COURSE OUTLINE BRIEFS

DEPARTMENT OF ZOOLOGY

SARGODHA UNIVERSITY
Pathway to Progress

FACULTY OF SCIENCES

OVERVIEW

Zoology tries to understand and preserve the vast diversity existing on our planet. It is a major part of our scientific knowledge opening gateways to the medical science. Zoology is a science that has taken us back to our ancestors through break through studies on DNA (the molecule of life). It is a multidisciplinary field equipping its degree holders in environmental science, forensics, conservation and population genetics, microbiology, immunology toxicology, biochemistry, cell and molecular biology, wildlife, animal behavior, fisheries palaentology, physiology and zoogeography.

The Department of Zoology was established initially as part of biological sciences and later on gained independent status in 2014. The department has highly professional and qualified faculty having expertise in multiple disciplines of Zoology. Various projects of inter-disciplinary nature have been bagged by the faculty under ORIC (UOS) research initiative.

Degree programs like BS, MSc, MPhil and PhD are successfully running at the department under capable research supervisors. Department of Zoology has richly contributed in success of University as our graduate are working both in public and private sectors and playing effective role in various fields.

Academic Programs Offered

1. BS Zoology (Semester/term system)
2. MSc Zoology (Semester/term system)
3. MPhil Zoology
4. PhD Zoology

BS Zoology

Eligibility: At least 45% marks in F.Sc with Biology (at least 33% marks) or equivalent.
Duration: 04 Year Program (08 Semesters)
Degree Requirements: 136 Credit Hours

Semester-1

Course Code	Course Title	Credit Hours
URCE-5101	Grammar	3(3+0)
URCM-5101	Introduction to Mathematics	3(3+0)
BOTN-5101	Diversity of Plants	4(3+1)
CHEM-5101	Physical Chemistry	4(3+1)
ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3+1)

Semester-2

URCE-5102	Language Comprehension & presentation Skills	3(3+0)
URCI-5105	Islamic Studies	2(2+0)
BOTN-5102	Plant Systematics, Anatomy and Development/Embryology	4(3+1)
CHEM-5102	Inorganic Chemistry	4(3+1)
ZOOL-5102	Animal Diversity-II (Chordates)	4(3+1)

Semester-3

URCE-5103	Academic Writing	3(3+0)
URCI-5109	Introduction to Information & Communication Technologies	3(2+1)
BOTN-5103	Cell Biology, Genetics and Evolution	4(3+1)
CHEM-5103	Organic Chemistry	4(3+1)
ZOOL-5103	Animal Form & Function-1	4(3+1)

Semester-4

URCE-5104	Introduction to English Literature	3(3+0)
ZOOL-5104	Animal Form & Function-1I	4(3+1)
SOCI-5101	General Sociology –I	3(3+0)
ZOOL-5105	Biological Techniques	3(1+2)

PSYC-5101	Psychology/Geography/etc. (Introduction to Psychology Minor)	3(3+0)
URCP-5106	Pakistan Studies	2(2+0)

Semester-5

ZOOL-6106	Research Methodology	2(2+0)
ZOOL-6107	Economic Zoology	3(2+1)
ZOOL-6108	Biochemistry	4(3+1)
ZOOL-6109	Cell and Molecular Biology	4(3+1)
ZOOL-6110	Evolution & Principles of Systematics	4(3+1)

Semester-6

ZOOL-6111	Physiology	4(3+1)
ZOOL-6112	Ecology	3(2+1)
ZOOL-6113	Developmental Biology	4(3+1)
ZOOL-6114	Genetics	4(3+1)
ZOOL-6115	Wildlife	3(2+1)

Semester-7

ZOOL-61XX	*Special Paper A1/ Thesis (Univ. Option)	3(2+1)/(0+3)
ZOOL-6116	Biostatistics	3(2+1)
ZOOL-61XX/ ZOOL-6130	*Special Paper A2/ Univ. Option/ Ichthyology	3(2+1)
ZOOL-61XX / ZOOL-6140	*Univ. Option/ Principles & Kinetics Of Toxicology	3(2+1)
ZOOL-6117	Bioinformatics	3(1+2)

Semester-8

ZOOL-6118	Animal Behavior	3(3+0)
ZOOL-61XX	*Special Paper B1/ Thesis (Univ. Option)	3(2+1)/(0+3)
ZOOL-61XX /ZOOL-6122	*Special Paper B2/ Univ. Option=Biotechnology	3(2+1)
ZOOL-61XX	*Univ. Option	3(2+1)
ZOOL-6119	Zoogeography & Paleantology	3(2+1)

Thesis option will be available to only 2 top students / class.

*****Annexure-I (list of optional courses)

Course Code	Course Title	Credit Hours
ZOOL-6120	Aquaculture	3(2+1)
ZOOL-6121	Biodiversity and Wildlife	3(2+1)
ZOOL-6122	Biotechnology	3(2+1)
ZOOL-6123	Comparative Developmental Biology	3(2+1)
ZOOL-6124	Endocrinology	3(2+1)
ZOOL-6125	Entomology-I	3(2+1)
ZOOL-6126	Entomology-II	3(2+1)
ZOOL-6127	Environmental Issues	3(2+1)
ZOOL-6128	Fish Physiology and Breeding	3(2+1)
ZOOL-6129	Hematology	3(2+1)
ZOOL-6130	Ichthyology	3(2+1)
ZOOL-6131	Immunology	3(2+1)
ZOOL-6132	Integrated Pest Management	3(2+1)
ZOOL-6133	Microbiology-I	3(2+1)
ZOOL-6134	Microbiology-II	3(2+1)
ZOOL-6135	Molecular and Clinical Endocrinology	3(2+1)
ZOOL-6136	Ornithology	3(2+1)
ZOOL-6137	Physiological Systems and Adaptations	3(2+1)
ZOOL-6138	Physiology of Reproduction	3(2+1)
ZOOL-6139	Principles of Parasitology	3(2+1)
ZOOL-6140	Principles & Kinetics of Toxicology	3(2+1)

MSc Zoology

Eligibility: At least 45% marks in BSc with Zoology compulsory of 200 marks (at least 33% marks) or Equivalent.
Duration: 02 Year Program (04 Semesters)
Degree Requirements: 68 Credit Hours

Semester-1

Course Code	Course Title	Credit Hours
ZOOL-6201	Fisheries	3(2+1)
ZOOL-6202	General Biochemistry	4(3+1)
ZOOL-6203	Cell and Molecular Biology	4(3+1)
ZOOL-6204	Biostatistics	3(3+0)
ZOOL-6205	Wildlife	3(3+0)

Semester-2

ZOOL-6206	Environmental Biology	4(3+1)
ZOOL-6207	Animal Physiology	4(3+1)
ZOOL-6208	Developmental Biology	4(3+1)
ZOOL-6209	Biological Techniques	3(2+1)
ZOOL-6210	Animal Behavior	3(3+0)

Semester-3

ZOOL-6211	Synopsis and Research Methodology	2(2+0)
ZOOL-6212	Principles & Kinetics of Toxicology	4(3+1)
ZOOL-6213	Evolution & Principles of Systematics	4(3+1)
ZOOL-6214	Bioinformatics	3(2+1)
ZOOL-62XX	*Optional Paper I/ Thesis	4(3+1/0+4)

Semester-4

ZOOL-6215	Seminar	1(1+0)
ZOOL-6216	Genetics	4(3+1)
ZOOL-6217	Zoogeography & Paleontology	3(2+1)
ZOOL-6218	Biotechnology	4(3+1)
ZOOL-62XX	*Optional Paper II/Thesis	4(3+1/0+4)

Thesis option will be available to only 2 top students / class.

*Annexure-I (list of optional courses)

ZOOL-6219.	Basic Human Genetics	4(3+1)
ZOOL-6220.	Biodiversity and Wildlife	4(3+1)
ZOOL-6221.	Comparative Developmental Biology	4(3+1)
ZOOL-6222.	Endocrinology	4(3+1)
ZOOL-6223.	Entomology-I	4(3+1)
ZOOL-6224.	Entomology-II	4(3+1)
ZOOL-6225.	Environmental Issues	4(3+1)
ZOOL-6226.	Fish Physiology and Breeding	4(3+1)
ZOOL-6227.	Hematology	4(3+1)
ZOOL-6228.	Ichthyology	4(3+1)
ZOOL-6229.	Immunology	4(3+1)
ZOOL-6230.	Integrated Pest Management	4(3+1)
ZOOL-6231.	Microbiology-I	4(3+1)
ZOOL-6232.	Microbiology-II	4(3+1)
ZOOL-6233.	Molecular and Clinical Endocrinology	4(3+1)
ZOOL-6234.	Ornithology	4(3+1)
ZOOL-6235.	Physiological Systems and Adaptations	4(3+1)
ZOOL-6236.	Physiology of Coordination	4(3+1)
ZOOL-6237.	Physiology of Reproduction	4(3+1)
ZOOL-6238.	Principles of Parasitology	4(3+1)

MPhil Zoology

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-1

ZOOL-7101*	Advanced Animal diversity	3(3+0)
ZOOL-7116 **	Aquaculture and Fisheries	3(3+0)
ZOOL-7115**	Applied Microbiology	3(3+0)
ZOOL-7117 **	Behaviour of Spiders	3(3+0)

Semester-2

ZOOL-7109*	Environmental Sciences	3(3+0)
ZOOL-7114**	Analysis of development	3(3+0)
ZOOL-7125**	Medical Biotechnology	3(3+0)
ZOOL-7130**	Statistical Ecology	3(3+0)

Semester 3-4

	Research work and Thesis write up	6(0+6)

*****To be offered from Annexure I (list of compulsory courses) based on the availability of faculty

******To be offered from Annexure II (list of optional courses) based on the availability of faculty and on the recommendation of the research supervisor

Annexure I- (list of compulsory courses)

Course code	**Course Title**	**Credit hours**
ZOOL-7101	Advanced Animal Diversity	3(3+0)
ZOOL-7102	Advances in Molecular Biology	3(3+0)
ZOOL-7103	Animal Biotechnology	3(3+0)
ZOOL-7104	Applied Biostatistics	3(3+0)
ZOOL-7105	Classification of Insects and Pest Management	3(3+0)
ZOOL-7106	Comparative Vertebrate Anatomy	3(3+0)
ZOOL-7107	Conservation Biology of Wildlife	3(3+0)
ZOOL-7108	Economic Zoology	3(3+0)
ZOOL-7109	Environmental Sciences	3(3+0)
ZOOL-7110	Modern Techniques in Zoological Research	3(3+0)
ZOOL-7111	Recombinant DNA Technology	3(3+0)

Annexure II- (list of optional courses)

ZOOL-7112	Advances in Immunology	3(3+0)
ZOOL-7113	Advances in Reproductive Technology	3(3+0)
ZOOL-7114	Analysis of Development	3(3+0)
ZOOL-7115	Applied Microbiology	3(3+0)
ZOOL-7116	Aquaculture and Fisheries	3(3+0)
ZOOL-7117	Behaviour of Spiders	3(3+0)
ZOOL-7118	Behavioural Ecology	3(3+0)
ZOOL-7119	Biological Insect Pest Control	3(3+0)
ZOOL-7120	Biology of Birds and Mammals in Pakistan	3(3+0)
ZOOL-7121	Cellular and Molecular Physiology	3(3+0)
ZOOL-7122	Clinical Teratology	3(3+0)
ZOOL-7123	Concepts of Toxicology	3(3+0)
ZOOL-7124	Fish Nutrition	3(3+0)
ZOOL-7125	Medical Biotechnology	3(3+0)
ZOOL-7126	Medical Parasitology	3(3+0)
ZOOL-7127	Physiology of Homoeostasis	3(3+0)
ZOOL-7128	Protozoans Parasitology	3(3+0)
ZOOL-7129	Reproductive Endocrinology	3(3+0)
ZOOL-7130	Statistical Ecology	3(3+0)
ZOOL-7131	Vascular Biology	3(3+0)
ZOOL-7132	Vector Biology	3(3+0)
ZOOL-7133	Wildlife of Pakistan	3(3+0)

PhD Zoology

Eligibility: MPhil/MS Zoology 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

Semester-1

ZOOL-8101*	Clinical Immunology	3(3+0)
ZOOL-8110	Advanced Cell and Molecular Biology	3(3+0)
ZOOL-8116	Bacterial Genetics	3(3+0)

Semester-2

ZOOL-8104*	Molecular Physiology	3(3+0)
ZOOL-8122	General Microbiology	3(3+0)
ZOOL-8123	Insect Physiology	3(3+0)

Semester 3 & onward

	Comprehensive Examination Synopsis Defense Research work Dissertation	

Any three courses being offered in the given semester by faculty can be taken in consultation of his/her supervisor. **One course*** from A**nnexure I** (list of compulsory courses) must be opted throughout course work.

Annexure -I (list of compulsory courses)

ZOOL-8101	Clinical Immunology	3(3+0)
ZOOL-8102	Wildlife Conservation and Management	3(3+0)
ZOOL-8103	Human Genetics	3(3+0)
ZOOL-8104	Molecular Physiology	3(3+0)
ZOOL-8105	Molecular Endocrinology	3(3+0)
ZOOL-8106	Molecular Entomology	3(3+0)
ZOOL-8107	Biological Toxicology	3(3+0)
ZOOL-8108	Research Methodology and Report Writing	3(3+0)
ZOOL-8109	Advanced Analytical Techniques	3(3+0)

Annexure- II (list of optional courses)

ZOOL-8110	Advanced Cell and Molecular Biology	3(3+0)
ZOOL-8111	Advances in Insect Biology and Pest Management	3(3+0)
ZOOL-8112	Advances in Wildlife	3(3+0)
ZOOL-8113	Applied Genetics	3(3+0)
ZOOL-8114	Applied Reproductive Physiology	3(3+0)
ZOOL-8115	Aquaculture System Management	3(3+0)
ZOOL-8116	Bacterial Genetics	3(3+0)
ZOOL-8117	Biology of Aging	3(3+0)
ZOOL-8118	Bio pesticides	3(3+0)
ZOOL-8119	Clinical Endocrinology	3(3+0)
ZOOL-8120	Comparative developmental Biology	3(3+0)
ZOOL-8121	Economic importance of Amphibians and Reptiles	3(3+0)
ZOOL-8122	General Microbiology	3(3+0)
ZOOL-8123	Insect Physiology	3(3+0)
ZOOL-8124	Medical Microbiology	3(3+0)
ZOOL-8125	Physiology of Endocrine Coordination	3(3+0)
ZOOL-8126	Physiology of Nervous Coordination	3(3+0)
ZOOL-8127	Regenerative Medicine	3(3+0)
ZOOL-8128	Research Methods in Entomology	3(3+0)
ZOOL-8129	Transgenic Animal Technology	3(3+0)

BS
ZOOLOGY

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 lexical grammar of English*. Amsterdam: John Benjamins.

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. 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. 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. 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
10. Matrix operations
11. Inverse of matrix
12. The determinants and its properties
13. Solution of system of linear equations by determinants: Cramer's rule, Inverse Matrices Method
14. Mathematics of Finance: Simple interest
15. Compound interest
16. Annuities
17. Sets and Sets Operations

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-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. Plants are really important for the planet and for all living things. Plants absorb carbon dioxide and release oxygen from their leaves, which humans and other animals need to breathe.

Contents

Comparative study of life form, structure, reproduction and economic significance of:

1. Viruses (RNA and DNA types) with special reference to TMV
2. Bacteria and Cyanobacteria (*Nostoc, Anabaena, Oscillatoria*) with specific reference to bio fertilizers, pathogenicity and industrial importance;
3. Algae (*Chlamydomonas, Spirogyra, Chara, Vaucheria, Pinnularia, Ectocarpus, Polysiphonia*)
4. Fungi (*Mucor, Penicillium, Phyllactinia, Ustilago, Puccinia, Agaricus*) their implication on crop production and industrial applications.
5. Lichens (*Physcia*)

Practical

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*. Singapore: 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. Pullaiah T., Bahadur, B., & Murthy, K. (2015). *Plant biodiversity*. Berlin: Springer-Verlag.

