the standard protocols for identification and measurements of different phytochemicals.
3. Processing of economically important plants for their domestic use; Preparation of decoctions, syrups, ointments and dried plants for domestic medicinal use.

Recommended Texts

1. Kochhar, S.L. (2016). *Economic botany*. UK, Cambridge: Cambridge University Press.

2. Wiersema, J.H. & León, B. (2016).*World economic plants: a standard reference*. Florida: CRC Press.

Suggested Readings

1. Bagetta, G., Cosentino, M., Corasanitiand, M.T. and Sakurada, S. (2016). *Herbal medicines: development & validation of plant-derived medicines for human health*. Florida: CRC Press.
2. Pandey, B.P. (2016). *Economic botany*. New Delhi: S Chand & Company Pvt. Ltd.

BOTN-7113 Advances in Physiology and Molecular Biology of Plants 3(2+1)

Plant molecular biology is the study of the molecular basis of plant life. It is particularly concerned with the processes by which the information encoded in the genome is manifested as structures, processes and behaviors. This optional course aims to introduce students with advances in physiology and molecular biology of Plants. A deepened understanding of the molecular mechanisms and metabolic processes in plants and structural and functional significance of genome is the main aim of this course which include genome anatomy, detailed mechanism of genome replication, transcription and translation. Most biobased materials are of plant origin, and therefore students should expand their knowledge of plants, plant products and how these products are produced. The molecular biology of microbes will in part concentrate on the isolation of building blocks from these organisms. Another focus will be the microbial enzymes that can be used to synthesize interesting building blocks.

Contents

1. Genome Anatomies: Anatomy of eukaryotic genome, unusual chromosomal types, eukaryotic organelle genomes, anatomy of prokaryotic genome, repetitive DNA content of genomes, , role of DNA-binding proteins, methods for studying DNA-binding proteins, interactions between DNA and DNA binding proteins, RNA-binding motifs.
2. Genome Replication: DNA replication mechanisms, DNA repair processes, issues relevant to genome replication, topological problem, variations on semi-conservative theme, replication process, diverse function of DNA topoisomerase, regulation of eukaryotic genome replication.
3. Initiation of Transcription: First step in gene expression, accessing genome, DNA methylation and gene expression, assembly of transcription initiation complexes of prokaryotes and eukaryotes, regulation of transcription initiation, cis and trans, regulation of RNA polymerase I initiation
4. Translation I: The information problem, synthesis and processing of RNA: RNA content of cell.
5. Translation II: The machinery and the chemical nature of protein, synthesis and processing of mRNAs, Regulation of gene activity in eukaryotes, genetic recombination between homologous DNA sequences, role of tRNA in protein synthesis, role of ribosome in protein synthesis, post translational processing of proteins.
6. Protein sorting: Targeting of proteins to organelles, organization and expression of chloroplast and mitochondrial genomes, heat shock proteins and metallotheonins.
7. Phosphorylation as a mechanism of regulation, role of phytochrorme in plant development.
8. Molecular genetics of photosynthesis. Photo-chemical centers: Structure and organization. Mitochondria genome and male sterility, transport of protein into mitochondria

Lab work

1. Isolation/estimation of DNA from various plants, Separation of proteins by gel electrophoresis.
2. Effect of colchicine on chromosome movements during mitosis.

Recommended Texts

1. Clark, D., Pazdernik, N. & McGehee, M. (2019).*Molecular biology*. Amsterdam: Elsevier Inc.
2. Buchanan, W.G. & Russell, L. (2015).*Biochemistry and molecular biology of plants*.New Jersey: John Wiley & Sons.

Suggested Readings

1. Rapley, R. & Whitehouse, D. (2015). *Molecular biology and biotechnology*. UK, Cambridge: RSC.
2. Jugulam, M. (2017). *Biology, Physiology and molecular biology of weeds.* Florida: CRC Press.

BOTN-7114 Proteomics and Genomics 3(2+1)

Proteomics is a relatively-recent field. Studying proteins generates insight into how they affect cell processes. The goal of proteomics is to analyze the varying proteomes of an organism at different times in order to highlight differences between them; more simply proteomics analyzes the structure and function of biological systems. Proteomes can be studied using the knowledge of genomes because genes code for mRNAs and the mRNAs encode proteins, not all mRNAs are translated into proteins. Thus, the genome is constant, but the proteome varies as many proteins are modified after translation. Although the genome provides a blueprint, the final architecture depends on several factors that can change the progression of events that generate the proteome. This course will familiarize students with scope of proteomics and genomics, protein separation techniques, protein identification and sequencing, protein modifications, methods of preparing genomic DNA, sequence analysis of DNA, protein engineering and applications of proteomics and genomics.

Contents

1. Introduction and scope of proteomics; Protein separation techniques: ion exchange, size-exclusion and affinity chromatography techniques; Polyacrylamide gel electrophoresis; Isoelectric focusing (IEF); Two dimensional PAGE for proteome analysis; Image analysis of 2D gels.
2. Introduction to mass spectrometry; Strategies for protein identification; Protein sequencing, protein modifications and proteomics.
3. Applications of proteome analysis to drug; Protein-protein interaction (two hybrid interaction screening).
4. Protein engineering; Protein chips and functional proteomics; Clinical and biomedical application of proteomics; Proteome database; Proteomics industry.
5. Methods of preparing genomic DNA; DNA sequence analysis methods: Sanger dideoxy method and Fluorescence method;
6. Gene variation and Single Nucleotide Polymorphisms (SNPs); Expressed sequenced tags (ESTs); Gene disease association.
7. Recombinant DNA technology: DNA cloning basics, Polymerase chain reaction, DNA fingerprinting, human genome project and the genetic map.

Lab work

1. Protein separation techniques, Polyacrylamide gel electrophoresis (PAGE) for protein analysis
2. Isolation of genomic DNA from plant tissues
3. DNA amplification (PCR), Agarose gel electrophoresis of isolated DNA

Recommended Text

1. Strachan, T. & Andrew, P. (2018).*Human molecular genetics*. New York: Garland Science.

2. Thangadurai, D. & Sangeetha**,** J. (2015).*Genomics and proteomics: principles, technologies, and applications.* Florida: CRC Press.

Suggested Readings

1. Darvas, F., Guttman, A. & Dormán, G. (2016).*Chemical genomics and proteomics*. Florida:CRC Press.
2. Smejkal, G.B. & Lazarev, A. (2019). *Separation methods in proteomics.* . Florida: CRC Press.

BOTN-7115 Modern Molecular Biology 3(2+1)

Molecular biology is the study of living things at the level of the molecules which control them and make them up. While traditional biology concentrated on studying whole living organisms and how they interact within populations (a "top down" approach), molecular biology strives to understand living things by examining the components that make them up (a "bottom up" approach). Both approaches to biology are equally valid, although improvements to technology have permitted scientists to concentrate more on the molecules of life in recent years. Molecular biology is a specialized branch of biochemistry, the study of the chemistry of molecules which are specifically connected to living processes. Of particular importance to molecular biology are the nucleic acids (DNA and RNA) and the proteins which are constructed using the genetic instructions encoded in those molecules. Other biomolecules, such as carbohydratesand lipids may also be studied for the interactions they have with nucleic acids and proteins.

Contents

1. Introduction and scope: Mutations, types of mutations, biochemical basis of mutagenesis, base-analogue mutagens, chemical mutagens, intercalating agents, reversion.
2. Restriction and modification system, properties of restriction endonucleases, their occurrence and recognition sequences, assay procedures for restriction endonucleases and slab gel electrophoresis; *In vitro* genetic engineering; Cloning vehicles: plasmids, cosmids and phagemids, YAC and BAC etc.
3. Cloning strategies: Labeling methods of probes, construction of genomic libraries; Methods for screening the clones; PCR and its application in cloning; prokaryotes and eukaryotes expression systems; DNA sequencing; Genetic transformation system; Gene Knock down, knock out and knock in.
4. Organization and structure of genomes; genome sequencing genetic mapping (RFLP, microsatellite, SNP) high resolution physical mapping (STS, EST); comparative genomics and genome evolution, hierarchical and whole genome shotgun sequencing.
5. DNA sequencing strategies, manual and automated sequencing, different platforms used for next generation sequencing , sequence assembly, obstacles and solutions; estimating gene number over prediction and under prediction, homology searches, exon prediction programs, integrated gene finding software packages, structural variation in the genome and its applications, DNA microarray.

Lab work

1. Restriction digestion of DNA and preparation of restriction maps.
2. Gel Electrophoresis, PCR, Blotting Techniques, RNA isolation and RT – PCR.

Recommended Texts

1. Nelson, D. & Cox, M. (2017). *Lehninger: principles of biochemistry.* New York: W.H. Freeman-Macmillan Learning.
2. Lodish, H., Berk, A., Kaiser, C., Krieger, M. & Bretscher, A. (2016).*Molecular cell biology.* (8th ed.). New York: W.H. Freeman-Macmillan Learning.

Suggested Readings

1. Venkat, B., Sahijram, R. &Murthy, K. (2015).*Plant biology and biotechnology*. Singapore: Springer-Verlag.
2. Clark, D., Pazdernik, N. &McGehee, M. (2019). *Molecular biology*. Amsterdam: Elsevier Inc.

BOTN-7116 Biotechnology for Sustainable Development 3(2+1)

The major strength of biotechnology is its multidisciplinary nature and the extremely broad range of scientific approaches that it encompasses. Commercialization of biotechnology ranges from research to products and services. These are powerful technologies, supported by complementary bioprocess-engineering, to help translate new discoveries of life-sciences into lab work products and services. One of the important aspects of biotechnology is its role in the sustainable development of various sectors. Sustainability is fast becoming the corner stone of economy of many countries, both developed and developing. Biotechnology has great potential for solving many problems pertaining to agriculture, industry, environment and health, which have direct relevance to sustainable development. These features and potentials of biotechnology have generated great interest among the developing countries. This course explicates role of microbes in industry for commercial production of organic acids, amino acids, vitamins, antibiotics and enzymes.

Contents

1. Introduction; Crop Improvement: Clonal multiplication through, micropropagation, somatic embryogenesis, somaclonal variations, regeneration of haploids, isolation and yield of protoplast, regeneration of protoplast, somatic hybridization, vector construction, transformation.
2. Crop Protection: Bio-pesticides for use in agriculture and health sector, viral disease control through tissue culture technique. Microbial biotechnology for detoxification of industrial effluents and pesticides waste.
3. Microbes: Single cell protein production, microbial fermentation, choice of substrate, microbes in organic acid production, enzyme production, antibiotic, ergotin, vitamin and glycerin production, microbes in medicine. Mutant selection of microbe strain for high yield.
4. Energy transformation from source to services; Energy sources, sun as the source of energy; Biological processes; Photosynthesis, food chains, classification of energy sources, quality and concentration of energy sources, fossil fuel reserves - estimates, duration.
5. Theory of renewability, renewable resources; Overview of global/ Pakistan's energy scenario.
6. Food Processing: Production of beer, wine, cheese, bread, citric acid and amino acids.
7. Enzyme Technology: Enzymes: Enzyme fermentors and medium, enzyme extraction and purification of oxidoreductases, oxidases, hydrolases, penicillin amidases, transferases and applications of enzymes in therapeutics, clinical analysis and pharma industry
8. Biomass fuels, market barriers of biomass fuels, biomass fuel standardization, biomass fuel life cycle, sustainability of biomass fuels, economics of biomass fuels, fuel stoichiometry and analysis:

Lab work

1. Experiments pertaining to clonal plant propagation, protoplast isolation and regeneration, virus detection, enzymology, some food processing and bioconservations.

Recommended Texts

1. Mukhopadhyay, K., Sachan, A. & Kumar, M. (Eds.). (2017). *Applications of biotechnology for sustainable development*. Singapore: Springer.
2. Smith, R.H. (2013). *Plant tissue culture: techniques and experiments*. Massachusetts: Academic Press.

Suggested Readings

1. Venkat, B., Sahijram, R. &Murthy, K. (2015).*Plant biology and biotechnology*. Singapore: Springer-Verlag.
2. Clark, D., Pazdernik, N. & McGehee, M. (2019).*Molecular biology*. Amsterdam: Elsevier Inc.

BOTN-7117 Radiation Biology 3(2+1)

The course provides basic knowledge on radiation biological effects and risks from cells to humans as well as in-depth knowledge of radiation protection of ionizing and non-ionizing radiation, introducing students to radiobiology, radioisotopes and types of radiations and sources, effects of radiations on living cells, exposure and dose-effect, molecular basis of cellular effects and cell radiation sensitivity, radiation therapy, radiation protection, safety measures, treatment of radiation injuries, aspects and relationship of imaging physics and radiobiology. The course also familiarizes the students with radiological technologies, labeling techniques, use of radioisotopes as diagnostic and therapeutic tools. Radiation sensitivity and tolerance is evaluated based on normal tissue architecture and kinetics. The mechanisms of radiobiological damage, radiation effects are elucidated. The impact of time, dose, and fractionation on tumor control and radiation effects are clarified and related to established and newer treatment modalities, including combination therapies and emerging technologies.

Contents

1. Introduction to radiobiology, radioisotopes and types of radiations and sources, effects of radiations on living cells, exposure and dose-effect, molecular basis of cellular effects and cell radiation sensitivity, radiation therapy, radiation protection, safety measures, treatment of radiation injuries, aspects and relationship of imaging physics and radiobiology, current regulation and recommendations in radiations in radiation biology.
2. Radiological technologies, labeling techniques, use of radioisotopes as diagnostic and therapeutic tools, computational approaches in molecular radiation biology, health risks due to radiation biology, diagnostic radiology.
3. Radiobiological damage, oxygenation, fractionation, and 4 R's of radiobiology, cell and tissue radiosensitivity.

Lab work

1. Visit of different medical centers/hospitals for study of use of different types of radiation,
2. Visit to different stations/offices where any type of radio waves, electromagnetic waves etc. are in continuous use and collecting data.

Recommended Texts

1. Eric, H. (2018). *Handbook of evidence-based radiation oncology.* Basel, Switzerland: Springer International Publishing AG.
2. Michael, C.J. (2018). *Basic clinical radiobiology.* UK, Oxfordshire:Taylor & Francis Ltd.

Suggested Readings

1. Kieran, M. & Fergus,R. (2013). *Interventional neuroradiology*. London: Springer-Verlag London Ltd.
2. Abass, A., Ghassan,E., Marnix, G.E. &Stephen, S. (2019). *Evolving role of pet in interventional radiology based procedures: an issue of pet clinics*. Edinburgh: Elsevier - Health Sciences Division.