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 equilibria 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. Schrodinger wave equation, solution for particle in 1D box.
4. Chemical Thermodynamics: laws of thermodynamics, Spontaneous and non-spontaneous processes,
5. Chemical Equilibrium: Law of Mass Action, equilibrium constant, and LeChaterlier's Principle.
6. Solutions: composition, ideal and non-ideal solutions. Raoult's law. Colligative properties,
7. Chemical Kinetics: Zero, first and second order reaction, Arrhenius equation, activation energy,
8. Electrochemistry: Conductance, Kohlrausch's law and its applications

Physical Chemistry Lab

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.

Recommended Texts

1. Atkins, P., Paula, J., & Keeler, J. (2017). *Atkins' Physical Chemistry* (11th ed.). Oxford: 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., & Nabi, G. (2006). *Text Book of Physical Chemistry.* Lahore: Ilmi Kitab Khawna.
2. Das, R.C., & Behera, B. (2003). *Experimental Physical Chemistry.* Dehli: Tata McGraw Hill.

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 multicellularity;
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

Practical

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.

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. It majorly comprises of the importance of life and that after death. It is one of the best systems of education, which makes an ethical groomed person with the qualities which he/she should have as a human being. 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. Seeratul-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

Recommend 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.

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. 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. 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

Plant Systematic

1. 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

Practical

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*. Oxford Shire: 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.
3. Lyons, S., Sheila, R. C., W., & W. Robert. (2018). *Plant Anatomy*. Berlin: Springer-Verlag.

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 and 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 and d-Block Elements
5. Chemistry of Elements:
6. Separation Techniques: General introduction and Applications

Inorganic Chemistry Lab

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.

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*, (5^{th} ed.). London: Chapman and Hall.

Suggested Readings

1. Graham, H., and Man, H. (2000). *Chemistry in Context*, (5^{th} ed.). Nashville: Thomas Nelson Ltd.
2. Skoog, D. A., West, D.M., & Holler, F.J. (1994). *Analytical Chemistry* (6^{th} ed.). Philadelphia: Saunders College Publications.

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

This course will enable students to understand the taxonomic characteristics of protectorates and chordates. It provides knowledge about the phylogenetic relationships of protectorates 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. Protochordates: 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.

Practical

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

URCE-5103 Academic Writing (3+0)

Academic writing is a formal, structured and sophisticated writing to fulfill 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

1 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.
2 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.

Suggested Readings

1. O'Leary, D. A., O'Leary, T. J. & O'Leary, L. I. (2018). *Computing essentials* (27th ed.). San Francisco: McGraw Hill Higher Education.
2. Schneider, G. M. & Gersting, J. (2018). *Invitation to computer science*. Boston: Cengage Learning.

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 practical 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

Genetics

3. Introduction, scope and brief history of genetics. Mendelian inheritance
4. 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.

Practical

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.

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*). Dehli: S. Chand Publishing.
2. Milo, R., & Phillips, R. (2015). *Cell biology by the numbers* (1st ed.) London: Taylor and Francis publications.

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.

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* (12^{th} ed.). New York: Wiley.
3. Vogel, A. I. (1996). *A TextBook of Practical Organic Chemistry*. New Jersey: Prentice Hall.

Suggested Readings

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

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 and 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.

Practical:

1. Study of insect chitin, fish scale, amphibian skin, reptilian scales, feathers and mammalian skin
2. Study and notes of skeleton of fish (*Labeo rohita*), frog (*Hoplobatrachus tigerinus*), varanus (*Varanus bengalensis*), fowl (*Gallus domesticus*) and rabbit (*Oryctolagus cuniculus*): 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* (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.

URCE-5104 ` Introduction to English Literature 3 (3+0)

The course is designed to provide the familiarity and comprehension of English literary pieces. The students may not be familiar or well-versed in the various genres of literature prior to taking this course. The course provides training and skills necessary to engage, understand, critically analyze, and enjoy the literary genres of literature: short story, poetry, novel and drama. The students will explore the basic concepts of literary technique, narrative, poetic, and dramatic structures and innovations to engage with the more advanced cognitive aspects of literature. In addition to these theoretical skills, students will also read below the surface of the texts for their historical, ethical, psychological, social, and philosophical value by developing insights in how literature gives us a window into both the experiences of others and wider appreciation for the human condition. The course explores literary production in English against local context in particular, by emphasizing shifts in thought as well as genre innovation, i.e. medieval to modern. It provides an introduction to key texts, authors and literary periods, exploring the relationship of texts to their contexts and considering multiple perspectives in the different literary genres.

Contents

1. Poems, Milton: *Book IX*, lines 897–959.
2. Shakespeare: All the World is a Stage.
3. Browning: My Last Duchess
4. Wordsworth: The Leech Gatherer
5. Keats: Ode to Autumn
6. Walter De La Mare: Tartary
7. Short Stories, *The Necklace*
8. The Woman Who had Imagination
9. Shadow in the Rose Garden
10. Essays, *My Tailor*
11. Whistling of the Birds
12. One Act Play, *Riders to the Sea*
13. Novel, *Animal Farm*

Recommended Texts

1. Kennedy, X. J. & Gioia, D. (2014). *Literature: An introduction to fiction, poetry, drama, and writing*. Boston: Pearson.
2. Mays, K. J. (2014). *The Norton introduction to literature*. New York: Norton.

Suggested Readings

1. Bausch, R. & Cassill, R. V. (2006). *The Norton anthology of short fiction*. New York: Norton & Company.
2. Gardner, J. E., Lawn, B., Ridl, J. & Schakel, P. (2016). *Literature: A portable anthology*. Boston: Bedford St. Martins.

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.

Practical

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.

SOCI-5101 **General Sociology-I** **3 (3+0)**

Sociology is the study of society, patterns of social relationships, social interaction, and culture that surrounds everyday life. It is a social science that uses various methods of empirical investigation and critical analysis to develop a body of knowledge about social order and social change. Subject matter can range from micro-level analyses of society to macro-level analyses .The course is designed to introduce the students with basic sociological concepts and to get familiarity with the overall discipline. The focus of the course shall be on basic concepts like scope and significance of Sociology, How Sociology is related as well as distinct from other social sciences. It focuses on the constituent parts of the society i.e. social systems and structures, socio-economic changes and social processes. This will also give an understanding of the Culture, elements of culture and the relationship of culture and personalities. The course will provide due foundation for further studies in the field of sociology.

Contents

1. Introduction to Sociology: The Science of Society, Scope and significance
2. Fields of Sociology: Sociology and other Social Sciences
3. Social interaction and social structure: The Nature and Basis of Social Interaction
4. Social Processes: Social structure Status, Roles, Power and Authority, Role Allocation
5. Culture: Meaning and nature of culture, Elements of culture: Norms, values beliefs, sanctions
6. Culture and Socialization, Transmission of Culture, Cultural Lag, Cultural Variation
7. Cultural Integration, Cultural Evolution, Cultural Pluralism, Culture and personality
8. Socialization & personality: Socialization, Agents of socialization
9. Personality: components of personality
10. Deviance and social control: Deviance and conformity
11. Mechanism and techniques of social control, Agencies of social control
12. Social organization: Definition, meaning and forms, Social groups; Functions of groups
13. Social Institutions: forms, nature and inter-relationship
14. Community: definition and forms (Urban and rural).
15. Social Institutions: Structure and functions of Institutions
16. Family, Religion, Education, Economy and political institution

Recommended Texts

1 Giddens, A. (2018). *Sociology* (11th ed.).Cambridge: Polity Press.
2 Macionis, J. J. (2016). *Sociology* (16th ed.). New Jersey: Prentice-Hall.

Suggested Readings

1 Anderson, M., & Taylor, F. H. (2014). *Sociology the essentials* (8th ed.). Boston: Cengage Learning.
2 Schaefer, T. R. (2012). *Sociology* (13th ed.). New York: McGraw Hill College.
3 Henslin, M. J. (2011). *Sociology: A down to earth approach* (11th ed.). Melbourne: Pearson.

ZOOL 5105 **Biological Techniques** **3(1+2)**

Students will be able to identify the instrument and to use instrument for identification, measurement, fixation and cutting of tissue. It also enables students to apply a practical and research skill and to operate the lab equipment efficiently. Students will learn to collect and preserve the specimen in dry and wet form and develop expertise in preservation techniques like taxidermy, rearing techniques in laboratory and field. At the end of the course students will have some understanding of the basic generally applicable tools, techniques, methodologies and methods of analysis in biological research and become comfortable and proficient working in the lab, the field, and on the computer for those tools, techniques, etc. Moreover learner will know how to acquire, learn about and implement a new tool or technique, how to order and store supplies and will learn what scientific lab integrity is all about.

Contents

1. Microscopy: Principles, magnification, resolution, types, SEM and TEM.
2. Different measurement systems for weight, length, volume, calculations and related conversions , concentrations, preparation of stock solutions of various strength
3. Micrometery: stage and ocular micrometers usage, calibration and measurement of cell & nuclei size.
4. Specimen preparation for optical microscopy: introduction to microtome, tissue mounting, staining
5. Separation and purification techniques, cell fractionation, centrifugation and its types, filtration
6. Chromatography: principle, applications and types,
7. Electrophoresis: principle, applications and types (agarose and PAGE).
8. Spectrophotometry: principle, applications, types, visible/UV spectrophotometry

Practical

1. Preparation of slides (dry and wet mount), measurement of cell size: bacterial and eukaryotic cell
2. Recording of microscopic observations with the help of camera lucida
3. Liquid handling: proper use of pipettes and micropipettes, Hematoxylin, eosin and Gram's staining,

Recommended Texts

1. Cheesbrough, M. (2005). *District laboratory practice in tropical countries (Part I)* (2nd ed.). Cambridge: Cambridge University Press.
2. Cheesbrough, M. (2009). *District laboratory practice in tropical countries* (*Part II)*. Cambridge: Cambridge University Press.

Suggested Readings

1. Gallagher, S. R., & Wiley E. A. (2008). Current protocols essential laboratory Techniques. New Jersey: John Wiley & Sons.
2. Jones, A., Reed, R. & Weyers, J. (1994). *Practical skills in biology*. Singapore: Longman Ltd.

PSYC-5101 Introduction to Psychology (Minor) 3 (3+0)

This course has been designed to ensure an effective orientation of students towards the discipline of psychology so that they may come to appreciate the diversity of the subject and its pragmatic significance. This course provides an introduction to the concepts and theories of psychology and to their application to real life situations. Topics include history, research methods, sensation, perception, consciousness, stress and coping, learning, memory, motivation and emotions. Main objectives of the course include making students familiar with the essentials features of human personality; to inculcate a sense of personal relevance of Psychology as a subject with the potential of gaining better insight into one's own self and others. Upon the successful completion of course students will have an introductory knowledge of selected areas of basic psychological enquiry and they will be able to: differentiate between scientific and non-scientific information about human behaviors and mental processes, describe major developments and research methods used in psychology; Explain psychological processes involved in sensation, perception, learning, memory, motivation, emotion, states of consciousness and health; Analyze the variety of factors affecting sensation, perception, consciousness, learning, memory, motivation, emotion, and health; and can apply psychological concepts and principles to situations in everyday life.

Contents

1. Introduction to Psychology: definition of psychology, goals of psychology, major schools of thought in psychology, major fields of psychology
2. Basic research methods in psychology: survey research, experimental research, case study method
3. Biological basis of behavior: brain and nervous system, structure and function of major brain areas, neurotransmitters and their functions
4. Sensation and perception: difference between sensation and perception, principles of perception, role of perception in human cognition
5. Motivation and emotion: concept & theories of motivation and emotion
6. Learning: definition of learning, types of learning (i) classical conditioning (ii) operant conditioning, (iii) observational learning
7. Memory and intelligence: definition and stages of human memory, types of memory, concept of intelligence, basic theories of intelligence

Recommended Texts

1. Weiten, W. (2017). *Psychology: themes and variations* (10th ed.). Boston: Cengage Learning.
2. Nolen-Hoeksema, S., & Hilgard, E. R. (2015). *Atkinson and Hilgard's introduction to psychology* (16th ed.). New Dehli: Cengage Learning.

Suggested Readings

1. Flanagan, C., Berry, D., Jarvis, M., & Liddle, R. (2015). *AQA psychology.* London: Illuminate Publishing - Cheltenham.
2. Coon, D., Mitterer, J. O., & Martini, T. S. (2018*). Introduction to psychology: Gateways to mind and behavior* (15th ed.). Boston: Cengage Learning.

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. 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 endeavors to develop and progress in the contemporary world. For this purpose, the foreign policy objectives and Pakistan's foreign relations with neighbouring and other countries are also included. This curriculum has been developed to help students analyse 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.
   Talbot, I. (1998). *Pakistan: A modern history*. London: Hurst and Company.

ZOOL 6106 Research Methodology 2(2+0)

The course is aims to develop research skills, provide understanding how to design scientific research, to collect data and its interpretation; emphasize the importance of ethics in scientific research and enable students to write a research proposal. It also introduces the data collection methods, data processing techniques, analysis options, writing review of literature, to deal with research problem and hypothesis development. 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 introducing them to the basic concepts used in research and to scientific social research methods and their approach. It includes discussions on sampling techniques, research designs and techniques of analysis by developing an understanding of the ethical dimensions of conducting applied research, identifying various sources of information for literature review and data collection and appreciating the components of scholarly writing and evaluate its quality.

Contents

1. Introduction: Objectives of research, motivations
2. Research process: Research methods vs. research methodology, scientific method,
3. Types of research, general steps involved in research, problems of research in Pakistan
4. Topic selection
5. Problem identification for research, criteria and evaluation
6. Literature review: importance and sources, referencing and citation and bibliography, plagiarism
7. Research design: parts, important concepts in research design
8. Aims and objectives: Research objectives, qualities of research objectives
9. Material and methods: bioethics, sampling, data collection and data analysis, sampling requirement,
10. Scales of measurement, error of measurement and its sources
11. Data analysis: processing, statistics in research, hypothesis testing, t-tests and ANOVA
12. Scientific writing: difference between thesis/report/synopsis/research proposal, parts of synopsis/project proposal, parts of thesis/report.
13. Budgeting: Cost estimates for a research project, funding sources e.g. USAID, HEC, DOST, HED, PMRC, WWF, PSF etc.

Recommended Texts

1. Leedy, P. D., & Ormord, J. E. (2018). *Practical research: planning and design* (12th ed.). New York: Pearson.
2. Creswell, J. W., & Creswell, J. D. (2018). *Research design quantitative qualitative and mixed methods approaches* (5th ed.). California: SAGE Publications.

Suggested Readings

1. Khan, J. A. (2008). *Research methodology*. New Delhi: APH Publishing.
2. Walliman, N. (2005). *Your research project, a step by step guide for the first-time researcher* (2nd ed.). California: SAGE Publications.
3. Hess-Biber, S. N., & Leavy, P. (2004). *Approaches to qualitative research, a reader on theory and practice*. New York: Oxford University Press.

ZOOL-6107 Economic Zoology 3(2+1)

The course will enable students to learn about the relationship of commerce with domestic animals, their products, by-products and associated farming practices. They will also learn about the importance of human and domestic animal diseases and their vital relation to the economy. This course also provides knowledge about internal and external parasites and their effects on domestic animals and their farming practices. It also familiarizes the students with the value of studying various general practices, principles and techniques in farming and rearing of animals in sericulture (silk worms), apiculture (honey bees), aquaculture (fisheries, pearl culture, prawns and oysters), poultry (domestic fowl and ostriches) and cattle husbandry. Students will acquire basic knowledge of commerce and economics in relation to Zoology. Economic zoology imparts knowledge about application of zoological knowledge for the benefit of mankind which mainly includes culturing animals for mass production for human use and to control or eradicate animals that are injurious to man directly or indirectly.