BOTN-7118 Plant Developmental Processes 3(2+1)

Plant developmental processes of flowering plants or angiosperms comprise the twin processes of growth and differentiation in vascular plants in general, focused on the clearly ordered process of growth whereby the structural and functional organization of the plant body, beginning with the single-celled fertilized egg or the zygote, became progressively established. This led to the thesis that the fundamental phenomena embodied in plant development are the production of specialized cells and their organization into tissues and organs of the adult plant. In this scenario, the study of meristems, most importantly of the shoot apical and root apical meristems-first organized during embryogenesis -became a matter of great importance. At the same time development of plants appeared to center on the coordination of the dynamic activities of the root, stem, leaves, and flowers and that some fine-tuning of their growth and development occurs as a result of the prevailing environmental conditions.

Contents

1. Introduction to plant development, central dogma of genetic analyses, general strategies of genetic analyses.
2. Plant cell division and its regulation, cell expansion, embryogenesis, genetic analysis of embryogenesis, regulation of embryogenesis.
3. Plant meristem, types, cell fate determination.
4. Root development: Models of root growth, genetic analysis of root development.
5. Stem development: Genetic analyses of stem development, regulation of stem development.
6. Leaf development, role of cytoskeleton in leaf development, role of genetics in leaf development
7. Vascular development and secondary growth.
8. Vegetative to reproductive transition; Floral morphogenesis fertilization: Pollen pistil interaction, role of cytoskeleton in pollen tube growth.
9. Development of seed, development of fruit and its ripening, seed germination and development of seedling, central role of hormones in plant development.
10. Light perception and developmental responses to light. Epigenetic regulation of developmental responses.

Lab work

1. Study of organization of shoot and root growth, different primary and secondary tissues from the living and preserved material in macerates and sections, hairs, glands, and other secondary structures.
2. Study of embryological stages.
3. Peel and ground sectioning and maceration of fossils material.

Recommended Texts

1. Geitmann, A. (2019). *Plant biomechanics from structure to function at multiple scales*. Switzerland, Basel: Springer Nature.
2. Minelli, A. (2018).*Plant evolutionary developmental biology*. Cambridge, UK: Cambridge University Press.

Suggested Readings

1. Hejatko, J. & Hakoshima, T. (2018). *Plant structural biology: hormonal regulations*. Basel, Switzerland: Springer International Publishing AG.
2. Bhatla, S.C. &Lal, M.A. (2018). *Plant physiology, development and metabolism*. Singapore: Springer.

BOTN-7119 Biohazards and Biosafety 3(2+1)

Biological agents pose a significant challenge to public health across the world. The emergence of pathogens which have developed resistance to antibiotics and their potential use in bioterrorism has prompted governments to manage the threats posed by these agents by adopting stringent bio risk management practices. This course has been designed and developed to introduce students to diverse biological agents, their classification into risk groups and the practices and procedures recommended by global organizations such as the World Health Organization (WHO). This course will discuss each of these aspects of bio risk management, through this course students will learn about bio risk management, basic knowledge of life sciences will benefit more from the course. However, the specific target of the course are bio-safety in labs, hospitals, public and public organizations with large number of staff, and sanitation officials in the municipal/ local governments.

Contents

1. Detailed concept of Biohazards. Types and different levels of biohazards. Application to use biohazardous materials, Classification of pathogens by risk group. Biohazard events related to the World and Pakistan, their causes and effects. Impact of biohazards on the economy of a country. Enlist Biohazards responsible for Disasters in the World.
2. Designating labs based on biosafety and containment parameters. Biohazards associated with animal handling, Laboratory safety protocols, Safe handling of laboratory equipment, Reporting of accidents, Waste disposal, Laboratory Biosafety level criteria, Laboratory Biosafety level 1-4, Essential Biosafety measures for TB laboratories, Safety equipment, Personal protective equipment and clothing, Plans for emergency preparedness and response, Introduction to the transport of infectious materials, Biosafety and recombinant DNA technology.
3. Design Biosafety plan, Objectives of Laboratory biosafety, Laboratory Biosafety and risk of Bioterrorism, Laboratory Biosafety and International obligations, Pakistan Biosafety legislations and guidance.
4. Risk assessment, Overview of Biosafety risk assessment methodology, Evaluate the pathogens and toxins, Evaluate the potential Adversaries, Characterize the risk, Risk reduction.
5. Risk management; Preventions, surveillance, monitoring committee.
6. Judicial Right/ Penalties, Policies and Practices. Concepts of biosafe environment: Terrestrial, marine, atmosphere.

Lab work

1. Visit to relevant labs, observation and preparation of inventory of report on biosafety measures.
2. Visit to hospitals and other relevant units and preparation of report on biosafety measures

Recommended Texts

1. Karen, B. (2016). *Biosafety in microbiological and biomedical laboratory*. USA, Massachusetts: U.S. Department of human health.
2. Lytton, T.D. (2019). *Outbreak: foodborne illness and the struggle for food safety*. Chicago: University of Chicago.

Suggested Readings

1. Wooley, D.P. & Byers, K.B. (2017).*Biological safety: principles and practices*. Ohio, USA: ASM Press.
2. Rita, Y.M. (2015).*Construction safety and waste management*: *an economic analysis*. Basel, Switzerland: Springer International Publishing AG.

BOTN-7120 Food Industrial Waste Management 3(2+1)

Food service sector is one of the most significant areas of food waste, the simplest and the most preferable practice is prevention of waste at the source, for example better food management at restaurants and cafeterias will consequently reduce the amount of food wastes in this sector. Despite the fact that landfilling is the least preferable waste management option, yet food waste generated from leftovers, perished produce and spoiled food is the number one material taking up landfill space. Food waste is much more costly that is obviously seen, and its impact is much more serious. When food is wasted all of the natural resources that were expended in the supply chain are also lost, including the use of land, water and energy. Except for economic impact, the impact that food waste have on environment and society is bitterer. This course will enable the students to know about food industrial wastes, its types, source and characteristics, waste disposal, physical, chemical and biological treatments, bio processing of waste food for sustainable environmental management.

Contents

1. Food industrial wastes, types, source and characteristics of industrial wastes, waste disposal. Physical, chemical and biological treatments, BOD, COD.
2. Bio processing in food waste treatment, management of waste by products: Sugars, fruits, vegetables, meat, fish oil, and fat.
3. Diary and cereals recovery of the useful materials from effluents by different systems.
4. Utilization of food industry wastes, food waste management innovations in the foodservice industry, adsorption of organic pollutants from dairy wastewater on soil
5. Pollution problem and control, recovery and utilization of effluents from meat processing industries.

Lab work

1. Visit to food industrial units
2. Visit to waste recycling plants

Recommended Texts

1. Elina, N., Nina,M., Malla, M.& Anna,H. (2019). *Food waste management: solving the wicked problem*. Basel, Switzerland: Springer Nature Switzerland AG.
2. 2. Kalamdhad, A.S. & Dhamodharan, K. (2018). *Advances in waste management: select proceedings of recycle*. Singapore: Springer Verlag. .

Suggested Readings

1. Ramesha, C.&Das, D.B. (2016). *Solid waste management: principles and practice*. Berlin: Springer-Verlag Berlin and Heidelberg GmbH & Co. KG.
2. Rita, Y.M. (2015).*Construction safety and waste management*: *an economic analysis*. Basel, Switzerland: Springer International Publishing AG.

PhD
BOTANY

BOTN-8101 Methods in Plant Cell Tissue and Organ Culture 3(2+1)

Plant tissue culture broadly refers to the an in vitro cultivation of plants, seeds and various parts of the plants (organs, embryos, tissues, single cells, protoplasts).With the advances made in the tissue culture technology, it is now possible to regenerate species of any plant in the laboratory. In this process the growth medium or culture solution is very important as, it is used for growing plant tissue because it contains various plant nutrients in the form of 'jelly' known as agar and plant hormones which are necessary for the growth of plant. Plant tissue culture is used widely in the plant sciences, forestry, and in horticulture. Students will know about various tissue culture methods / techniques for somatic embryogenesis, cell suspension culture, another culture and artificial / synthetic seeds. This course elaborates the role of tissue culture methods in somatic hybrids, somaclonal variation and cryopreservation for crop improvement.

Contents

1. Different methods of aseptic techniques and their requirements, media composition, effect of chemical and physical factors, different types of media used in plant tissueculture.
2. Explant; Types of explant, meristem culture, stages of micropropagation.
3. Types of callus, factors effecting regeneration, Direct and indirect somatic embryogenesis.
4. Protoplast isolation, t fusion, methods of protoplast fusion, somatic hybridization, methods of selection of somatic hybrids, cybrids, major application of cybrids.
5. Cell suspension culture. Production of different phytochemicals by suspension culture. Bioreactors, mass production by bioreactors, types of bioreactors
6. Principle of anther culture (microspore or pollen culture), Ovary culture or gynogenesis
7. Artificial/Synthetic seed, methods for synthetic seed production
8. Mechanism causing somaclonal variation
9. Methods of *in vitro* conservation at different temperatures

Lab work

Study of apparatus in plant tissue culture laboratory, a septic techniques used inlaboratory preparation of stock solutions MS. (Murashiage & Skoog). Preparation of stock solutions of growth regulators for medium M S, preparation of 1LMS medium. Study of micropropagation. Study of callus induction in plants.

Recommended Texts

1. Rapley, R. &Whitehouse, D. (2015).*Molecular biology and biotechnology*. UK, London: Royal Society of Chemistry.
2. Pullaiah, T., Rao, M.V.S. &Sreedevi, E. (2016). *Plant tissue culture: theory and lab work* (2nd ed.). Jodhpur, India. Scientific Publishers.

Suggested Readings

1. De-Smet, I. (2016). *Plant organogenesis: methods and protocol*. Totowa, New Jersey: Humana Press

2. Loyola-Vargas, V.M. &Neftalí, O. (2016). *Somatic embryogenesis: fundamental aspects and applications*. Basel, Switzerland: Springer International Publishing.

BOTN-8102 Ecological Genetics 3(2+1)

Ecology is the study of the relationships between organisms and their environments, whereas ecological genetics focuses more specifically on the genetics of ecologically important traits, i.e., traits that influence ecological relationships. At its inception, ecological genetics focused particularly on traits that influence fitness, such as those that affect survival and reproduction. This focus is maintained in its current form, although ecological genetics now also investigates the ecological and evolutionary processes that influence patterns of genetic variation in natural populations. Therefore, it can also be considered a study of genetic processes associated with microevolutionary change, so ecological genetics is the study of genetics in natural field population. It focuses on traits involved in interactions between and within species, and between an organism and its environment, particularly those that determine fitness. This course explicates the importance of genetic variation within and among the population, gives an insight into gene flow and mating system and influence of biological and environmental factors on gene flow.

Contents

1. Ecological genetics: What is ecological genetics? Genetics review.
2. Population Genetics: Measuring genetic variation, within population and among populations, patterns of mating.
3. Genetic diversity and differentiation: Definitions, factors influencing diversity and differentiation, statistical approaches, use of genetic diversity statistics.
4. Gene flow and mating system: Introduction; Factors governing gene flow, considerations for measuring gene flow, measuring gene flow-indirect estimates, measuring gene flow-direct estimates. The importance of biological and environmental factors on gene flow.
5. Phylogeny and phytogeography: Introduction; Homolog,gene trees and species trees, tree form and building, tree interpretation.
6. Natural Selection and Local adaptation: Definition and differences

Lab work

1. Extraction of DNA from plant material.
2. Separation of DNA by gel electrophoreses.
3. Gene amplification through PCR

Recommended Texts

1. Hartl, L.D. &Cochrane, B. (2017). *Genetics: analysis of genes and genomes* (9th ed.). Burlington, Massachusetts: Jones and Bartlett Learning.
2. Peter, D., & Turnpenny, S.E. (2016). *Emery's elements of medical genetics* (15thed.). Amsterdam Netherlands: Elsevier.

Suggested Readings

1. Klug, W.S., Cummings, M.R., Spencer, C.A. &Palladino, M.A. (2018). *Concepts of genetics* (12th ed.). London: Pearson.
2. Lewis, R. (2017). *Human genetics* (12th ed.). New York: McGraw Hill Higher Education.

BOTN-8103 Forensic Botany 3(2+1)

A forensic botanist looks to plant life in order to gain information regarding possible crimes. Leaves, seeds and pollen found either on a body or at the scene of a crime can offer valuable information regarding the timescales of a crime and also if the body has been moved between two or more different locations. The forensic palynology can often produce specific findings of location of death, decomposition and time of year. The knowledge of systematics leads to identification of evidences at crime scene. The morphological and anatomical study revels in collection of samples from crime scene and it's in vitro analysis. It leads to proper submission of evidences in court of law. The aim of this course is to provide students with an overview of a variety of topics within the area of forensic sciences including crime scene investigation, forensic photography, digital forensics, fingerprinting, court and police organizational structures and forensic DNA analysis.

Contents

1. Introduction to forensic botany: Legal plant definition; Botanical evidence in legal investigations, Alibis, timing, gravesite growth, stomach contents.
2. Types of plant, non-plant groups traditionally studied by botanists, basic plant characteristics for the forensic investigator, habit and plant dispersal.
3. Initial crime scene notation, step-wise method for the collection of botanical evidence
4. Habitat documentation
5. The common law
6. Types of samples and collection for DNA analyses, uses of genetic data, genotyping methods, finding a laboratory for analysis.
7. Microscopes and microscopic botanical structures relevant to forensic botany. The importance of reference collections in microscopic analysis.
8. Dendrochronology, The Lindbergh case. Further reading.
9. Palynology: Fossil and modern pollen grains, spores, etc.
10. Finding an algal botanist and identifying algae. Application of algal evidence in forensic investigations, collection and processing of algal evidence in forensic investigations

Lab work

Types of samples and collection for DNA analyses, Uses of genetic data, Genotyping methods, Finding a laboratory for analysis, Case studies, Visits of forensic labs.

Recommended Texts

1. Miller, M.T. &Massey, P. (2018). *The crime scene*: *a visual guide*. Amsterdam: Elsevier Science.
2. Triv, S., Rehman, H., Saggu, S., Panneerselvam, C. & Ghosh, S.K. (2018). *DNA barcoding and molecular phylogeny*. Switzerland, Basel: Springer.

Suggested Readings

1. Primorac, D. &Schanfield, M. (2015). *Forensic DNA applications: an interdisciplinary perspective*. Boca Raton, Florida: CRC Press.
2. Clifton, J. (2018). *Forensic science*. Connecticut, USA: Larsen and Keller Education.

BOTN-8104 Molecular Basis of Morphogenesis 3(2+1)

Morphogenesis in living organisms relies on the integration of both biochemical and mechanical signals. During the last decade, attention has been mainly focused on the role of biochemical signals in patterning and morphogenesis, leaving the contribution of mechanics largely unexplored. Fortunately, the development of new tools and approaches has made it possible to re-examine these processes. In plants, shape is defined by two local variables: growth rate and growth direction. At the level of the cell, these variables depend on both the cell wall and turgor pressure. Multidisciplinary approaches have been used to understand how these cellular processes are integrated in the growing tissues. In this review, we will discuss these issues focusing on the shoot apical meristem, a population of stem cells that is responsible for the initiation of the aerial organs of the plant. This course will help students to understand the molecular lines to plant development and evolution of plant architecture, *Arabidopsis thaliana* as model plant will help in developing conceptual understanding about the molecular basis of morphogenesis of plant organs among students.