Contents

1. Parasitic protozoans and human disease, economic importance of protozoa
2. Vectors of human and domestic animals
3. Ecto-parasites and endo-parasites of fish, poultry, cattle and man (crustacea, helminthes and arachnida)
4. Pests of pulse crops, oil seed crops, stored grain pests, pests of cotton, vegetables, fruits and tea
5. Apiculture, sericulture, lac insect culture and pearl culture
6. Aquaculture and fisheries (edible fresh water, pond and marine fish, prawns, pearl oysters)
7. Economic importance of fishes
8. Bird farming (poultry, quail, turkey, ostrich and pigeon)

Practical

1. To study the prepared slides of various types of ecto- and endo-parasites
2. To observe and study museum specimens of vertebrate and invertebrate
3. Collection of pests of important crops and stored grains in Pakistan
4. Visit to honey bee farm and bird farm and writing a report on their observations
5. Visit to Sericulture farm in a nearby locality and write report on their observations
6. Study visit to fish hatchery, nursery ponds, stocking ponds, commercial fish breeding farms
7. Identification of important species of fish

Recommended Texts

1. Ravindranathan, K. R. (2003). *Economic zoology* (1st ed.). New Delhi: Dominant Publishers and Distributers.
2. Primack, R. B. (2000). *A Primer of conservation of biology* (2nd ed.). Massachusetts: Sinauer Associates.

Suggested Readings

1. Mirza, Z. B. (1998). *Animal biodiversity of Pakistan* (1st ed.). Rawalpindi: Printopack.
2. Akhtar, M., & Muzaffar, N. (2008). *Introduction to apiculture*. Lahore: Punjab University Press.
3. Blackiston, H. (2001). *Beekeeping for dummies*. Indiana: Wiley Publishing.

ZOOL-6108 **Biochemistry** **4(3+1)**

The course aims to provide in-depth knowledge about the polymerized organic compounds of life. It will develop an understanding about the dynamism in life as it proceeds with inter-conversion of the chemicals from feeding to the liberation of energy for work. It enables students to know how organisms harvest energy for growth and duplication. This course will help students to understand the principles of bioenergetics and the dietary requirements of man and animals. It will also provide knowledge of metabolism of dietary and endogenous carbohydrate, lipid, and protein as well as the principles and major mechanisms of metabolic control and molecular signaling by hormones. This course helps students with a basic understanding of the principles of bioenergetics and enzyme catalysis, understand the chemical nature of biological macromolecules, their three-dimensional construction, and the principles of molecular recognition and demonstrates understanding of the molecular machinery of living cells in the students.

Contents

1. Amino acids, peptides and proteins; enzymes: introduction; important characteristics of enzymes
2. Classification, types, important characteristics and structure of carbohydrates: mono, disaccharides
3. Polysaccharides, storage and structural types; structure and major functions of polysaccharides
4. Lipids: fatty acids, their types and major characteristics, structural lipids in membranes, lipoproteins
5. Vitamins and cofactors: ocurrence, structure and biochemical function of vitamins B complex
6. Metabolism- glycolysis, aerobic and anaerobic conditions, feeder pathways, regulation
7. Citric acid (TCA) cycle: bioenergetics, regulation, ETC, oxidative phosphorylation, chemiosmosis
8. Lipid metabolism: biosynthesis of triacylglycerol, beta-oxidation, omega oxidation pathway
9. Ketone bodies their biosynthesis, utilization and role in the tissues

Practical

1. Preparation of standard curve for glucose; acid hydrolysis of polysaccharides
2. Biochemical tests for detection of carbohydrates, reducing sugars & non-reducing sugars, amino acids
3. Separation and identification of various types of sugars, fatty acid and amino acids (TLC)

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2012). *Lehninger principles of biochemistry*. New York: McMillan worth Publishers.
2. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2011). *Biochemistry* (7th ed.). London: Palgrave MacMillan.

Suggested Readings

1. Lodish, H., Berk, A., Zipursky, S. L., Paul, M., Baltimore, D., & Darnell, J. (2012). *Molecular cell biology.* New York: Freeman.
2. McKee, T., & McKee, J. R. (2003). *Biochemistry: The molecular basis of life* (3rd ed.). New York: McGraw Hill.
3. Wilson, K., & Walker, J. (1994). *Practical biochemistry: principles and techniques* (4th ed.). Cambridge: Cambridge University Press.

ZOOL-6109 Cell and Molecular Biology 4(3+1)

The course aims to impart knowledge about the animal cell and its complex organization and architecture. It enables students to understand various ultra-structural, molecular and functional aspects of the cells. Students will be able to describe and discuss the properties and biological significance of the major classes of molecules found in living organisms and the relationship between molecular structure and biological function, can relate how cell movement and cell-cell communication occur and discuss mechanisms of signal transduction and the lab work will provide platform to became familiar with various cell types through techniques of slide preparation. Understanding of microscopy to study cell structure and cellular compartmentalization will be provided to learners. Main emphasis of course is to develop familiarity with structure and function of cells at the molecular level, including the flow of information from genes to proteins, and regulation of cellular processes, signaling and proliferation in eukaryotic cells.

Contents

1. Introduction to prokaryotic and eukaryotic cells; plasma membrane, structure and functions
2. Cytoskeleton: microfilaments, microtubules, intermediate filaments.
3. Ultrastructure, chemical composition and functions of endoplasmic reticulum, golgi apparatus
4. Mitochondrial respiration and its significance as semi- autonomous organelle
5. Cellular roles of lysosome, peroxisome and glycoxysome; structure and functions of nucleus
6. Replication: mechanism, DNA replication in prokaryotes and eukaryotes
7. Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA, post transcriptional processing, RNA transduction
8. Translation: specific role of ribosomes, various factors, and posttranslational processing
9. Genetic code, point mutations; control of gene expression in prokaryotes

Practical

1. Identification of cell organelles; preparation of human blood smear and identification of leucocytes
2. Permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone
3. Mounting of polytene chromosomes (drosophila); study of mitosis in onion root tips
4. Quantitative determination of chromosomal DNA and RNA; agarose gel electrophoresis
5. Isolation and characterization of proteins on polyacrylamide gel electrophoresis

Recommended Texts

1. Cooper, G. M., & Hausman, R. E. (2018). *The cell: A molecular approach* (8th ed.). Massachusetts: Sinauer Associates.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2016). *Molecular cell biology* (8th ed.). New York: W. H. Freeman.

Suggested Readings

1. Iwasa, J., & Marshall, W. (2016). *Karp's cell and molecular biology: concepts and experiments* (8th ed.). New Jersey: John Wiley and Sons.
2. De-Robertis, E. D. (2014). *Cell and molecular biology* (8th ed.). New York: Lea & Febiger.
3. Alberts, B., Johnson, A. D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). New York: W. W. Norton & Company.

ZOOL-6110 Evolution & Principles of Systematics 4(3+1)

The course aims to provide extensive knowledge about origin of life and concepts about forces responsible for evolutionary changes. This study covers the importance and history of systematics with basic rules and regulations about the identification and naming of organisms. This course will also provide information about origin, classification and evolution of fauna. The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity. Moreover, the students will be able to understand the basic principles of evolution and systematics, and the inference of evolutionary patterns in the major animal groups. Students will be able to demonstrate evolutionary implications of animal diversity, nature and origin to life, systematic zoology, microtaxonomy and taxonomic categories. The practical section will enable the students to preserve invertebrate species and classify them up to class level, how to identify animal by the help of key and how to make keys of different types for identification of animals.

Contents

1. The nature and origin to life: evidences of evolution (molecular, embryological & paleontological).
2. Theories of Evolution: theories to explain the diversity of life - modern synthetic theory
3. Factors initiating elementary evolutionary changes (micro-evolution)
4. Role of isolation in evolution: factors of large evolutionary changes (macro/mega evolution)
5. Modern concept of natural Selection: levels, selection patterns
6. Action of natural selection leading to convergence, radiation, regression and extinction
7. Batesian mimicry, mullerian mimicry, sexual selection
8. Importance and applications of systematics: systematics as a profession and its future perspectives
9. History of taxonomy: systematics, basic terminology of systematics
10. Taxonomic characters: Kinds and weightage, microtaxonomy, taxonomic categories
11. Species concept: typological, nominalistic, biological and evolutionary species concept.
12. Speciation, taxonomic procedures, taxonomic collection, taxonomic keys
13. Systematics publications: International code of zoological nomenclature

Practical

1. Study of preserved invertebrate species and their classification up to class level.
2. Preparation of keys for the identification of specimens.
3. Methods of statistical analysis of samples from populations T-test, Analysis of variance etc.

Recommended Texts

1. Strickberger, M. W. (2012). *Evolution.* Burlington: Jones & Barrett Publisher.
2. Mayer, E. (1994). *Principles of systematic zoology*. New York: McGraw-Hill.

Suggested Readings

1. Moody, P. A. (1989). *Introduction to evolution.* New York: Harper and Row Publishers.
2. Dobzhansky, T., Ayala, F. J., Stebbins, G. L., & Valentine, J. W. (1977). *Evolution*. New York: W.H. Freeman and Company.
3. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: theory and practice of phylogenetic systematics.* New Jersey: Wiley-Blackwell.
4. Heywood, V. H. (1975). *Taxonomy and ecology*. London: Academic Press.

ZOOL-6111 Physiology 4(3+1)

This course will provide an introduction to the basic physiological principles common to humans and other animals. It will include basic physical and chemical processes in animal tissues, detailed consideration of organ systems, and an integrative approach to understand how animals meet the demands in variable conditions. It will not only emphasize human physiology, but also will consider other animal systems for comparison. This course enable the students to understand the molecular and cellular mechanisms of physiological function as the basis of unity in diverse animals e.g. membrane excitability, exchange of respiratory gases, removal of nitrogenous wastes, osmosis and other physiological mechanisms underlying animal homeostasis and temperature effects. On the completion of course students will be able to understand mechanisms and adaptations of physiological systems in animals and understand the working of various systems of organisms. The practical portion will let the learners to investigate physiological questions, collecting, analyzing, interpreting, and reporting experimental data.

Content

1. Concept of Physiology: Principles of homeostasis, conformity, regulation and adaptation
2. Membrane Physiology: resting membrane potentials: electrogenic ion pump and ion channels
3. Muscle Physiology: Action potentials in neurons, synaptic transmission, postsynaptic potentials, neuronal networks and their role in nervous integration,
4. Muscles: Structure, types, components, basis of muscle contraction, neuromuscular interaction.
5. Endocrine Physiology: hormones of invertebrates, vertebrates,
6. Endocrine organs and mechanisms of hormone actions,
7. Cardiovascular physiology, relationship between blood flow, pressure and resistance.
8. Respiratory physiology, respiratory structures, control and respiration adaptations
9. Excretory physiology, filtration, reabsorption and patterns of excretion in mammals & other animals.

Practical

1. Study of respiratory pigments in various animals and hemoglobin in various vertebrates,
2. Normal cardiac activity in amphibian model and effect of temperature, drug, heart block,
3. Blood pressure alteration in exercise, oxygen consumption in fish and terrestrial animal (mouse).
4. Study of electromyography, excitable and contractile properties of a nerve-muscle preparation.

Recommended Texts

1. Moyes, C. D., & Schulte, P. M. (2015). *Principles of animal physiology*. New Jersey: Pearson.
2. Guyton, A. C., & Hall, J. E. (2016). *Textbook of medical physiology*. Philadelphia, Sherwood: W.B. Saunders Company.

Suggested Readings

1. Sherwood, L., Klandorf, H., & Yancey, P. (2012). *Animal physiology: from genes to organisms* (2nd ed.).California: Brooks/Cole.
3. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). *Animal physiology* (4th ed.). Massachusetts: Sinauer Associates.

ZOOL-6112 Ecology 3(2+1)

This course will enable students to understand about habitat, ecology, ecosystems and environmental threats along rehabilitation of destroyed ecosystems. They will also be capable to learn methods to protect and safe environment. The students will be literate about the biogeochemical cycles, applied ecology, population ecology, community ecology and global ecosystems. Upon successful completion of the course students will develop an appreciation of the modern scope of scientific inquiry in the field of Ecology, become familiar with the variety of ways that organisms interact with both the physical and the biological environment and develop an understanding of the differences in the structure and function of different types of ecosystems. Moreover, this subject imparts knowledge to compare the relationships among organisms, including predation, parasitism, competition, commensalism, and mutualism. The students will also able to explain the general distribution of life in aquatic systems as a function of chemistry, geography, light, depth, salinity, and temperature.

Contents

1. Energy: basic concepts, types of energy, laws of thermodynamics, trophic levels and energy variation, energy flow, food chains and food webs.
2. Biogeochemical cycle**:** nitrogen, phosphorus, sulphur, water, carbon and nutrient.
3. Limiting factors: basic concepts, temperature, soil, water, humidity, light and fire.
4. Global ecosystems: atmosphere, hydrosphere, lithosphere and ecosphere, major ecosystem of world, forest, grassland, desert, tundra, agricultural, marine, estuarine, freshwater and wetlands
5. Population ecology: basic population characters, growth, population dynamics and regulations.
6. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions
7. Applied ecology: resources and their ecological management
8. Pollution: definition, types, water, air, land and noise, sources and management.
9. Radiation ecology: global environmental changes and laws).
10. Exotic and invasive species: desertification, deforestation

Practical

1. Population sampling techniques,
2. Study and measurements of physical factors of different ecosystems
3. Ecological notes and adaptive features of animals in relation to food and environment.
4. Food chain studies through analysis of gut contents.
5. Analysis of polluted and fresh water for biotic and abiotic variations.

Recommended Texts

1. Molles, M. C. (2005). *Ecology: concepts and applications* (6th ed.). New York: McGraw Hill.
2. Cox, C. B., & Morre, D. (2000). *Biogeography: An ecological and evolutionary approach* (6th ed.). London: Life Sciences King's College.

Suggested Readings

1. Dondson, S. I., Allen, T. F. N., Carpenter, S. R., Ives, A., Jeanne, R. L., Kitchell, J. F., Langston, N. E., & Turner, M. G. (1998). *Ecology*. Oxford: Oxford University Press.
2. Chapman, J. L. & Reiss, M. J. (1997). *Ecology: principles and applications*. Cambridge: Cambridge University Press.
3. Odum, E. P. (1994). *Fundamentals of ecology* (3rd ed.) Philadelphia: W.B. Saunders.

ZOOL-6113 Developmental Biology 4(3+1)

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction. It provides understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology has significant impact on our understanding of evolution and modern medicine, including the treatment of birth defects, infertility and cancer in humans. The students will be able to compare basic principles of embryology through understanding the developmental patterns with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through the structure of gametes of animals (like. frog, fish and mammal), to study of fertilization, early development of frog/fish through induced spawning under laboratory conditions and to know about the dactylography and its uses in developmental biology.

Contents

1. Introduction: history, basic concepts, principal features with special emphasis on vertebrate models,
2. Origin of sexual reproduction, developmental patterns
3. Spermatogenesis: mammalian spermatogenesis as model
4. Primates menstrual cycle, mechanism of oogenesis, vitellogenesis &hormonal control
5. Fertilization: external & internal fertilization, polyspermy: slow and fast blocks to polyspermy
6. *IN VITRO* Fertilization (IVF): history, steps and advantages, disadvantages and risk factors of IVF.
7. Patterns of cleavage and blastulation among different vertebrate classes,
8. Gastrulation: fate maps, gastrulation in amphibians, birds and mammals
9. Early vertebrate development
10. Neurulation, ectoderm, mesoderm and endoderm formation
11. Placenta and extraembryonic membranes

Practical

1. Study of the structure of gametes in some representative cases, *i.e.* frog, fish and mammal.
2. Hen's egg internal and external structural details.
3. Study of cleavage and subsequent development from prepared slides in frog, mammals and chick etc.

Recommended Texts

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental biology* (11th ed.).Oxford: Oxford University Press, Incorporated.
4. Gilbert, S. F. (2016). *Developmental biology*. Sunderland, Massachusetts: Sinauer Associates.