Contents

1. Molecular lines to plant development, positional information and cell lineage
2. Seedling development, shoot development and leaf development
3. Embryogenesis and flower development.
4. Transition to flowering, development of floral reproductive organs and gametophytes,
5. Pollination and apomixes, seed and fruit development,
6. Root development, vascular development.
7. Arabidopsis thaliana as model plant to study molecular basis of morphogenesis

Lab work

1. Comparative study of molecular based morphogenesis in dicot and monocot root, leaves, stem and embryo.
2. Molecular based morphogenetic study of reproductive organs and gametophytes of plants.

Recommended Texts

1. Mokwala, P.W. &Mangena, P. (2018). *Pollination in plants*. Norderstedt Germany: BoD-Books on Demand.
2. Buchana, B.B., Gruissem, W. & Russel, L.J. (2015). *Biochemistry and molecular biology of plant*. Hoboken, New Jersey: John Wiley & Sons.

Suggested Readings

1. Sinnott, E.W. (2018). *Plant morphogenesis*. New Zealand, Aukland: Franklin Classics Trade Press.
2. De-Smet, I. (2016). *Plant organogenesis: Methods and Protocols*. Totowa, New Jersey: Humana Press.

BOTN-8105 Environmental Biotechnology 3(2+1)

Environmental biotechnology is a system of scientific and engineering knowledge related to the use of microorganisms and their products in the prevention of environmental pollution through biotreatment of solid, liquid, and gaseous wastes, bioremediation of polluted environments, and biomonitoring of environment. Environmental biotechnology is a coordination of scientific and engineering acquaintance associated with the use of plants, algae and microorganisms like bacteria in the prevention of environmental pollution through biotreatment of wastes and biomonitoring of environment and treatment processes. Environmental biotechnology is the multidisciplinary combination of sciences and engineering in order to employ the enormous biochemical efficacy of microorganisms and plants, for the restoration and perpetuation of the environment and for the sustainable utilization of resources. The most significant considerations for purpose of biotechnology in waste treatment are technically and economically sound for biodegradability or detoxification of substances during biotechnological treatment, huge amount of treated wastes, and capability of natural microorganisms to degrade substances.

Contents

1. Introduction: Concepts, historical background, conventional and environmental biotechnology: Environmental biotechnology: Bioremediation; Biological control. Aquatic biotechnology: Aqua culture, and sea food resources; Bioprocessing. Economic perspectives of environmental biotechnology. Future challenges in environmental biotechnology.
2. Bioremediation for Air Environment: Atmospheric environment for microorganisms, microbial degradation of contaminants in gas phase, biological filtration processes for decontamination of air stream. Biofiltration; Biotrickling and filtration; Bioscrubbers.
3. Bio-treatment of Metals, Microbial Transformation of Metals: Biological treatment technologies for metals remediation; Bioleaching, biobenificiation, bioaccumulation, oxidation / reduction processes, biological methylation
4. Environmental Biotechnologies: Phytoremediation, sequestering carbon dioxide biomonitoring. Application of microbial enzymes. Biomembrane reactors.

Lab work

Isolation of bacteria from oil wastes, polluted water from industries and sewage. Spray plate technique for testing the degradation ability of bacteria for different aromatic hydrocarbons. Bioremediation from culture by metal resistant, bacteria. Bio degradation, toxic chemicals especially aromatics (pesticides & crude oil components). Bio accumulation/Bio absorption of heavy metals by bacteria, fungi, protozoa, and plants.Solubilization of insoluble metal complexes.Production of bio polymers.

Recommended Texts

1. Vallero, D. (2015). *Environmental biotechnology*: *a biosystems approach*. Massachusetts: Academic Press.
2. Sangeetha, J., Thangadurai, D., David, M. &Abdullah, M.A. (2016). *Environmental Biotechnology: Biodegradation, Bioremediation, and Bioconversion of Xenobiotics for Sustainable Development.* Massachusetts: Apple Academic Press.

Suggested Readings

1. Singh, H.R.L. (2015). *Principles and applications of environmental biotechnology for a Sustainable Future.* Singapore: Springer Verlag.
2. Sirinivas, T. (2019). *Environmental biotechnology*. New Delhi: New Age International Publishers.

BOTN-8106 Advanced Cell and Molecular Biology 3(2+1)

Molecular biology is the branch of biology that concerns the molecular basis of biological activity in and between cells, including molecular synthesis, modification, mechanisms and interactions.This course provides an insight into cell and molecular biology with focus on the molecules of the cell. The cell is the building block of all living things. The important molecules in the cell are the DNA, RNA, proteins, and mitochondria. DNA is made of small molecules called nucleotides and contains genes which are sequences of nucleotides. These sequences in genes are used to form RNA in the transcription process, and RNA in turn is used to produce amino acid sequences to form proteins in the translation process. This course reviews the molecular biology methods. Students will know about advanced techniques of DNA fingerprinting, genotyping, sequencing ISH, FISH, Chip sequencing, NGS, CRISPR and Flow cytometry. This course comprehensively covers recombinant DNA technology, GMOs, molecular cloning, genomics, analysis of genome and gene expression.

Contents

1. DNA extraction and quantification, cDNA synthesis and library, expressed sequence tag, quantitative real time PCR, DNA fingerprinting, genotyping, ISH, FISH, microarray, laser capture microdissection, immune -histochemistry, immune-precipitation, 2D gel, Chip on Chip, Chip sequencing, NGS, CRISPR, Flow cytometry; Somatic cell and radiation hybrids; Artificial chromosomes in bacteria and yeast. High resolution melting analysis.
2. Telomere maintenance. DNA repair and recombination.
3. Recombinant DNA technology, molecular cloning and some tools for analyzing gene expression.
4. Transcription in prokaryotes; Transcription in eukaryotes. Epigenetics and monoallelic gene expression. RNA processing and post-transcriptional gene regulation.
5. Mechanisms of translation, Genetically modified organisms: Use in basic and applied research. Genome analysis: DNA typing genome analysis, Genomics and beyond.

Lab work

1. Counting of prokaryotic cells (bacteria) and blood cells by using hemocytometer
2. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights), Separation of different sized DNA fragments of agarose gel
3. Study of transformed bacteria on the basis of antibiotic resistant
4. Microchemical detection of following in the structure of the plant cell: Proteins, carbohydrates, cellulose, cutin and pectin, RNA isolation and quantification
5. DNA synthesis by Reverse transcriptase, Real time PCR, DNA finger printing techniques

Recommended Texts

1. Chandar, N. &Viselli, S. (2018). *Lippincott illustrated reviews: cell and molecular biology*. Pheladelphia: Lippincott Williams & Wilkins.
2. Cox, M.M. &Donnell, M. (2015). *Molecular biology: principles and practice*. New York: W.H. Freeman Publisher.

Suggested Readings

1. Mauseth, J.D. (2016). *Botany: An introduction to plant biology (*6th ed.). Burlington, Massachusetts: Jones and Bartlett Learning.
2. Helms, I. (2019). *Principles of computational cell biology*: *from protein complexes to cellular networks* (2nd ed.). Hoboken, New Jersey: Wiley-Blackwell.

BOTN-8107 Conservation and Management of Plant Resources 3(2+1)

Conservation and management of plant resources is important for achieving sustainable development through harmonization of human being with nature. It involves dealing with diverse biophysical, socioeconomic, cultural, political and legal issues to resolve conservation problems and natural resource use conflicts. The objective of the course is to provide students with a sound knowledge of conservation biology, methods for biodiversity assessment, an overview of current approaches to plant resources biodiversity conservation. Research related to natural resources management involves a variety of techniques and methods, as it cut across different sciences, namely biophysical, spatial, socioeconomic and political. The objective of this course is to let students understand and learn to design and execute a research project in various afore-mentioned aspects of natural resources. This course provides updated knowledge on plants conservation, existing plant diversity in Pakistan, phytogeographical zones of Pakistan, biodiversity action plan of Pakistan and explores various conservation strategies/techniques.

Contents

1. Introduction to conservation and management, existing plant diversity in Pakistan. Phytogeographical zones of Pakistan. Biodiversity action plane of Pakistan
2. Introduction; Identification of ecosystems to be conserved, relationships with the local population, protection legislation, monitoring, maintaining the ecosystem: A Management Plan
3. Introduction: consequences of habitat fragmentation: Genetic hazards, small isolated populations face, conclusion: Developing informative habitat, fragmentation research
4. Introduction: Historical context, seed and ultra-dry seed storage, botanic garden conservation, DNA storage, field gene banks, *in vitro* techniques, pollen storage, germplasm collection and management, core collections, complementary conservation
5. Introduction; Conservation and multiplication of plant genetic resources in the country of origin, Database evaluation for heterogeneous plant genetic resources.
6. Critical factors in using Botanic Gardens for conservation science
7. Wildlife management plans. Major issues with the current management of the protected areas

Lab work

Fields visits: visit to national park herbarium and gene bank (IABGR). Role of NGOs in conservation. Preparation of inventory of flora of assign region.

Recommended Texts

1. Ahuja, M.R. & Jain, S.M. (2017). *Biodiversity and conservation of woody plants*. Switzerland, Basel: Springer International Publishing.
2. Peshin, R. & Dhawan, A.K. (2018). *Natural resource management: ecological perspectives*. Basel, Switzerland: Springer nature Switzerland AG

Suggested Readings

1. Abid, A.A., Gill, S.S., Abbas, Z.K. & Naeem, M. (2016). *Plant biodiversity: monitoring, assessment and conservation.* Germany, Edinburg: Gutenberg Press Limited.
2. Blackmore, S. &Oldfield, S. (2017). *Plant conservation science and practice: the role of botanic gardens*. Cambridge, U K: Cambridge University Press.

BOTN-8108 Bioinformatics 3(2+1)

The past 15-20 years have been exciting in plant biology. Hundreds of plant genomes have been sequenced, RNA-seq has enabled transcriptome-wide expression profiling, and a proliferation of "-seq"-based methods has permitted protein-protein and protein-DNA interactions to be determined cheaply and in a high-throughput manner. These data sets in turn allow us to generate hypotheses at the click of a mouse. For instance, knowing where and when a gene is expressed can help us narrow down the phenotypic search space when we don't see a phenotype in a gene mutant under "normal" growth conditions. Using Gene Ontology enrichment analysis and pathway visualization tools can help us make sense of our own 'omics experiments and answer the question "what processes/pathways are being perturbed in our mutant of interest. This course introduces students to data mining, computer hardware and software, computer applications for biotechnologists, genomics and proteomics, sequence software and bioinformatics tools, also explicit the applications of bioinformatics in genome comparison and database hierarchies.

Contents

1. Introduction to bioinformatics, its definition, and history. Introduction to data mining and its application, introduction to computer hardware and software, computer applications for biotechnologists. Graphical and statistical analysis packages.
2. Biocomputing (Introduction to String Matching Algorithms; Database Search techniques, Sequence Comparison and Alignment Techniques).
3. Use of Biochemical Scoring Matrics: Introduction to Graph Matching Algorithms; Genome comparison; Prediction and its implication; Database hierarchies.
4. Genomic and Proteomic Sequence: Database and their interpretation (UCSC, Genome Database, NCBIPDB, EcoCyc. DDBJ, SWISS-PRO, TIGR, KEGG etc).
5. Bioinformatics Tools: Prepeat masker, PHRED, PHRAP, BLAST, Prosite/Blocks/PEAM; CLUSTALW, Emotif, RasMol-Oligo, Primer3, Molscript. Tree view, Alscript, Genetic Analysis Software; Phylip.etc

Lab work

1. Training of students in Biocomputing such as String Matching Algorithms; Database Search techniques, Sequence Comparison and Alignment Techniques etc
2. Training of students in Bioinformatics Tools such as, BLAST, Prosite/Blocks/PEAM; CLUSTALW, Emotif, RasMol-Oligo, Primer3, Molscript. Tree view, Alscript, Genetic Analysis Software; Phylip. etc

Recommended Texts

1. Helms, V. (2019). *Principles of computational cell biology: from protein complexes to cellular networks*. Hoboken, New Jersey: Wiley-Blackwell.
2. Rajora, O.P. (2019). *Population genomics: concepts, approaches and applications*. Switzerland, Basel: Springer.

Suggested Readings

1. Coghlan, A. (2017). *A little book of R for informatics*. Cambridge: Welcome Trust Sanger Institute.
2. Zhanjiang, L. (2017). *Bioinformatics in aquaculture**:** principles and methods*. Hoboken, New Jersey: Wiley and Sons.

BOTN-8109 Fermentation Technology 3(2+1)

Fermentation-based processes have been of great interest for humans. The aims of using fermentation-based processes have been evolving along time, due to cultural and social issues or due to technology and engineering facilities. Fermentation is the process involving the biochemical activity of organisms, during their growth, development, reproduction, even senescence and death. Fermentation technology is the use of organisms to produce food, pharmaceuticals and alcoholic beverages on a large scale industrial basis. The basic principle involved in the industrial fermentation technology is that organisms are grown under suitable conditions, by providing raw materials meeting all the necessary requirements such as carbon, nitrogen, salts, trace elements and vitamins. This course explains role of microbes in industry for commercial production of organic acids, amino acids, ethanol, vitamins, antibiotics and enzymes and also provides updated knowledge of use of microorganisms in industrial wastes reduction and environmental technology.

Contents

1. History and prospects of Fermentation Technology. Microorganisms - possibilities and limitation of the metabolites production,
2. Principals of fermentation processes, fermentation techniques and facilities
3. Production microorganisms -primary and secondary metabolisms and overproduction, methods of selection, Raw material of industrial biotechnology
4. Microbial biomass preparation,
5. Industrial enzymes production - methods of preparation, isolation and stabilization
6. Ethanol production-alcohols biosynthesis, production microorganisms and fermentation procedures, production of biogas, Malting and beverage production
7. Enology- basics processes, wine technology, microorganisms in wine production
8. Production of secondary metabolites and natural substances
9. Biotechnological production of organic acids and amino acids
10. Preparation of organic solvents, polyols and biopolymers
11. Pharmaceutical biotechnology - antibiotic, vitamins.
12. Application of microorganisms in industrial wastes reduction and environmental technology

Lab work

1. Citric acid fermentation by molasses by *Aspergillus niger*
2. Production of alpha amylase by *Bacillus* spp, Production of proteases by bacteria and fungi.
3. Enzyme purification by filtration and chromatography
4. Study visits to the industry and student have to submit the report of their visit

Recommended Texts

1. Stanbury, P., Whitaker, A. & Hall, S. (2016). *Principles of fermentation technology* (3rd ed.) Oxford: Butterworth-Heinemann,
2. Rapley, R. & Whitehouse, D. (2015). *Molecular biology and biotechnology*. London: Royal Society of Chemistry.