Suggested Readings

1. Klaus, K. (2001). *Biological development* (2nd ed.). New York: McGraw-Hill.
2. Oppenheimer, S. B. & Lefevre, G. (1998). *Introduction to embryonic development* (3rd ed.). San Fransisco: Benjamin Cummings.
3. Balinsky, B. I. (2012). *An introduction to embryology* (5th ed.). Dehli: Cengage.

ZOOL-6114 **Genetics** **4(3+1)**

This course aims to provide understanding of basic concepts of genetics, providing a conceptual framework for future reference. It provides understanding about the continuity of the life from one generation to other generation is based on the mechanisms involving nucleus, chromosomes and genes. The course develops the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment; understanding of probability concepts and using these concepts to solve problems. The main goals of this subject are to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes, to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis and to describe what are causes, consequences and prevention of DNA sequence changes.

Contents

1. Introduction to genetics, the basic principles of inheritance (Mendelism)
2. Multiple alleles: blood groups, coat color in rabbits, genetics of Rh factor & erythroblastosis foetalis.
3. Chromosomal basis and chromosomal theory of inheritance, aberrations & change.
4. Pedigree Analysis: Normal human chromosome complement; karyotyping,
5. Sex-determination and sex-linkage, sex influenced and sex limited traits,
6. Prenatal diagnosis: amniocentesis, choriovillus sampling, ultrasound, fetoscopy. genetic counselling, Chromosome mapping: linkage, recombination, chromosome mapping in eukaryotes.
7. Molecular genetics: gene concept, genetics of viruses and bacteria, transposons, mutation and DNA repair molecular genetic analysis,
8. Regulation of gene expression in prokaryotes, eukaryotes, genetic basis of diseases, like cancer,

Practical

1. Drosophila culture techniques, salivary chromosomes, mutation induction in Drosophila ,
2. Human karyotyping from photographs & prepared slides
3. Preparation of human metaphase chromosomes from blood lymphocytes
4. Study of mitosis in onion root tip cells & meiosis in the testes of male grasshopper
5. Extraction of genomic DNA from WBC and separation of bio-molecules through electrophoresis
6. Study of blood group, quantitative traits & pedigree analysis in local population

Recommended Texts

1. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2018). *Concepts of genetics* (12th ed.). New Jersey: Pearson.
2. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's GENE-XII* (12th ed.). Massachusetts: Jones & Bartlett Learning.

Suggested Readings

1. Snustad, D. P., Simmons, M. J., & Gardner, E. J. (2003). *Principles of genetics* (8th ed.). New York: John Wiley & Sons Ltd.
2. Tamarin, R. H. (2001). *Principles of genetics* (7th ed.). New York: McGraw-Hill.

ZOOL 6115 Wildlife (2+1)

The objective of this course is to enable the student to understand philosophy and significance of wildlife its conservation and management. Literature about geographical distribution, factors effecting distribution and status of different wildlife species will be discussed in this course. Rules and regulations, role of national and international agencies involved in conservation and management of wildlife will be familiarized. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the conservation and management of threatened species (of amphibians, reptiles, birds and mammals). The major aim of the subject includes knowing what type of wildlife exist in Pakistan and what are the threats it is facing and how it can secured in Pakistan? After this course students will become able to participate in conservation of wildlife. The practical section will cover the visit to protected areas of Pakistan (captive, semi-captive and wild areas).Knowledge about use of ecological indices and animal distribution maps will be provided.

Contents

1. Wildlife of Pakistan: biodiversity and its categories, wildlife in context of its services, wildlife prior to the establishment of Pakistan,
2. Current status of wildlife, vegetative zones and its associated wildlife in Pakistan
3. Conservation and management of threatened amphibians, reptiles, birds and mammals of major importance in Pakistan
4. Major challenges faced during wildlife conservation
5. Threats to wildlife in Pakistan.
6. Wildlife rules and regulations in Pakistan
7. National and international agencies involved in conservation and management of wildlife in Pakistan, national organizations, international organizations
8. Protected Areas in Pakistan: sanctuaries, game reserves, national parks
9. Ramsar convention: wetlands, ramsar criteria, ramsar sites
10. Threatened species of Pakistan: vulnerable, endangered, critically endangered

Practical

1. Visit to protected areas of Pakistan (captive, semi-captive and wild areas)
2. Ecological indices
3. Animal distribution maps

Recommended Texts

1. Odum, E. P. (2007). *Fundamentals of ecology* (5th ed.). San Francisco: Cengage Learning.
2. Miller, A. S. & Harley, J. B. (2016). *Zoology* (10th ed.). New York: McGraw Hill.

Suggested Readings

1. Smith, R. L. & Smith, T. M. (2000). *Ecology and field biology* (6th ed.). Massachusetts: Benjamin Cummings.
2. Ali, S. S. (1999). *Palaeontology, zoogeography and wildlife management*. Hyderabad: Nasim Book Depot.
3. Roberts, T. J. (1997).*The mammals of Pakistan*. Oxford: Oxford University Press.

ZOOL-6116 **Biostatistics** **3(2+1)**

The course aims to provide knowledge about the importance and use of statistics in life sciences and familiarize students with the methods of data analysis pertaining to their research work and to assess the significance of their experimental designs. Specific topics include tools for describing central tendency and variability in data; methods for performing inference on population means and proportions. After finishing this course, students will be able to recognize the importance of data collection and its role in determining inference, can demonstrate a solid understanding of interval estimation and hypothesis testing, can choose and apply appropriate statistical methods for analyzing one or two variables and can interpret statistical results correctly and effectively. More specifically, they will be able to identify cases and variables in a dataset, and classify variables as categorical or quantitative and to recognize appropriate method to use sample data to infer information about a population.

Contents

1. Introduction: definition, branches, scope and importance of statistics
2. Data: population and sample, variable, categorical and non-categorical data, scales of measurements,
3. Presentation of data: tabulation, parts and construction of table, diagrams and graphs,
4. Pictogram, line chart, histogram, Bar chart, pie chart, gantt chart, timeline, infograph, pedigree chart
5. Frequency distribution: empirical FD, relative FD, cumulative FD, class frequency, limits, boundaries,
6. Measures of central tendency : types of averages, arithmetic, harmonic, geometric mean for grouped and ungrouped data,
7. Median, quartiles ,deciles, percentiles and mode, their advantages and disadvantages

Practical

1. Data collection, presentation in table, graphs, construction of timeline chart, pedigree chart, organogram, Gantt chart, infogram
2. Calculating arithmetic, harmonic and geometric mean, median & mode from ungrouped & grouped data
3. Calculating mean deviation, standard deviation and variance from ungrouped and grouped data
4. Probability distribution, Z-test, T-test, ANOVA, Correlation, Regression

Recommended Texts

1. Field, A. (2017). *Discovering statistics with IBM SPSS statistics* (5th ed.). New York: SAGE Publications Ltd.
2. Belle, G. V., Fisher, L. D., Heagerty, P. J., & Lumley, T. (2014). *Biostatistics – A methodology for the health sciences* (2nd ed.). Dehli: Wiley.

Suggested Readings

1. Campbell, M. J., & Swinscow, T. D. V. (2011). *Statistics at square one* (11th ed.). London: BMJ Books.
2. Quinn, G. P., & Keough, M. J. (2002). *Experimental design and data analysis for biologists*. Cambridge: Cambridge University Press.

ZOOL-6117 Bioinformatics 3(1+2)

The course will provide an introduction to bioinformatics with a focus on fundamental bioinformatics problems and information on the tools used to compute solutions to those problems, and the theory upon which those tools are based. This involves algorithm, and storage/database development of genomics data. It also describes the different types of data found at the NCBI and EBI resources. This course has these main objectives i.e. to organize vast reams of molecular biology data in an efficient manner; to develop tools that aid in the analysis of such data; and to interpret the results accurately and meaningfully. The advent and rapid rise of bioinformatics has been due to the massive increases in computing power and laboratory technology in recent years. These advances have made it possible to process and analyze the digital information regarding DNA, genes and genomes. A student completing Bioinformatics course shall be able to apply it for problem-solving skills and to develop new algorithms and analysis methods.

Contents

1. Introduction to computers, software, hardware, operating systems
2. Bioinformatics: scope, useful websites, aims and bioinformatics tools
3. Biological databases: data acquisition, NCBI, major protein databases in the world, specialized databases, genome and organism databases, miscellaneous databases
4. Genome mapping: genetic and linkage mapping, physical mapping
5. Gene family, protein family, globin family as an example,
6. Data retrieval: searching sequence databases, FASTA format, retrieval of nucleotide/protein,
7. Primer designing, probe, qualities of primer, general rules and websites for primer designing
8. Sequence alignment: importance and significance of alignment, methods for sequence alignment,

Practical

1. Introduction to NCBI, retrieving literature from NCBI and classification of an organism using NCBI. Retrieving FASTA sequence for nucleotide and protein
2. Retrieving disease gene information
3. Searching gene families, Primer designing, Blasting a nucleotide / amino acid sequence

Recommended Texts

1. Selzer, P. M., Marhofer, R. J., & Kock, O. (2018). *Applied bioinformatics: an introduction*. Berlin: Springer Publishing.
2. Lesk, A. (2019). *Introduction to bioinformatics* (5th ed.). Oxford; Oxford University Press.

Suggested Readings

1. Rastogi, S. C., Mendiratta, N. & Rastogi, P. (2013). *Bioinformatics methods and applications: genomics, proteomics and drug discovery*. Dehli: PHI Publishing.
3. Krane, D. E. & Raymer, M. L. (2002). *Fundamental concepts of bioinformatics*. San Francisco: Benjamin Cummings.

ZOOL-6118 **Animal Behavior** **3(3+0)**

This course will give the baseline information about animal behavior and associate the likely role of external and internal stimuli on various animals during the day, season and year. It also relates daily behavioral rhythms in diurnal and nocturnal periodicities and predicts and anticipates variety of animal actions (costs and benefits) as assessed by innate and learned behavioral displays. The unifying theme of this course will be evolution by means of natural and sexual selection. It includes the scientific study of the mechanistic and evolutionary causes of animal behavior, including communication, foraging and anti-predator behavior, spatial behavior, mating behavior, parental care, and social behaviors. After successful completion of this course, students should be capable of understand and identify behaviors in a variety of taxa, can competently discuss the evolutionary origins of various behaviors and can design and implementing experiments to test hypotheses relating to animal behavior.

Contents

1. Introduction: behavior and its types, proximate and ultimate causes of behavior.
2. Development of behavior: Impact of neural and physiological mechanisms; role of external and internal stimuli and animal responses, physiology of behavior in changed environments.
3. Hormones and behavior in animals. Innate behavior and innate releasing mechanisms; built in programmed performance by offspring to that of parents.
4. Innate behavior of three spines stickle back fish. Learned behavior and its mechanisms: quick learners' vs slow learners.
5. Concept of animal cognition: key to understand and develop multiple behavioral choices,
6. Ecological and genetics to maintain animal behavior, concept of territoriality and defense in animals.
7. Circadian rhythms and concept of bio-rhythmicity in animals.
8. Maintenance of internal biological clock to perform various diurnal and nocturnal periodicities.
9. Costs and benefit ratios in behavior; successful foragers and winners of predator prey relationships.
10. Altruism and parental sacrifice to nurture the young.
11. Competition for resources; survival of the most suitable individuals;
12. Social organization in animals and concept of group living; benefits and losses,

Recommended Texts

1. Dngatkin, L. A. (2012).*Principles of animal behavior*. New York: W.W. Nortan & Co.
2. Alcock, J. (2010). *Animal behavior, an evolutionary approach* (9th ed.). Massachusetts: Sinauer Publishers.

Suggested Readings

1. Scott, G. (2005). *Essential animal behavior.* New York: Blackwell Publishers.
2. Goodenough, J., McGuire, B., & Wallace, R. A. (2009). *Perspective on animal behavior*. New York: John Wiley & Sons.

ZOOL-6119 Zoogeography and Paleontology 3(2+1)

The objectives of the course are to provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time; to impart knowledge and concepts of evolution mainly on the basis of fossil record and give understanding that fossil records also provide information about the distribution of animals in the past eras. After completion of this course students will be able to reconstruct the biological traits of extinct organisms, can interpret the modes of life of fossil organisms. The students will learn about Paleogeography focusing on theories of continental drift and plate tectonics, zoogeographical regions mainly faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian and Neotropical regions, Zoogeography of Pakistan and Geochronometry. The practical section will empower them with the knowledge of fauna of various zoogeographical regions and invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.

Contents

1. Paleogeography: theories of continental drift and plate tectonics, pangea
2. Animal distribution, barriers and dispersal
3. Zoogeographical regions: boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian, and Neotropical regions,
4. Zoogeography of Pakistan
5. The planet earth, history, age, shells of earth, atmosphere, hydrosphere, biosphere and lithosphere.
6. Rocks: igneous rocks, sedimentary rocks, metamorphic rocks.
7. Fossil and fossilization: fossil types, uses, nature of fossils, fossilization, invertebrates and vertebrates fossil, biostratigraphy, fossils of Pakistan, Paleontologically important areas of Pakistan.

Practical

1. Study of fauna of various zoogeographical regions.
2. Study of mold, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4. Study of vertebrate fossils e.g. horse/elephant/camel/bovids. Study and identification of rocks
5. Map work for identification of various zoogeographical regions of the World.

Recommended Texts

1. Beddard, F. E. (2015). *A textbook of zoogeography*. Cambridge: Cambridge University Press.
2. Tiwari, S. K. (2006). *Fundamentals of world zoogeography.* Delhi: Sarup & Sons.

Suggested Readings

1. Michael, J. B. & Haper, D. A. T. (2009). *Paleobiology and the fossil record*. New York: Wiley & Blackwell.
2. Foote, M., & Millar, A. I. (2006). *Principles of paleontology*. New York: W. H. Freeman & Co.
3. Ali, S. S. (1999). *Palaeontology, zoogeography and wildlife management*. Hyderabad: Nasim Book Depot.

ZOOL-6120 Aquaculture 3(2+1)

As there is an increased demand of natural and organic food globally, there are various scientific strategies being adapted at commercial level to fulfil the demand of natural food resources with growing population. This course will equip the students with advanced knowledge about aquaculture, its development and future role in human nutrition. This will enable the young students to understand principles of aquaculture and its relationship with biological systems which is important for better planning and management of aquatic resources in Pakistan. Different assisted reproductive technologies and rearing techniques will be discussed for maximum growth of required species on large scale. It will teach about different aquaculture species, their rearing facilities and management by using advanced techniques in practical section. Students will be able to understand the basic requirements to develop aquaculture on commercial scale and be familiar with the outcomes with relevance to their practical life.

Contents

1. The concept of aquaculture, principles of aquaculture management.
2. Aquaculture in raceways, cages and enclosures,
3. Use of waste waters in aquaculture.
4. Mari-culture: substrate system, sea water, ponds.
5. Aquaculture in fresh and brackish waters.
6. Aquaculture in practice: culture of algae, culture of seaweed, culture of mollusks, culture of crustaceans.
7. Culture of freshwater prawns and shrimps:
8. Artificial feeds for aquaculture: Feed constituents, Diet formulation and Processing.
9. Role of biotechnology in sustainable aquaculture development.

Practical

1. Determination of water quality for aquaculture
2. Determination of metals (Cd, Zn, Co, Mn, Fe) in water, plankton and fish
3. Fish feed formulation and processing

Recommended Texts

1. Metha, V. (2009). *Fisheries and aquaculture biotechnology* (2nd ed.). Dehli: Campus Books International.
2. Sharma, O. P. (2009). *Handbook of fisheries and aquaculture*. Dehli: Agrotech Publishing.

Suggested Readings

1. Stickney, R. R. (2009). *Aquaculture: an introductory text*. London: CABI Publishing.
2. Pandey, B. N., Deshpande, S. & Pandey, P. N. (2007). *Aquaculture.* Dehli: APH Publishing Corporation.
3. Parker, R. O. (2004). *Aquaculture science* (4th ed.). London: Delmar Learning.

ZOOL-6121 Biodiversity and Wildlife 3(2+1)

The objective of this course is to enable the student to understand philosophy and significance of wildlife conservation; understand the wildlife management rules and regulations in Pakistan and to understand how national and international agencies are involved in conservation and management of wildlife. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the biodiversity of amphibians, reptiles, birds and mammals, along with the wildlife and its distribution in different major eco zones of Pakistan. The major aims of the subject include knowing what type of wildlife exist in Pakistan and its biodiversity, moreover, how wildlife is being secured in Pakistan. After this course students will become able to participate in wildlife census. The practical section will cover the mammal's population census techniques, ecological indices and procedures for studying species richness, Simpson Index, Shannon and Weiner Function.

Contents

1. Biodiversity: definition, types, levels,
2. Status of biodiversity; importance
3. Natural resources and biodiversity: ecological aspects, impacts, loss of biodiversity,
4. Protection and conservation of biodiversity.
5. Wildlife: introduction, important wild animals of Pakistan,
6. Wildlife importance, wildlife management.
7. Eco zones of Pakistan: wildlife and its distribution in different major eco zones of Pakistan.

Practical

1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population census techniques.

Recommended Texts

1. Kumar, U., & Asija, M. J. (2002). *Biodiversity: principles and conservation*. Ohio: Crescent News.
2. Starr, C. & Taggart, R. (2005). Biology: *the unit and diversity of life* (11th ed.).Boston: Cengage Learning.

Suggested Readings

1. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed.). West Sussex: Wiley-Blackwell.
2. Bolen, E. G., & Robinson, W. (2002). *Wildlife ecology and management* (5th ed.). London: Pearson.

ZOOL- 6122 **Biotechnology** **3(2+1)**

This course is designed to familiarize students with the basic concepts and significance of biotechnology. This course is designed to introduce learners with a solid understanding of science, technology and business management, along with the entrepreneurial skills required to exploit technological advances within a competitive environment. The goal of biotechnology is to produce pharmaceutical products by using living organisms such as bacterial cells, yeast, mammalian cells, etc., that are placed in culture to produce substances with pharmacological activity, such as monoclonal antibodies for the treatment of tumors. The main objectives of the subject are to teach, train and qualify skilled scientists in many disciplines of biotechnology and to provide an intensive and in-depth learning about technical and critical thinking skills necessary for success in the field of biotechnology. Upon completion of the course, the students will develop awareness and knowledge of different basic topics of biotechnology through lectures and practical classes.

Contents

1. Introduction: definitions, types of modern biotechnology and historical perspective,
2. Genetics and biotechnology: genome, human genome, diversity of human genome, nomenclature,
3. Polymerase Chain Reaction, principle, requirements, procedures and applications,
4. Gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder
5. Genetic engineering introduction, steps, vectors and its types, restriction enzymes,
6. Genetically modified organisms, cloning, its types, applications and uses
7. Animal and insect biotechnology: introduction, reasons for producing GM animals.
8. Bioprocess technology: introduction, requirements & typrs of bioreactors,
9. Bacterial and mammalian cell culturing, production of industrially important chemicals

Practical

1. DNA Extraction and quantification of DNA using gel electrophoresis and spectrophotometer
2. Amplification of DNA using PCR
3. PCR product measurement using gel electrophoresis
4. Gender typing of human and animal samples using PCR
5. Restriction fragment length polymorphism of samples
6. Species identification of different animal samples using PCR and RFLP

Recommended Texts

1. Clark, D. B., & Pazdernik, N. J. (2015). *Biotechnology* (2nd ed.). Cambridge: Academic Cell.
2. Schmid, R. D., Schmidt-Dannert, C., & Hammelehle, R. (2016). *Biotechnology: an illustrated primer*. New York: Willey-Blackwell.

Suggested Readings

1. Brown, T. A. (2016).*Gene cloning and DNA analysis: an introduction* (7^{th} ed.). New York: Willey- Blackwell.
2. Butler, J. M. (2009). *Fundamentals of forensic DNA typing*. Amsterdam, Boston: Academic Press.

3. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge: Cambridge University Press.

ZOOL-6123 Comparative Developmental Biology 3(2+1)

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction and provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology is having a significant impact on our understanding of modern molecular techniques in developmental biology and uses of transgenic animals in developmental biology. The students will be able to understand and compare basic principles of embryology through understanding the embryonic adaptations with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through study of prepared slides for the development of amphioxus, mammals, frog and chick isolation, identification and culture of various developmental stages.

Contents

1. Historical review of embryology.
2. Uses of modern molecular techniques in developmental biology.
3. Origin of germ cells (gametogenesis).
4. Spermatogenesis & oogenesis, structure and organization of male and female gametes.
5. Fertilization: chemistry of fertilization, molecular biology of fertilization, surface changes in the egg and sperm surface.
6. Twinning, parthenogenesis, cleavage, blastulation, fate maps and their preparation,

Practical

1. Study of model eggs of different invertebrates and vertebrates.
2. Dactylography, and its uses in embryology.
3. Isolation, identification and culture of various developmental stages of *Ascaris lumbricoides* eggs from human/ *Neoascaris vituolarum* eggs from cattle dung.
4. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.
5. Semen analysis by using improved Neubar Hemocytmeter,

Recommended Texts

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental biology* (11th ed.). Oxford: Oxford University Press, Incorporated.
2. Patten, B. N. (2004). *Foundation of embryology*. New York, London: McGraw Hill Books Company, Inc.

Suggested Readings

1. Rao, K. V. (2003). *Developmental biology: A modern synthesis*. Delhi: Oxford Publishing Ltd.
2. Oppenheiner, S. (2004). *Introduction to embryonic development* (4th ed.). New Jersey: Pearson Education.
3. Saddler, T.W. (2011). *Langmans medical embryology* (Revised ed.). Phledelphia: Wolters Kluwer Health.

ZOOL-6124 Endocrinology 3(2+1)

The course is aimed to impart knowledge about endocrine glands, their anatomy, the hormones released from them and the physiological role of these hormones in body. Endocrinology involves the evaluation and management of disorders of the body's glands, hormonal secretions, and resultant changes in body metabolic activity. The course is designed to provide an understanding to structures and function of endocrine glands. It also provides an understanding of the common endocrine disorders, metabolic regulations, and metabolic abnormalities, and their management. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms of structure, function and its role in regulating metabolism, growth and reproduction in different animals, with reference to some disorders resulting from dysfunction. By the end of this course, the students should be able determine hormonal impact and syndromes.

Contents

1. The endocrine system; type of hormones; endocrine and nervous system relationship
2. Hypothalamus and pituitary: hypothalamic hormones: origin, chemistry and actions; anterior pituitary & hormones: hypothalamic pituitary regulation, general chemistry, physiological action and metabolism of prolactin-growth hormone family, glycoprotein hormones, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: release, regulation and actions.
3. Thyroid gland: anatomy and histology of gland; formation and secretion of thyroid hormones.
4. Calciotropic and mineral metabolism hormones: chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols.
5. Pancreatic hormones physiological roles and mechanism of action. Regulatory peptides of the gut

Practical

1. Demonstration of endocrine glands (Histological and ultra-structure) and associated structures
2. Experiments to demonstrate physiological roles of hormones of different endocrine glands;
3. Experiments to demonstrate regulation of hormones releases and functional diversity in vertebrates.

Recommended Texts

1. Greenspan, F. S., & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Wilson, J. D., Foster, D. W., Kronenberg, H. M., & Larsen, P. R. (2008). *William's textbook of endocrinology*. Philadelphia: W.D. Saunders Company.

Suggested Readings

1. DeGroot, L. J., & Jameson, J. L. (2001). *Endocrinology (*4th ed.). Philadelphia: W.B. Saunders.
2. Giffin, J. E., & Ojeda, S. R. (2000). *Textbook of endocrine physiology* (4th ed.). Oxford: Oxford University Press.

ZOOL-6125 Entomology 3(2+1)

The course is designed to impart knowledge to students about morphology and body parts of the insects. The objective of the entomology undergraduate is to provide students with a broadly-based education in the science and practice of entomology. After this course, students can demonstrate an understanding of insect identification, structure, and function. It includes general characteristics of insects, relationship with other arthropods and evolutionary study of insects splitting up into different evolutionary lines. This subject also imparts knowledge about ecology of insects by learning carrying capacity, food chains, predation and competition, diapause insect population and community studies and insect communication. The practical section will enable the students to prepare permanent slides, distinguish the several body parts (antennae, mouth parts, wings, legs, terminal segments and genitalia) of insects; can study the different systems, especially digestive and reproductive system of the insecst.

Contents

1. General characteristics of insects and their classification
2. Hard parts: general segmentation, tagmatosis and organization.
3. Cuticle: colors of insects, cuticular outgrowths and appendages sclerotization.
4. Head: cephalization, sclerites, modifications.
5. Antennae: different modes of ingestion and types of mouth parts.
6. Neck: sclerites, thorax: sclerites: legs, their different modifications and functions.

Practical

1. Permanent slides of hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia).
2. Digestive & reproductive system of cockroach, gryllus, grasshopper, housefly, butterfly, mosquito, beetle, red cotton bug, wasp and honey bee.
3. Sympathetic nervous system of cockroach and gryllus.
4. Salivary glands of cockroach, red cotton bug and honey bee.

Recommended Texts

1. Richards, O. W., & Davies, R. G. (1977). *Imm's general textbook of entomology* (Vol. 1; 10th ed.). London: Chapman & hall.
2. Chapman, R. F. (2013). *The insects: structure and function* (5th ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Wigglesworth, V. B. (2012). The principles of *insect physiology*. Berlin: Springer Science & Business Media.
2. Peterson, P. G. (2018). *Elements of insect ecology.* London: Edtech Press.

ZOOL-6126 Entomology-II 3(2+1)

The main objective of the course is to develop knowledge about classification of insect orders and their economic importance. This subject provides students with a broadly-based education in the science and practice of entomology. After this course, students can classify the insects up to orders level. It also includes diagnostic characters of the insect orders, knowledge about insects of economic and medical importance and brief account of biological control, chemical control and integrated pest management. This subject also imparts knowledge about common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary of insects. Moreover, some brief account on household pests and their management and knowledge of pests of cotton, rice and sugarcane will also be the part of learning. The practical section will enable the students to collect, preserve and identify insects up to families and can have core knowledge of entomology.

Contents

1. A general account including classification of insect orders: Collembola, Orthoptera, Dictyptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera.
2. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera,
3. Insects of economic importance.
4. Brief account of integrated pest management.
5. Concept of economic levels
6. Household pests and their management.
7. Knowledge of pests of cotton, rice, sugarcane.

Practical

1. Collection, preservation and identification of insects up to families.
2. Identification up to species of a few pests of great economic importance with the help of keys/literature.

Recommended Texts

1. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Long Grove: Waveland Press.
2. Richards, O. W., & Davies, R. J. (1977). *Imm's general textbook of entomology* (Vol-II, 10th ed.). London: Chapman & Hall.

Suggested Readings

1. Metcalf, C. L., & Flint, W. P. (2018). *Destructive and useful insects: their habits and control*. Dehli: AgriHorti Press.

ZOOL-6127 Environmental Issues 3(2+1)

This course is designed to provide review of the different environmental subjects including ecological, conservation, pollution, resources, population and socioeconomic issues of Pakistan. To impart knowledge about management and planning issues using case studies. The environmental study prepares students for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective. In this subject students will learn about environmental and social impacts of growing population and affluence by addressing population problems, food production and its distribution, integrated pest management and several types of pollution with their impact on human life and their combating strategies. The learners will also have knowledge about major atmospheric changes due to acid deposition, global warming, greenhouse effect and ozone depletion. Energy sources and issues related to fossil fuel and nuclear power will also be discussed along with the alternate energy resources. In the end of this course students can analyze various environmental issues.

Contents

1. Environmental and social impacts of growing population
2. Food production and its distribution, pest and pest control: need and approach to pest control.
3. Water pollution: human impact on water resources,
4. Sewage pollution: sewage hazards and sewage managements.

Practical

1. Study of the various characteristics of the population with the help of the statistical data (Age profile, family size and educational status, etc.), study of the types of the pesticides
2. Study of the relationship b/w relative humidity and temperature of Lahore for a particular period. Estimation of total particulate matter in air by using air sampler.

Recommended Texts

1. Botkin, D. B., & Keller, E. A. (2000). *Environmental science: earth as a living planet* (3rd ed.). New York: John Wiley and Sons Inc.
2. Wright, R. T., & Nebel, B. J. (2008). *Environmental science* (10th ed.). New Jersey: Pearson.

Suggested Readings

1. Ahmad, R. Z. (2000). *Pakistan- a descriptive atlas: a comprehensive geo-politics course* (1st ed.). Lahore: Feroze sons Pvt. Ltd.
2. Khan, F. K. (1993). *A geography of Pakistan environment (environment, people and economy)*, (1st ed.). New York: Oxford University Press.

ZOOL-6128 Fish Physiology and Breeding 3(2+1)

This course is formulated to provide sufficient knowledge about all physiological phenomena in fishes. The objective of this course is to provide practical information to obtain better growth of fishes during extensive or semi-intensive culture, to impart knowledge about breeding of most culturable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons. The course presents an introduction to physiological adaptations in fish in relation to their environment. An important part of the course relates to functional physiological regulatory mechanisms. The course is adapted to a focus of fish physiology, breeding including other physiological processes in fishes as respiration, circulation, acid-base balance, osmoregulation and ionic regulation, swimming and buoyancy, sensory physiology, egg and larval physiology, digestion, energetics and growth, reproduction, fish health and diseases. In the end of the course the students will also have knowledge of fish migration (to nursery ground, to maturation grounds, freshwater to marine water, marine water to freshwater) and fish behavior.

Contents

1. Fish nutrition: digestive system, stomach less fishes, stomach fishes, digestion and absorption, food,
2. Transportation: blood, blood cells, circulation, arterial system, venous system, capillaries,
3. Respiration: gills, lungs, skin, swim bladder, homeostasis, excretion: kidneys, osmoregulation
4. Reproduction: gonads, testes and ovaries, artificial fertilization of sex cells.
5. Breeding: natural (seasonal), artificial, hormonal induced breeding, temperature & photoperiod,
6. Growth: extensive culture, semi intensive culture, Intensive culture
7. Fish health: water quality, hygiene of fish culture facilities, hygiene of fish culture
8. Diseases and their control: viral, bacterial, fungal, parasitic, protozoan, helminths, arthropods
9. Fish migration: to nursery ground, to maturation grounds, freshwater to marine water & vice versa
10. Fish behavior: learning and memory, courtship behavior, aquarium fish behavior

Practical

1. Study of gut contents. Study of feeding modification and adaptation in fish.
2. Study of respiratory adaptation in fish, blood cells & their counts in normal and diseased fish.
3. Study of water quality parameters. Study of various forms of swim bladder and fecundity fish.
4. Study the effects of reproductive hormone (GnRH) on fish maturation.
5. Diagnosis of bacterial infection in infected fish and study of fish parasites.
6. Visit to various fish seed hatcheries during breeding seasons.

Recommended Texts

1. Kestin, S. C., & Warris, P. D. (2002). *Kestin farmed fish quality*. Oxford: Blackwell Science.
2. Saksena, D. N. (1999). *Ichthyology: recent research advances*. Dehli: Oscar Publications.

Suggested Readings

1. Stickney, R. R. (2016). *Aquaculture* (3rd ed.). Oxfordshire: CABI.
2. Maseke, C. (1987). *Fish aquaculture*. Oxford: Pergamon Press.

ZOOL-6129 Hematology 3(2+1)

This course provides knowledge about blood formation, morphology, physiology and biochemistry of blood cells, basic mechanisms and types. This course presents the functional morphology of blood cells (normal and abnormal), how important blood diseases manifest, and the approaches to diagnosis and treatment of blood and clotting diseases. It imparts knowledge about advanced techniques in studying serological and hematological techniques including blood coagulation. By the end of this course the student should be able to demonstrate an understanding of the components of human blood and characteristics, functions, abnormalities and disease states of each and can demonstrate proficiency in the skills necessary to perform blood cell counts, and evaluation of blood elements within stated limits of accuracy. After the laboratory practice they will be able to apply principles of safety, quality assurance and quality control in hematology, can compare and contrast hematology values under normal and abnormal conditions and can evaluate normal and abnormal cell morphology with associated diseases.