Suggested Readings

1. Galanakis, C.M. (2015). *Food waste recovery: processing technologies and industrial techniques.* Massachusetts: Academic Press.
2. Sharma, H. &Singh, P.K. (2018). *Laboratory manual for bioinstrumentation, biochemistry, microbiology, cell biology and enzyme technology*. New Delhi: Excellent Publishing House.

BOTN-8110 Environmental and Nutritional Physiology 3(2+1)

Two classes of nutrients are considered essential for plants. Mineral nutrients are usually obtained from the soil through plant roots, but many factors can affect the efficiency of nutrient acquisition. Many of the classic deficiency symptoms such as tip burn, chlorosis and necrosis are characteristically associated with more than one mineral deficiency and also with other stresses. Plants do not grow in isolation, they are part of the overall environment and as such they respond to environmental changes as that affect nutrient availability. Also, plants do influence their environment and can contribute to environmental changes, which in turn can affect the nutrient status of the plant. This course aims to give comprehensive and advance knowledge of mechanism of water uptake, role of essential nutrients in plant metabolism and effects of deficiency and toxicities of nutrients on physiological process. This course also provides an insight into plant responses to environmental stress and long term effects of fertilization and diffuse deposition of heavy metals on soil and crop quality.

Contents

1. Plant and environment, uptake assimilation and distribution of macronutrients, mechanism and concept. Micronutrients and toxic elements in plant and crop nutrition. Effect of CO_2 and pollutants on physiology of crop growth and development. Physiological strategies for increasing crop productivity in relation to greenhouse effect.
2. Plant responses to acidity, salinity and other stress factors in the root environment. Fertilizer application in relation to yield formation, quality characteristics and environment. Essential elements and their physiological roles.
3. Deficiency and toxicities of nutrients on physiological functional process. The influence of toxics on plants, fungicides, insecticides, chemical fertilizers on plants and their transport in plants.
4. Environmental Impacts of nutrient recycling and adaptation strategies. Sand and water culture method used in study of plant nutrition.
5. Responses of plants to environmental stress (chilling, freezing, and high temperature stress). Long term effects of fertilization and diffuse deposition of heavy metals on soil and crop quality.

Lab work

3. Experiments of plant growth under different nutrient supplies.
4. Experiments of plant growth with application of different fertilizers in soil and hydroponic conditions/culture

Recommended Texts

1. Barker, A.V. &Pilbeam, D.J. (2015). *Handbook of plant nutrition (*2nd ed.) Florida: CRC Press.
2. Willey, N. (2016). *Environmental plant physiology* (1st ed.). New York: Garland Science.

Suggested Readings

1. Kumar, V., Wani, S.H., Penna, S. &Tran, L. (2018). *Salinity responses and tolerance in plants, targeting sensory, transport and signaling mechanisms*. Switzerland, Basel: Springer.
2. Taiz, L., Zeiger, E., Moller, I.M. & Murphy, A. (2018). *Fundamentals of plant physiology*. Oxford: Oxford University Press.

BOTN-8111 Advanced Conservation Ecology 3(2+1)

Humankind harnesses a multitude of natural resources for the provision of food, materials, energy and recreation. Many of these resources have become overexploited or under severe pressure in both wild and managed landscapes. Biodiversity and its conservation need to be considered at a range of levels; habitat, species and genetic. There is also a need to consider how these interact with each other. The course will include consideration of, for example, the evolutionary roles of key species within natural ecosystems and introduce the concepts of ecosystem functions, ecosystem services, biogeography, population dynamics and adaptation to climatic change. On completion of this course students will be able to develop practical skills for conservation and ecological consultancy and discuss critically the concept and components of an ecosystems approach, they will get awareness about environmental problems and their solution for sustainable environmental management, role of natural resources (renewable and non-renewable) in conservation of biodiversity for survival and proper functioning of ecosystem.

Contents

1. Introduction to conservation ecology, history. Importance of edaphic factors in conservation. Importance of topographic factors, biotic factors and abiotic factors
2. Ecosystem: Physical conditions and availability of resources. Applied issues in conservation: Effects of pollution on species conservation and biodiversity.
3. Role of natural resources in conservation ecology.
4. Types of natural resources (renewable and non-renewable), wildlife management, species preservation, conservation of habitat
5. Introduction of exotic species, natural parks, forests resources, soil and water resources, food and agriculture resources.
6. Threats to biodiversity. Status of biodiversity in world and Pakistan
7. Conservation of renewable and non-renewable resources

Lab work

1. Visits to different disturbed ecosystem
2. Survey of different important species for conservation
3. Visit to different sanctuaries

Recommended Texts

1. Vaughan-Lee, L. (2016). *Spiritual ecology: the cry of the earth*. California: The Golden Sufi Centre.
2. Chapman, J.L. & Reiss, M.J. (2017). *Ecology: Principles and applications*. Cambridge, UK: Cambridge University Press.

Suggested Readings

1. Franklin, J. (2018). *Ecology, biodiversity and conservation: mapping species distributions: spatial inference and prediction*. Cambridge, UK: Cambridge University Press.
2. Keddy, P.A. (2018). *Wetland ecology: principles and conservation* (2nd ed.). Cambridge: Cambridge University Press.

BOTN-8112 **Bioethics** **3(3+1)**

Bioethicists are concerned with the ethical questions that arise in the relationships among life sciences, biotechnology, medicine, politics, law, and philosophy. It also includes the study of the more commonplace questions of values ("the ethics of the ordinary") which arise in primary care and other branches of medicine. Some bioethicists would narrow ethical evaluation only to the morality of medical treatments or technological innovations, and the timing of medical treatment of humans, others would broaden the scope of ethical evaluation to include the morality of all actions that might help or harm organisms capable of feeling fear. The scope of bioethics can expand with biotechnology, including cloning, gene therapy, life extension, human genetic engineering, as troethics and life in space, and manipulation of basic biology through altered DNA, and proteins. This course is designed to disseminate the knowledge of bioethics, biosafety, risk related to GMOs and regulations for biosafety and GMOs. Bioethics course also addresses ethical issues related to GMOs and Euthanasia from moral and Islamic point of view.

Contents

1. Bioethics; Definition and concept.
2. History of Bioethics.
3. Bioethics vs Islam.
4. Introduction to Biosafety (Definition, concepts, uses and abuses of genetic information, biohazards), Good Laboratory Practices.
5. Risk related to GMOs. International rules and regulations for biosafety. Regulations for biosafety and GMOs.
6. Ethical issues regarding GMOs and Euthanasia.
7. Issues related to reproductive and cloning technologies
8. Issues to transplants and Eugenids
9. Patenting, commercialization and benefits sharing, role of National Bioethics Committees.

Lab work

1. Visit to food industrial units and labs to observe and preparation of report on biosafety measures
2. Preparation of reporton use of GMOs

Recommended Texts

1. Marta, S. (2018). *The ethics of reproductive genetics*. Switzerland: Springer.
2. Brigitte, F.L. & Kristina, O. (2018). *The reality of human dignity in law and Bioethics*. Switzerland, Basel: Springer.

Suggested Readings

1. Elaine, E. & Michael, S. (2018). *Ethics across the curriculum pedagogical perspectives.* Switzerland, Basel: Springer.
2. Lysaught, M.T. &McCarthy, M. (2018). *Catholic bioethics and social justice*. Collegeville, Minnesota: Liturgical Press.