Contents

1. Blood formed elements and plasma.
2. Erythropoiesis and general aspects of anemia
3. Megaloblastic anemia and other meroblastic anemia.
4. Blood collection techniques.
5. Anticoagulants.
6. Hemolytic anemia.
7. Structure, types and genetic disorders of hemoglobin.
8. Leukopoiesis.
9. Lymphocytes, monocytes, granulocytes and their disorders.

Practical

1. Blood smear of different vertebrates to compare the RBCs morphology.
2. Total erythrocyte and leucocyte counts. Study of granulocytes and agranulocytes.
3. Differential leukocytes. Estimation of Hemoglobin. Study of erythrocytes sedimentation.
4. Comparison of blood counts of diseased (Anemia) and healthy individuals.

Recommended Texts

1. Hoffbrand, A. V., & Moss, P.A.H. (2002). *Essential hematology*. London: Wiley Blackwell.
2. Bain, B. J., Bates, I. & Laffan, M. A. (2016). *Dacie & Lewis practical haematology* (12th ed.). London: Elsevier Health Sciences.

Suggested Readings

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K. & Watson, J. D. (2017). *Molecular biology of the cell*. New York: Garland Publishing Inc.
2. Cooper, G. (2018). *The cell: A molecular approach* (8th ed.). Oxford: Oxford University Press.

ZOOL-6130 Ichthyology 3(2+1)

This course is formulated to study the evolution and taxonomy of fish, to provide the knowledge regarding fish biology and to elaborate the anatomy and physiology of fish. The overarching goal of this course is to learn how the biological evolution process has shaped the existing taxonomic diversity and physiological variability of fishes. To achieve this goal, students will allow to survey fish diversity and examine the connections between anatomical traits and biological function as exemplified by living fish species. After this course students will be able to describe how the aquatic environment shapes all aspects of the biology of fish species, can explain how anatomy relates to function across major organ systems in fishes and can describe the basic function and organization of fish organ systems. The course focuses on physiological processes in fish including, respiration, circulation, acid-base balance, osmoregulation and ionic regulation, locomotion and energetics of swimming, swimming and buoyancy and digestion and control of gastro-intestinal motility in fish. Therefore, students will be provided an in-depth review of each topic in ichthyology.

Contents

1. Classification of Pisces
2. Morphological features of fish,
3. Fish muscular system and locomotion.
4. Physiology of respiration and air breathing among fishes.
5. Cardiovascular system, blood and its circulation
6. Digestion and control of gastro-intestinal motility in fish.
7. Physiology of gas bladder: use of gas by the fish as a source of static lift.
8. Gas in the gas bladder: loss, retention and secretion of gas.

Practical

1. Study of classification of fishes and some selected fish species
2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological and economic importance of fishes

Recommended Texts

1. Lagler, K. F., Baradach, J. E. & Miller, R. R. (2009). *Ichthyology*. New York: John Wiley and Sons, Inc.
2. Moyle, P. B. & Cech, J. J. (2008). *Fishes: An introduction to ichthyology* (6th ed.). New Jersey: Prentice Hall.

Suggested Readings

1. David, H. (2003). *The physiology of fishes* (3rd ed.). Florida: CRC Press.
2. Smith, L. S. (2002). *Introduction to fish physiology* (2nd ed.). Washington: Argent Labs.

ZOOL-6131 Immunology 3(2+1)

The course aims to give understanding of the basic concepts of immunology and its importance in biological sciences, provide information about immunological mechanisms against different diseases and gives understanding of immunization, immunological tolerance etc. After this course the students will be able to understand immunobiology, immunohistology and immunopathology. The course have brief account on natural and acquired immunity, active and passive immunity, antigens and elicitation of immune responses. The students will be able to describe immunological response and how it is triggered and regulated. This subject also focuses on detection and application of antigen-antibody reactions, antigen antibody interactions and monoclonal antibodies. Cellular basis of immune response will also be discussed in detail along with the immunological tolerance and autoimmunity. The students will be able to describe immunological response and how it is triggered and regulated and they acquire for problem-solving capacity about immune responsiveness.

Contents

1. Immunology: introduction. Immunity: types: natural and acquired immunity.
2. Antigens and their types, antigenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens
3. Immunoglobulins: synthesis and types of antibodies. Detection of antigen-antibody reactions
4. Antigen antibody interactions. Monoclonal antibodies: importance, synthesis. Major histocompatibility complex: types and importance.
5. Cellular basis of immune response: origin of lymphocytes, primary and secondary lymphoid organs, specific response of individual lymphocytes to antigenic stimulation,
6. Hypersensitivity: Immediate hypersensitivity, delayed type or cell mediated hypersensitivity.

Practical

1. Study of different types of leucocytes in blood, bone marrow, spleen and thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbent assay (ELISA).

Recommended Texts

1. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). *Kuby's immunology* (8th ed.). New York: W. H. Freeman Company.
2. Delves, P. J., Martin, J. S., Burton, D. R., & Roitt, I. M. (2017). *Roitt's essential immunology* (13th ed.). New Jersey: Wiley Blackwell.

Suggested Readings

1. Abbas, A., Lichtman, A., & Pilla, S. (2017). *Cellular and molecular immunology* (9th ed.). Amesterdam: Elsevier.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (1994). *Cellular and molecular immunology*. London: Elsevier Health Sciences.

ZOOL-6132 Integrated Pest Management 3(2+1)

The course aims to impart knowledge about approaches to control pest in an integrated manner. It will develop the understanding of multiple strategies to control various pests of human interest. This course will provide introduction, historical background and geographical distribution of various insect species along factors that makes them pest. Available biological pest control, their identification and distribution will be introduced through these learnings. Students will be given knowledge about biological features and varieties of biological mediators to control insect pests. Theoretical foundation of pest control will be highlighted. Moreover, it includes opportunities and challenges for insect pest control in developing countries, concept of economic threshold level and concept of classical biological control. Understanding about recent strategies which are in practice nationally or internationally to manage pests will be given to students. Several techniques which are commercially used for rearing of biological pest control agents including culturing of bacteria and virus will be familiarized.

Contents

1. Introduction: foundation, approaches and objectives.
2. Opportunities and challenges for insect pest control.
3. Concept of economic threshold level, economic injury level.
4. Ranking of natural enemies, major threats to the natural enemies.
5. Concept of classical biological control.
6. Effects of different agronomic practices on the population of predators.
7. Relationship of biological control to the sustainable agriculture.
8. Augmentation and inoculation of natural enemies.
9. Limitation of biological control and modern trends to overcome this problem.

Practical

1. Collection and identification of important pests and their enemies,
2. Techniques to culture and maintain selected natural enemies of insect pests in the laboratory and in the fields.

Recommended Texts

1. Bradford, A. H. & Howard V. C. (2008). *Theoretical approaches to biological control*. New York: Cambridge University Press.
2. DeBach, P. (1991). *Biological control by natural enemies* (2nd ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Dent, D. (2005). *Insect pest management* (2nd ed.). Oxfordshire: CABI.
2. Pedigo, L. P. & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Long Grove: Waveland Press.
3. Van Driesche, R. G. & Bellows, T. S. Jr. (2012). *Biological control*. Berlin: Springer Science & Business Media.

ZOOL-6133 Microbiology-I 3(2+1)

Microbiology is the study of microorganisms which include: bacteria, viruses, viroids, yeast, molds, protozoans, algae, fungi and other very small organisms. Microbiology is important because it helps us to understand and treat diseases. This course covers basic principles of microbiology and provides an introduction to the characterization and classification of microorganisms and cultivation of bacteria. Students are expected to gain a fundamental understanding of microbes including viruses, Bacteria, Archaea and eukaryotic microorganisms. After completion of the lecture component of the course, successful students will be able to understand morphology and fine structure of bacteria, cultural characteristics and microbial metabolism processes. It will also help students to recognize how microorganisms solve the fundamental problems their environments present. The laboratory practice can help them to study of bacteria, fungi and protozoa, staining techniques and can apply scientific method to collect, interpret, and present scientific data in microbiology and related fields.

Contents

1. Microbiology introduction and history.
2. Microscopic examination of microorganisms.
3. Characterization and classification of microorganisms.
4. Morphology of bacteria.
5. Morphology of Protozoa
6. Methods of bacteria cultivation
7. Culturing techniques
8. Observation of culture and metabolism

Practical

1. Study of bacteria, fungi and protozoa.
2. Staining of microorganisms: simple staining, negative staining.
3. Demonstration of special structures by stains; capsular stain, spore stain, metachromatic granule stain, acid fast stain, flagella stain.

Recommended Texts

1. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). New York: McGraw-Hill.
2. Pelczar, Jr., Chan, E. C. S., & Krieg, M. R. (2010). *Microbiology: application based approach.* London: McGraw Hill.

Suggested Readings

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). New Jersey: Pearson.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6134 Microbiology-II 3(2+1)

The course aims to develop knowledge about phylogeny of bacteria, their mode of nutrition and their diversity. The course will impart knowledge about phylogenetic relationship of the bacteria with other prokaryotes. Microbiology is important because it helps us to understand and treat diseases. This course covers basic evolutionary lineage of bacteria (proteobacteria). Students are provided fundamental understanding ofphototrophic, chemolithotrophic and methanotrophic proteobacteria, aerobic and facultative aerobic chemoorganotrophic proteobacteria and morphologically unusual proteobacteria. After completion of the lecture component of the course, successful students will be able to understand the structural similarities and differences among delta and epsilon proteobacteria, firmicutes, mollicutes and actinobacteria. It will also help students to appreciate the diversity of cyanobacteria and prochlorophytes and can recognize how microorganisms solve the fundamental problems their environments.

Contents

1. Diversity of Archea,
2. The phylogeny of bacteria andproteobacteria,
3. Aerobic and facultative aerobicproteobacteria,
4. Bacterial physiology
5. Delta and epsilon proteobacteria,

Practical

1. Culturing of microorganisms: preparation and sterilization of culture media, broth culture, agar slope, agar slab, streak plates, pour plates.
2. Isolation and stock culturing of bacteria.
3. Quantitative plating method.

Recommended Texts

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). New Jersey: Pearson.
2. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). New York: McGraw-Hill.

Suggested Readings

1. Pelczar, Jr., Chan, E. C. S. & Krieg, M. R. (2010). *Microbiology: application-based approach.* London: McGraw Hill.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L. & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6135 Molecular and Clinical Endocrinology 3(2+1)

The course is designed to develop understanding of molecular mechanisms of hormone action, their molecular assessment and use of molecular techniques to treat endocrine disorders. The course of Molecular and Clinical Endocrinology aims to provide excellence in clinical care for all aspects of health and disease related to endocrine management like thyroid, adrenal, parathyroid, diabetes, pituitary, bone, obesity and lipid disorders. It also provides an understanding of the general mechanisms in molecular endocrinology, radioimmunoassay, immunoradiometric, immunochemiluminometric and radioreceptor assays and their statistical procedures. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms functional pathology in endocrine glands, disorders of growth and puberty, endocrine hypertension and Polyendocrine syndromes. By the end of this course, the students should be able to examine and describe glands and can determine their hormonal impacts.

Contents

1. General mechanisms in molecular endocrinology: structure of cells secreting protein hormones; process of hormone secretion;
2. Mechanisms of action of hormones: hormone systems and intracellular communication;
3. Hormones acting at cell surface: properties of hormone receptor interaction,
4. Biochemistry and molecular interaction of steroid receptor, gene expression,
5. Functional pathology in endocrine glands: neuroendocrine disorder
6. Pituitary disorders: prolactinomas, acromegaly, Cushing's syndrome. Diabetes insipidus,
7. Thyroid diseases of excess and deficient hormones

Practical

1. Studies on recognition & response of receptors. Studies of hormonal status in puberty and aging.
2. Studies of disorders of pituitary by observing anatomical and histological features.
3. Studies of thyroid status in deficient and excess hormone functions.
4. Study type 1 and type 2 diabetes mellitus, epidemiology & studies of management of the type 2.

Recommended Texts

1. Greenspan, F. S. & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S. & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10th ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. DeGroot, L. J. & Jameson, J. L. (2001). *Endocrinology* (4th ed.). Philadelphia: W.B. Saunders.
2. Neal, J. M. (2000). *Basic endocrinology: an interactive approach.* London: Blackwell Science Inc.

ZOOL-6136 Ornithology 3(2+1)

The course will provide knowledge about bird diversity, avian anatomy, physiology and adaptations, bird behavior and socioeconomic and ecological importance. This course is an advanced undergraduate survey of ornithology. This means that students will learn about both science and birds at the same time. This course combines traditional zoology with an emphasis upon avian biology and diversity, and is delivered along with aspects of conservation management and practices. Students will learn about birds: how to identify them, what are the major characteristics and distinguishing features of the major groups of birds, and how birds function in a diversity of environments. However, this course will also cover a modern scientific approach to birds, which has as its goal not just understanding birds, but using birds as a means to uncover general biological principles that may apply to all living things. Students will acquire by the end of the course a new appreciation and knowledge of birds.

Contents

1. Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species;
2. Biology of fossil bird's archaeopteryx, archaeornithes, neoornithes;
3. Morphology and surface anatomy of bird, and development structure of feathers, plumage; bones; basic embryology of birds; internal anatomy of birds; Systems physiology;
4. Blood circulatory, cardiovascular physiology, heart, blood cells
5. Respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption;
6. Urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste; digestive system, anatomy,

Practical

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, anatomy of bones, skull, girdles, spine, vertebrae, feathers, Study of gut contents of birds to understand feeding habits. Study of brood parasitism.
3. Incubation of chicken eggs to learn avian embryogenesis. Study of flying mechanics
4. Bird stuffing and preservation of eggs. Identification of bird species through feathers and eggshells.

Recommended Texts

1. Howell, S. N. G. (2010). *Peterson reference guide to molt in North American birds.* Amazon: Peterson Reference Guides.
2. Urfi, A. J. (2009). *Birds of India: a literary companion.* Oxford: Oxford University Press.

Suggested Readings

1. Rank, B. (2004). *Ornithology: ecology and evolution of Darwin's finches.* Princeton: W. H. Freeman.
2. Sibley, D. A., & Alfred, A. (2002). *Sibley's birding basics.* New York: New York Press.
3.

ZOOL-6137 Physiological Systems and Adaptations 3(2+1)

This course gives details of physiological systems maintaining the homeostasis of animals. Inter-relations of the systems and regulatory features of the each system's function will be focused. The major goal of the course is to provide a course of study in mammalian, principally human, systems physiology, building on knowledge of basic physiological principles. Its contents mainly cover cardiovascular system, respiratory system, renal system, gastrointestinal system and osmoregulation. It also focuses on environmental challenges of temperature regulation like temperature and animal energetics, temperature relation of ectotherms, heterotherms and endotherms. Laboratory practice will enable the students to study of heart in prepared frogs, to study blood pressure in various physiological states, study of electrocardiograms and to determine the oxygen consumption in fish and mouse and effects of various factors affecting it. Physiological systems and adaptations also focus on how the metabolic, neuromuscular, cardiovascular, and respiratory systems respond to the demands of varying adaptations and it modifies these systems.

Contents

1. Cardiovascular System: blood and homeostasis, arterial system; microcirculation and lymphatics;
2. Special circulations: cutaneous, skeletal, coronary, cerebral and fetal.
3. Respiratory System: overview of respiratory system & respiratory responses in extreme conditions.
4. Renal System: elements of renal function; tubular function in nephron and osmolarity;
5. Gastrointestinal System: gastrointestinal secretions and their control: salivary, gastric, pancreatic and liver; digestion and absorption of carbohydrates, proteins, lipids, vitamins, ions and water; motility of gastrointestinal tract:

Practical

1. Experiments on the study of heart in frogs.
2. Study of blood pressure in various physiological states. Study of electrocardiograms.
3. Blood coagulation study. Determination of oxygen consumption in fish and mouse.
4. Demonstration of respiratory volume and pulmonary function tests.
5. Experiments on digestion on nutrients by enzymes and effects of factors; Study of exocrine secretion in stomach or pancreas and effects of factors. Experiments on kidney regulation of osmolality.

Recommended Texts

1. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *Eckert animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman & Company.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

Suggested Readings

1. Berne, R. M., & Levy, M. N. (2000). *Principles of physiology* (3rd ed.). Missouri: Mosby.
2. Guyton, A. C. & Hall, J. E. (2015).*Textbook of medical physiology* (12th ed.). Philadelphia: W.B. Saunders Company.

ZOOL-6138 Physiology of Reproduction 3(2+1)

The course aims to provide knowledge about reproductive system and its role in the behavior of the animals. It will enable the students to develop the understanding about the role of sex hormone in sexual behavior and their interaction during development. The major objective of this course is to provide students with a sound coverage of human reproductive physiology within the framework of human body. This is achieved by first covering fundamentals of the structure and function of the male and female reproductive tracts, gametogenesis, fertilization, early embryogenesis, fetal development and preparation for birth, contraceptive methods and maternal adaptations to pregnancy. It particularly emphasize on the hormonal control of reproduction. This in turn provides an important foundation to consider sexual differentiation and development, contraception, infertility and current reproductive technologies. Finally, human reproductive behaviour and its implications to our future are considered in the light of our evolutionary history, culture and society.

Contents

1. Introduction, sex determination and differentiation:
2. Hormonal and neural factors and their interaction in ovarian, testicular and reproductive targets functions; the interactions in development in estrous and menstrual cycle
3. Reproductive behavior: physiological basis of male and female sexual behavior. Maternal behavior.
4. Endocrine basis of communication in reproduction
5. Pheromone in mammalian reproduction;
6. Rhythms in reproduction and pregnancy;
7. Hormonal mechanism in fertilization, zygote transport and implantation.
8. Placental steroid and polypeptide hormones; maternal metabolism gestation, hormonal mechanism in parturition.

Practical

1. Study of male and female reproductive tract; physiological histology of segments of male and female reproductive tracts;
2. Recognition of spermatogonial cells, ovarian follicles and corpus luteum in gonads; study of hormonal mechanisms in super ovulation and implantation;
3. Tests for pregnancy recognition;
4. Experiments on role of gonads in maintenance of accessory sex gland in males and target structures in females. Study of fertility control procedures in populations.

Recommended Texts

1. Evert, B. J. & Johnson, M. H. (2000). *Essential reproduction.* Oxford: Blackwell Science Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S. & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10^{th} ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. Knobil, E. & Neill, J. D. (2006). *The physiology of reproduction* (Vol. 2). Houston: Gulf Professional Publishing.

ZOOL-6139 Principles of Parasitology 3(2+1)

This course will provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance knowledge about their pathology, host parasite relationship and control measures. Overall aim of the course is to provide students with knowledge concerning biological, epidemiological and ecological aspects of parasites causing diseases to humans, enable them to understand the pathogenesis, clinical presentations and complications of parasitic diseases, to establish knowledge regarding pathogenesis, clinical presentations and complications of parasitic diseases and to provide students with adequate knowledge about endemic parasites and national parasitic problems as well as re-emerging parasitic infection. By the end of the courses, students will be able to describe the world distribution of important parasitic infections and the epidemiologic principles and the effect of social and demographic patterns on parasitic disease and vulnerability and can describe molecular, biochemical and cellular mechanisms that occur in the body of humans infected with parasites.

Contents

1. Introduction to parasitology. Relationship to other sciences. Some basic definitions and principles.
2. Immunology and pathology. Susceptibility and resistance, innate defense mechanisms.
3. Acquired immune response in vertebrates.
4. Immunodiagnosis and pathogenesis of parasitic infections. Host-parasite relationship.
5. Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin, forms of trypanosomatidae. The Amoebas: Order Amoebida, order Schizopyrenida.
6. Phylum Apicomplexa, Gregarines, Coccidia and relatedorganisms.
7. Phylum ciliophora, ciliated protistan parasites,

Practical

1. Preparation of temporary and permanent slides and identification of parasitic protozoan and local helminthes of medical and veterinary importance.
2. Section cutting of the infected tissues and the study of their pathology.
3. Methods of collection, preservation and transportation of parasitic material.
4. Qualitative and quantitative.

Recommended Texts

1. Roberts, L. S. & Janovy, J. Jr. (2005). *Foundations of parasitology* (7th ed.). Chicago/ London: W.M. Brown Publishers.
2. Urquhart, G. M., Hucan, J. L., Dunn, A. M. & Jennings, F. W. (2000). *Veterinary parasitology.* London: Longman Publications.

Suggested Readings

1. Watson, J. M. (2014). *Introduction to animal parasitology.* London: Elsevier.
2. Cheesbrough, M. (2006). *Laboratory practice in tropical countries* (2nd ed.). Cambridge: University Press Cambridge.

ZOOL-6140 Principles and Kinetics of Toxicology 3(2+1)

The course objectives are to provide knowledge about the nature and mode of action of different categories of toxicants and to provide knowledge about the procedural protocols used in toxicological studies. The major contents of the course includes measuring toxicity and assessing risk, chemistry of toxicants; toxicity testing methods; routes of exposure, responses to varying doses of substances and LD50 experiments. Toxicokinetics aims to empower the students with the understanding of absorption and bioavailability and contrasting kinetics of lipophilic substances, routes of absorption (the oral, respiratory and dermal) and elimination. In addition, students will learn about biotransformation (phase I reaction and phase II reaction), cellular sites of action, effect of toxicants on enzymes and mechanism of cell death(apoptosis, necrosis, stress, repair) and recovery. The aim of this subject is to train high-quality scientists in applied toxicology with a heightened respect for the environment. Students will develop a broad range of skills, knowledge and experience required for successful careers.

Contents

1. Introduction, Chemistry of toxicants; routes of exposure, responses to varying doses of substances, time of exposure; the LD50 experiments,
2. Toxicokinetics: Introduction; pharmacokinetics and toxicokinetics,
3. Absorption: the oral, respiratory and dermal route of exposure, distribution, Elimination, toxicokinetic models: mathematical models of elimination, Absorption and bioavailability; contrasting kinetics of lipophilic substances.
4. Biotransformation: Introduction, Primary biotransformation (phase I reaction)
5. Secondary metabolism (phase II reaction).
6. Cellular sites of action, introduction, interaction of toxicants with proteins,
7. Effect of toxicants on enzymes, receptors and ion channels,
8. Effects of toxicants on lipids and nucleic acids,
9. Mechanism of cell death; apoptosis, necrosis, stress, repair and recovery.

Practical

1. Study of Biotoxicity assay for LC50.
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo.
3. Study the effect of Ethanol on the development of chick embryo with different doses.
4. Study the effect of Xylene on the development of chick embryo.

Recommended Texts

1. Stine, K. E., & Brown, T. M. (2015). *Principles of toxicology*. London: CRC press.
2. Marquardt, H., Schafer, S. G., Mcclellan, R. O., & Welsch, F. (2004). *Toxicology*. San Diego: Academic press.

Suggested Reading

1. Barile, F. A. (2013). *Principles of toxicology testing*. London: CRC Press.

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ZOOLOGY

ZOOL-6201 Fisheries 3(2+1)

Fisheries is a multidisciplinary science, which draws on other disciplines in an attempt to provide an integrated picture. Over the most recent several decades, there has been declined in fish stocks (populations) in many regions along with increasing concern about the impact of intensive fishing on marine and freshwater biodiversity. Fishery science operates primarily through stock assessment in ponds meant for fish culture. Fisheries scientists analyze the ecological health and sustainability of fisheries, how the health of fisheries affects the people who interact with them and vice versa. Fisheries scientists assess and monitor fish and aquatic invertebrate populations to determine ecological and economic health of the environment as well as to determine harvest rates of various species. Harvest rates refer to the amount of fish or aquatic invertebrates caught for commercial, recreational or subsistence purposes. Fisheries science includes many areas of research, such as studying aquatic populations, habitats, ecological health, biodiversity, physiology and toxicology, socioeconomics and fisheries management. Aquatic resources management refers to the process of minimizing adverse impacts on aquatic populations within their shared habitat through science-based practices in order to conserve the aquatic resource as a whole.

Contents

1. Introduction to fisheries and aquaculture, national and international trends
2. Fish morphology and diversity in size and shape
3. Distribution of fishes in Pakistan, commercial fishes, marine and freshwater
4. Types of ponds, planning construction and pond preparation
5. Pond fertilization, application, food and feeding habits of fishes, feeding types, artificial and natural fish food, artificial fish feeds
6. Fish habitat, ecology and extant of distribution, water quality parameters (abiotic: temperature, light, salinity, pH, turbidity) and their effects on fish health and production

Practical

1. Morphological characters of a typical fish
2. Species identification, fin formula, key to identification of commercial fishes
3. Dissection of common fish to study its various systems
4. Practical demonstration of induced breeding. Introduction to artificial feed ingredients

Recommended Texts

1. Dunham, R. A. (2011). *Aquaculture and fisheries biotechnology: genetic approaches*. London: CAB International.
2. Sharma, O. P. (2009). *Handbook of fisheries and aquaculture*. Delhi: Agrotech Publishing Academy.

Suggested Readings

1. Stickney, R. R. (2009). *Aquaculture: an introductory text*. London: CAB International.
2. Pillay, T. V. R., & Kutty, M. N. (2005). *Aquaculture: principles and practices*. New York: Blackwell Science.

ZOOL-6202 General Biochemistry 4(3+1)

Biochemistry is the application of chemistry to the study of biological processes at the cellular and molecular level. 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, physics, molecular biology, and immunology to study the structure and behavior of the complex molecules found in biological material and the ways these molecules interact to form cells, tissues, and whole organisms. Biochemists are interested, for example, in mechanisms of brain function, cellular multiplication and differentiation, communication within and between cells and organs, and the chemical bases of inheritance and disease. The biochemist seeks to determine how specific molecules such as proteins, nucleic acids, lipids, vitamins, and hormones function in such processes. Particular emphasis is placed on the regulation of chemical reactions in living cells.

Contents

10. Amino acids, peptides and proteins; enzymes: introduction; important characteristics of enzymes
11. Classification, types, important characteristics and structure of carbohydrates: mono, disaccharides
12. Polysaccharides, storage and structural types; structure and major functions of polysaccharides
13. Lipids: fatty acids, their types and major characteristics, structural lipids in membranes, lipoproteins
14. Vitamins and cofactors: occurrence, structure and biochemical function of vitamins B complex
15. Metabolism- glycolysis, aerobic and anaerobic conditions, feeder pathways, regulation

Practical

4. Preparation of standard curve for glucose; acid hydrolysis of polysaccharides
5. Biochemical tests for detection of carbohydrates, reducing sugars & non-reducing sugars, amino acids
6. Separation and identification of various types of sugars, fatty acid and amino acids (TLC)
7. Separation of various protein fractions and differential solubility of lipids
8. Quantitative analysis of phospholipids and amylase activity, study of enzyme kinetics

Recommended Texts

3. Nelson, D. L., & Cox, M. M. (2012). *Lehninger principles of biochemistry*. New York: McMillan worth Publishers.
4. Berg, J. M., Tymoczko, J. L., & Stryer, L. (2011). *Biochemistry* (7th ed.). New York: MacMillan.

Suggested Readings

4. Lodish, H., Berk, A., Zipursky, S. L., Paul, M., Baltimore, D., & Darnell, J. (2012). *Molecular cell biology.* New York: Freeman.
5. McKee, T., & McKee, J. R. (2003). *Biochemistry: The molecular basis of life* (3rd ed.). London: McGraw Hill.

ZOOL-6203 Cell and Molecular Biology 4(3+1)

This is dynamic course deals with the study of prokaryotic and eukaryotic cells. Subcellular membrane bound and non-membranous organelles like mitochondria, smooth and rough endoplasmic reticulum, ribosomes, lysosomes, peroxisomes, glyoxysomes etc. The details of molecular structure and functions of plasma membrane and endomembrane system are also included. This study also includes the intracellular movement and transport of materials as well as the exocytosis (cell secretions and excretions) and endocytosis (phagocytosis, pinocytosis, active transport and bulk transport of materials). The study of the molecular basis of life, the structure and flow of information form nucleus (gene structure, regulation, mutations, whole genome analysis) to the cytoplasm (the structure of DNA, chromatin and chromosome DNA replication, transcription, post transcriptional processing including posttranscriptional addition of cap and tail RNA, splicing mechanisms, storage and translation of RNAs, protein synthesis and the post translation processing of the protein molecules, transcriptional and translational control mechanisms) and cellular replication processes are also included in this course.

Contents

1. Introduction to prokaryotic and eukaryotic cells; plasma membrane, structure and functions
2. Cytoskeleton: microfilaments, microtubules, intermediate filaments.
3. Ultrastructure, chemical composition and functions of endoplasmic reticulum, golgi apparatus
4. Mitochondrial respiration and its significance as semi- autonomous organelle
5. Cellular roles of lysosome, peroxisome and glycoxysome; structure and functions of nucleus
6. Replication: mechanism, DNA replication in prokaryotes and eukaryotes
7. Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA, post transcriptional processing, RNA transduction

Practical

1. Identification of cell organelles; preparation of human blood smear and identification of leucocytes
2. Permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone
3. Mounting of polytene chromosomes (drosophila); study of mitosis in onion root tips

Recommended Texts

1. Cooper, G. M., & Hausman, R. E. (2018). *The cell: A molecular approach* (8th ed.). Massachusetts: Sinauer Associates.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2016). *Molecular cell biology* (8th ed.). New York: W. H. Freeman.

Suggested Readings

1. Iwasa, J., & Marshall, W. (2016). *Karp's cell and molecular biology: concepts and experiments* (8th ed.). New Jersey: John Wiley and Sons.
2. De-Robertis, E. D. (2014). *Cell and molecular biology* (8th ed.). New York: Lea & Febiger.
3. Alberts, B., Johnson, A. D., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). New York: W. W. Norton & Company.

ZOOL-6204 **Biostatistics** **3(3+0)**

The course aims to provide knowledge about the importance and use of statistics in life sciences and familiarize students with the methods of data analysis pertaining to their research work and to assess the significance of experimental designs. Specific topics include tools for describing central tendency and variability in data, methods for performing inference on population means and proportions. After finishing this course, students will be able to recognize the importance of data collection and its role in determining scope of inference, demonstrate a solid understanding of interval estimation and hypothesis testing, choose and apply appropriate statistical methods for analyzing one or two variables and interpret statistical results correctly and effectively. More specifically, by the end of the course they will be able to identify cases and variables in a dataset, and classify variables as categorical or quantitative and to recognize when it is, and is not, appropriate to use sample data to infer information about a population.

Contents

1. Introduction and scope: use of statistics in biology
2. Population and sample: stages of research
3. Types of data: methods of data collection.
4. Data arrangement and presentation, formation of tables and charts
5. Measures of central tendency
6. Computation of mean, median and mode from grouped and un grouped data
7. Measures of dispersion: computation of variance, standard deviation, standard error and their coefficients
8. Probability rules: binomial, poisons and normal distributions
9. Hypothesis testing
10. Student 't' test
11. Chi square test
12. Handling of multiple samples
13. Analysis of variance and LSD
14. Correlation and regression
15. Experimental designing, planning of an experiment, replication and randomization

Recommended Texts

1. Field, A. (2017). *Discovering statistics with IBM SPSS statistics* (5th ed.). New York: SAGE Publications Ltd.
2. Belle, G. V., Fisher, L. D., Heagerty, P. J., & Lumley, T. (2014). *Biostatistics – a methodology for the health sciences* (2nd ed.). Dehli: Wiley.