BOTN-8113 Semi-Arid Region Ecology 3(2+1)

A semi-arid climate or steppe climate describes climatic regions that receive precipitation below potential evapotranspiration, but not extremely. A more precise definition is given by the Köppen climate classification that treats steppe climates (BSk and BSh) as intermediates between desert climates (BW) and humid climates in ecological characteristics and agricultural potential. Semi-arid climates tend to support short or scrubby vegetation, with semi-arid areas usually are dominated by either grasses or shrubs. Semi-arid regions are characterized by highly variable and unpredictable rainfall. The livelihood of at least one billion people depends on the use of this land. However, understanding patterns and processes of vegetation dynamics in semi-arid plant communities is an inherently difficult task due to several factors such as the mismatch in time scales between observation and vegetation change, the occurrence of complex event-driven dynamics, spatial heterogeneities, and non-equilibrium ecosystem dynamics. Students will acquire knowledge about semi-arid regions and flora adapted to semi-arid environment, causes of aridity, desertification and arid climate distribution in Pakistan and Climate-smart soil management in semi-arid regions.

Contents

1. Introduction: Characteristics and classification of semi-arid regions.
2. Characteristics of flora adapted to semi-arid environment.
3. Causes of aridity, deserts and causes of desertification.
4. Management of semi-arid region ecosystems.
5. Adaptation and problems of plants in semiarid zone.
6. Arid climate and their distribution in Pakistan.
7. Climate-smart soil management in semi-arid regions.
8. Vulnerability of water resources to climate, soil erosion and conservation.

Lab work

1. Seed bank classification and persistence of plant species in arid zone.
2. Plant architectural analysis.
3. Quantitative growth analysis.
4. Screening techniques for low soil water potential.
5. Study of desiccation tolerance of different species
6. Field visits of arid zone.

Recommended Texts

1. Bone, M., Johnson, D., Kelaidis, P., Kintgen, M., Vickerman, L.G. & Gardens, D.B. (2015). *Steppes*: *the plants and ecology of the world's semi-arid regions.* Portland: Timber Press.
2. Peter, A.T. (2019). *Trees: Their natural history*. Cambridge: Cambridge University Press.

Suggested Readings

2. West, P.W. (2015). *Tree and forest measurement*. Basel, Switzerland: Springer International Publishing AG.
3. Michael, J.H. (2014). *Biogeography of Australasia: a molecular analysis*. Cambridge: Cambridge University Press.

BOTN-8114 Biology of Halophytes 3(2+1)

Soil salinity is a major global issue owing to its adverse impact on agricultural productivity and sustainability. Salinity problems occur under all climatic conditions and can result from both natural and human-induced actions. Generally speaking, saline soils occur in arid and semi-arid regions where rainfall is insufficient to meet the water requirements of the crops, and leach mineral salts out of the root-zone. Soil salinity is a serious problem of agriculture in Pakistan. Salt-affected soils alone occur on more than six million hectares and more than 70% of the tube-wells in saline areas are pumping out brackish water. Efficient resource management and crop/livestock improvement for evolving better breeds can help to overcome salinity stress. So the purpose of teaching this course to students is to make them aware about the enhancement of productivity under stressed conditions and increased resistance of plants against salinity stress by application of plant growth promoting microorganisms.

Contents

1. Halophytes; Definition and classification, habitat of halophytes, adaptation and distribution of halophytes.
2. Sources of salinity and formation of saline soils.
3. Distribution and Synecology of halophytes. Water relation and mineral nutrition of halophytes. Regulation of salt content of shoots.
4. Effects of salt stress on growth and metabolism of halophytes.
5. Mechanisms of salt resistance in halophytes.
6. Reproductive physiology of halophytes, salt regulation in halophytes. Halophytes and climate change**.**

Lab work

1. Methods of assessment of salt stress in halophytes and their habitats.
2. Demonstration of morphological, anatomical, physiological, biochemical and molecular adaptations of halophytes under salt stress.
3. Study of halophytes growing in their natural habitats through field trips during the semester.

Recommended Texts

1. Hasanuzzaman, M., Shabala, S. & Fujita, M. (2019). *Halophytes and climate change: adaptive mechanisms and potential uses.* Oxfordshire: CABI Publishers.
2. Marius-Nicusor, G., Lacramioara, I. and Constantin, T. (2014). *Halophytes: an integrative anatomical study*. Switzerland, Basel: Springer.

Suggested Readings

1. Wani, S.H. & Hossain, M.A. (2015). *Managing salt tolerance in plants: molecular and genomic perspectives*. Florida: CRC Press.
2. Kumar, V., Wani, S.H., Suprasanna and, P. &Tran, L.P. (2015). *Salinity responses and tolerance in plants*. Switzerland, Basel: Springer.

BOTN-8115 Bioinstrumentation 3(2+1)

Bioinstrumentation is the use or application of instruments for observation, measurement, or control. It involves the use of or operation with instruments; especially: the use of one or more instruments in carrying out laboratory tests. Instrumentation is the development or use of measuring instruments for observation, monitoring or control, like use of centrifugation, chromatography, electrophoresis and ELISA. Laboratory instrumentation is a collection of laboratory test equipment. Such a collection of equipment might be used to automate testing procedure. It could also include: "The design, construction, and provision of instruments for measurement, control, etc; the state of being equipped with or controlled by such instruments collectively. This course will make students able to understand principle and applications of bioinstrumentation. This will also elucidate the basic principles and use of lab techniques, light microscopes, centrifugation, chromatography, electrophoresis and confocal microscopy.

Contents

1. Introduction: Basic lab techniques. Basic principles of light microscopes: Compound microscope; Phase contrast microscope; Scanning and Transmission electron microscopes.
2. Centrifugation: Principles, components, mechanism and application of clinical, refrigerated and ultracentrifuges. Chromatography: Basic principles; types – Paper, Column, Thin layer. Electrophoresis (SDS –PAGE).Blotting techniques – Southern, Northern and Western Blotting.
3. Protein isolation, protein concentration, protein separation and detection of protein
4. Electrophoresis protein separation and detection.
5. ELISA and RNA based technologies. RNA isolation and electrophoresis.
6. Overview of RNA-derived technologies and RNA based technologies. Introduction to RT-PCR confocal microscopy.
7. Introduction to confocal microscopy i. Plasmids and nucleic acids, ii. Gene cloning RT-PCR quantitative real-time pcr (qrt-PCR), analysis of qrt-PCR. Introductory bioinformatics
8. Gene bank data mining and sequence comparison.
9. Principle and application of colorimetry and spectrophotometer. Basic principles of pH meter and its operation, types of electrodes, measurement of pH.

Lab work

1. Bio-Rad assay. Determination of protein concentration, general lab safety (brush up),
2. Non-negotiable safety rules, quantitative transfer of liquids, measuring volumes, autoclaving, making solutions. Staining tissues (Giemsa staining enzymatic staining).Cells centrifugation, osmoticlysis and protein extraction.
3. Gel electrophoresis, Coomassieblue staining. Gel drying, western blotting.
4. RNA isolation and electrophoresis cleaning of RNA and reverse transcription.
5. Plasmid isolation and quantification. Restriction endonuclease digestion of plasmid DNA.
6. Agarose gel electrophoresis, gel extraction and quantification.
7. Determination of mRNA level in the cell lines using QRT-PCR

Recommended Texts

1. Agca, H.S. &Cotone. G. (2018). *Introduction to process plant projects* (1st ed.). CRC Press.
2. Swargiary, A. (2017). *Biological tools and techniques edition.* New Delhi: Kalyani Publishers

Suggested Readings

1. Altintas, Z. (2017). *Biosensors and nanotechnology: applications in health care diagnostics.* John Wiley & Sons.
2. Veerakumari, L. (2015). *Bioinstrumentation.* New Delhi: MJP Publishers.