Suggested Readings

3. Campbell, M. J., & Swinscow, T. D. V. (2011). *Statistics at square one* (11th ed.). London: BMJ Books.
4. Quinn, G. P., & Keough, M. J. (2002). *Experimental design and data analysis for biologists*. Cambridge: Cambridge University Press.

ZOOL-6205 **Wildlife** **3(3+0)**

Regional background information about zoogeographic influences upon animal distribution across the main ecological zones of Pakistan is the core area of this subject. The course outlines introduction, current and past status, distribution of animals, theories, practices, and issues of wildlife and its management in Pakistan. The mountainous areas embracing the Himalayan, Karakorum and Hindukush Ranges are rich in fauna and flora, compared to other parts of the country because of inaccessibility. The Himalayan foothills and the Potohar region, including the Salt Range and Kala Chitta Range, are covered with scrub forests, which have been reduced to scanty growth in most places. Vast Indus flood plains have been cleared of natural vegetation to grow crops. Very little wildlife habitat has been left untouched. Little vegetative cover, severity of climatic conditions and the great thrust of grazing animals on the deserts have left wild animals in a precarious position. The main threats to wild animals include, the competition with domestic livestock, increasing human interference, the construction of roads, and hunting. Establishment of protected areas is crucial to conservation of existing biodiversity.

Contents

1. Biodiversity and wildlife in context of its services
2. Wildlife prior to establishment of Pakistan and current status of wildlife through study of map
3. Vegetative zones, eco-regions and associated wildlife in Pakistan
4. Provincial biodiversity of Pakistan
5. Wildlife rules and regulations in Pakistan
6. Protected areas of Pakistan: Marine protected areas, land protected areas
7. National parks
8. Game reserves
9. Wildlife sanctuaries
10. Ramsar sites and wetlands
11. Major threats to wildlife of Pakistan
12. Endangered fauna of Pakistan
13. Role of national organizations in conservation and management of wildlife

Recommended Texts

1. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed). West Sussex: Wiley-Blackwell.
2. Bolen, E. G., & Robinson, W. (2002). *Wildlife ecology and management* (5th ed). London: Pearson.

Suggested Readings

1. Roberts, T. J. (1977). *Mammals of Pakistan* (1st ed.). London: Ernest Benon Ltd.
2. Roberts, T. J. (1991). *The birds of Pakistan, regional studies and non-passeriformes* (1st ed.). Oxford: Oxford University Press.
3. Roberts, T. J. (1992). *The birds of Pakistan, passeriformes: pittas to buntings* (1st ed.). Oxford: Oxford University Press.
4. Sharif, M. K. (2006). *The amphibians and reptiles of Pakistan*. Florida: Krieger Publishing Company

ZOOL-6206 **Environmental Biology** **4(3+1)**

Environmental science is focused on a holistic understanding of earth systems in order to learn from the past, comprehend the present and influence the future. The distribution and abundance of organisms on earth is shaped by biotic, living-organism-related, and abiotic, nonliving or physical, factors. This branch of science encompasses five discrete and overlapping areas of human science, population, community, ecosystem, and biosphere. Study at organism level involves understanding adaptations that allow organisms to live in specific habitats. These adaptations can be morphological, physiological, or behavioural. Research at population level encompasses the study of size, density, and structure of populations and how they change over time. Study of ecosystems often focuses on flow of energy and recycling of nutrients among biotic and abiotic components of ecosystem. Working at the biosphere level involves studying global patterns, climate or species distribution, interactions among ecosystems, and phenomena that affect the entire globe, such as climate change.

Contents

1. Energy: laws of thermodynamics, primary & secondary productions, trophic levels and energy flow
2. Biogeochemical cycle: nitrogen, phosphorus, sulphur, water, carbon, nutrient
3. Limiting factors: basic concepts, temperature, soil, water and humidity, light, fire
4. Global ecosystems: atmosphere, hydrosphere, lithosphere, ecosphere
5. An overview of ecosystem with special reference to ecological niche: basic concepts and types

Practical

1. Measurement of environmental factors on land, water and air
2. Study of different ecosystems: pond, agricultural or grassland, forest
3. Community analysis through different sampling techniques (quadrat, transect)

Recommended Texts

1. Molles, M. C. (2005). *Ecology: concepts and applications* (6th ed.). New York: McGraw Hill.
2. Cox, C. B., Morre, D., & Ladle, R. J. (2016). *Biogeography: an ecological and evolutionary approach* (6th ed.). London: Wiley-Blackwell.

Suggested Readings

1. Dondson, S. I., Allen, T. F. N., Carpenter, S. R., Ives, A., Jeanne, R. L., Kitchell, J. F., Langston, N. E., & Turner, M. G.(1998). *Ecology.* Oxford: Oxford University Press.
2. Chapman, J. L., & Reiss, M. J. (1997). *Ecology: principles and applications.* Cambridge: Cambridge University Press.

ZOOL-6207 Animal Physiology 4(3+1)

This study is based on the understanding how molecular and cellular processes give rise to complex physiologic functions in a living body. This course provides the study of molecular structure and function, molecular interactions and cell signaling through simple to complex cellular phenotypes. The course provides details how molecular machines can be the cause of physiological processes and how these mechanisms are regulated. The idea behind this kind of approach is that the whole of a living system can be understood by studying its individual parts, identifying the subset of genes and proteins that function in physiological context or malfunction to trigger disease. The course emphases on the diverse modules of molecular machines that facilitate movement, change molecular states, or stimulate membrane transport, in addition to their mechanisms of action. Focus is maintained on molecular structure and physiology of cellular compartments in addition to chromatin, proteomics, pharma informatics and drug designing.

Content

10. Concept of Physiology: Principles of homeostasis, conformity, regulation and adaptation
11. Membrane Physiology: resting membrane potentials: electrogenic ion pump and ion channels
12. Muscle Physiology: Action potentials in neurons, synaptic transmission, postsynaptic potentials, neuronal networks and their role in nervous integration,
13. Muscles: Structure, types, components, basis of muscle contraction, neuromuscular interaction.
14. Endocrine Physiology: hormones of invertebrates, vertebrates,
15. Endocrine organs and mechanisms of hormone actions,
16. Cardiovascular physiology, relationship between blood flow, pressure and resistance.
17. Respiratory physiology, respiratory structures, control and respiration adaptations
18. Excretory physiology, filtration, reabsorption and patterns of excretion in mammals & other animals.

Practical

1. Study of respiratory pigments in various animals and hemoglobin in various vertebrates,
2. Normal cardiac activity in amphibian model and effect of temperature, drug, heart block,
3. Blood pressure alteration in exercise, oxygen consumption in fish and terrestrial animal (mouse).
4. Study of electromyography, excitable and contractile properties of a nerve-muscle preparation.
5. Study of brains in different animals including human in relation to complexity of functions

Recommended Texts

1. Moyes, C. D., & Schulte, P. M. (2015). *Principles of animal physiology*. New Jersey: Pearson.
2. Guyton, A. C., & Hall, J. E. (2016). *Textbook of medical physiology*. Philadelphia, Sherwood: W.B. Saunders Company.

Suggested Readings

1. Sherwood, L., Klandorf, H., & Yancey, P. (2012). *Animal physiology: from genes to organisms* (2nd ed.). New York: Brooks/Cole.
2. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). *Animal physiology* (4th ed.). Massachusetts: Sinauer Associates.

ZOOL-6208 Developmental Biology 4(3+1)

Developmental biology is the science that investigates how a variety of interacting processes generate an organism's heterogeneous shapes, size, and structural features that arise on the trajectory from embryo to adult, or more generally throughout a life cycle. It represents an exemplary area of contemporary experimental biology that focuses on phenomena like gametogenesis, fertilization, embryogenesis, gastrulation, determination of cell fate, cell-autonomous specification and induction, cell-cell interactions, morphogenesis and factors controlling growth and development. This course covers the fundamental aspects of development, from the molecular to the organismal levels. Developmental mechanisms, especially at a molecular level, will be examined for differences and commonality among development of embryos of different vertebrate classes. Course will also touch important issues related to stem cell research, regenerative medicines, animal and embryonic cloning. The students will be able to understand and compare basic principles of embryology by understanding the developmental patterns in embryos of different vertebrates.

Contents

1. Introduction: history, basic concepts, principal features with special emphasis on vertebrate models,
2. Origin of sexual reproduction, Spermatogenesis: mammalian spermatogenesis as model
3. Primates menstrual cycle, mechanism of oogenesis, vitellogenesis &hormonal control
4. Fertilization: external & internal fertilization, polyspermy: slow and fast blocks to polyspermy
5. *IN VITRO* Fertilization (IVF): history, steps and advantages, disadvantages and risk factors of IVF.
6. Patterns of cleavage and blastulation among different vertebrate classes,

Practical

1. Study of the structure of gametes in some representative cases, *i.e.* frog, fish and mammal.
2. Hen's egg internal and external structural details.
3. Study of cleavage and subsequent development from prepared slides in frog, mammals and chick etc.
4. Study of fertilization, early development of frog/fish through induced spawning, semen analysis.
5. Study of developmental stages of nematodes through microscopic analysis of animal dung.

Recommended Texts

1. Gilbert, S. F., & Barresi, M. J. F. (2020). *Developmental biology* (11th ed.). Oxford: Oxford University Press, Incorporated.
2. Gilbert, S. F. (2016). *Developmental biology.* Massachusetts: Sinauer Associates.

Suggested Readings

1. Klaus, K. (2001). *Biological development* (2nd ed.). New York: McGraw-Hill.
2. Oppenheimer, S. B. & Lefevre, G. (1998). *Introduction to embryonic development* (3rd ed.). New Jersey: Benjamin Cummings.
3. Balinsky, B. I. (2012). *An introduction to embryology* (5th ed.). Dehli: Cengage

ZOOL-6209 Biological Techniques 3(2+1)

Biological techniques are methods or procedures that are used to study living things. They include experimental and computational methods, approaches, protocols and tools for biological research. Students learn to use common biological laboratory techniques and equipment in laboratory exercises to attain a level of competency equivalent to an expert. Students will be able to use instruments for identification, measurement, fixing and cutting of tissues. Students will learn to collect and preserve the specimen in dry and wet forms and develop expertise in preservation techniques like taxidermy. Students will also have understanding of techniques required to study the physiological properties of cells, their structure, the organelles they contain, interactions with their environment, their life cycle, division and cell function. Few such techniques are general biochemical and biophysical methods like microscopy, spectrophotometery, centrifugation, microtomy, staining, tissue mounting, dehydration, lyophiloization, fluorescence, radiochemistry, differential precipitation of proteins, chromatography, electrophoresis, immunoassays, hybridization and blotting techniques.

Contents

1. Microscopy: Principles, magnification, resolution, types, SEM and TEM.
2. Different measurement systems for weight, length, volume, calculations and related conversions , concentrations, preparation of stock solutions of various strength
3. Micrometery: stage and ocular micrometers usage, calibration and measurement of cell & nuclei size. Specimen preparation for optical microscopy: microtome, tissue mounting, staining
4. Separation and purification techniques, cell fractionation, centrifugation and its types, filtration
5. Chromatography: principle, applications and types,
6. Electrophoresis: principle, applications and types (agarose and PAGE).
7. Spectrophotometry: principle, applications, types, visible/UV spectrophotometry

Practical

1. Preparation of slides (dry and wet mount), measurement of cell size: bacterial and eukaryotic cell.
2. Recording of microscopic observations with the help of camera lucida.
3. Liquid handling: proper use of pipettes and micropipettes, Hematoxylin, eosin and Gram's staining,
4. Handling of centrifuge machines, paper chromatography, thin layer chromatography of amino acids

Recommended Texts

1. Cheesbrough, M. (2005). *District laboratory practice in tropical countries (Part I)* (2nd ed.). Cambridge: Cambridge University Press.
2. Cheesbrough, M. (2009). *District laboratory practice in tropical countries* (*Part II)*. Cambridge: Cambridge University Press.

Suggested Readings

1. Gallagher, S. R., & Wiley E. A. (2008). Current protocols essential laboratory Techniques. New York: John Wiley & Sons.
2. Jones, A., Reed, R. & Weyers, J. (1994). *Practical skills in biology*. Singapore: Longman Ltd.

ZOOL-6210 Animal Behavior 3(3+0)

This course will give the baseline information and knowledge for animal behavior and associates the likely role of external and internal stimuli on various animals during the day, season and year. It also relates daily behavioral rhythms in diurnal and nocturnal periodicities and predicts and anticipates variety of animal actions (costs and benefits) as assessed by innate and learned behavioral displays. The unifying theme of this course is the evolution by means of natural and sexual selection. It includes the scientific study of the mechanistic and evolutionary causes of animal behavior, including communication, foraging, anti-predator behavior, spatial behavior, mating behavior, parental care and social behavior. After successful completion of this course, students will be capable of understanding and identify behaviors in a variety of taxa, discussing the evolutionary origins of various behaviors and implementing experiments to test hypotheses relating to animal behavior. It will enable them to develop understanding of explorative themes of animal behavior and interpret genetic and environmental influences on behavior.

Contents

1. Introduction: behavior and its types, proximate and ultimate causes of behavior
2. Development of behavior: impact of neural and physiological mechanisms; role of external and internal stimuli and animal responses, physiology of behavior in changed environments
3. Hormones and behavior in animals
4. Innate behavior and innate releasing mechanisms
5. Innate behavior of three spines stickle back fish
6. Learned behavior and its mechanisms: quick vs slow learners
7. Concept of animal cognition: key to understand and develop multiple behavioral choices
8. Ecological and genetics to maintain animal behavior, concept of territoriality and defense in animals
9. Circadian rhythms and concept of bio-rhythmicity in animals, maintenance of internal biological clock to perform various diurnal and nocturnal periodicities
10. Cost and benefit ratios in behavior; successful foragers and winners of predator-prey relationships
11. Altruism and parental sacrifice to nurture the young
12. Competition for resources; survival of the most suitable individuals
13. Evolutionary arms races in behavior
14. Social organization in animals (insects and mammals) and concept of group living; benefits and losses, aggression, appeasement and selfish individuals
15. Communication in animals: visual, bio-acoustic, electrical, chemical and tactile
16. Various types of chemical signals in animals' behavior and their importance in ecosystems

Recommended Texts

1. Dngatkin, L. A. (2012). *Principles of animal behavior*. New York: W.W. Nortan & Co.
2. Alcock, J. (2010). *Animal behavior, an evolutionary approach* (9th ed.). Massachusetts: Sinauer Publishers.

Suggested Readings

1. Scott, G. (2005). *Essential animal behavior.* New York: Blackwell Publishers.
2. Goodenough, J., McGuire, B., & Jakob, E. (2009). *Perspectives on animal behavior* (3rd ed.). New York: John Wiley & Sons.

ZOOL-6211 Synopsis & Research Methodology 2(2+0)

The practical utility of research study depends heavily on the way it is presented to those who are expected to act on the basis of research findings. Research synopsis is a written document containing key aspects of research project employing different research methodologies and statistical tools. Research reports are recorded data prepared by researchers or statisticians after analysing information gathered by conducting organized research, typically in the form of surveys or qualitative methods. Reports usually are spread across a vast horizon of topics but are focused on communicating information about a particular topic and a very niche target market. The primary motive of research is to convey integral details about a study for relevant scientists and policy makers to consider while designing new strategies. A research report is a reliable source to recount details about a conducted research and is most often considered to be a true testimony of all the work done to garner specificities of research.

Contents

1. Significance: objectives of research
2. Types of research, research approaches
3. Research process: steps involved in research process
4. Survey, observation, case study, experimental, historical and comparative methods
5. Data: types of data, data collection, processing, analysis
6. Review of literature
7. Research problem and formulation of hypothesis
8. Bioethics: ethical, legal, social and scientific issues in biological research
9. Plagiarism
10. Funding sources: a brief idea about the funding agencies such as HEC, PSF, USAID etc.
11. Writing of research proposal: thesis/report and research paper
12. Footnotes and bibliography

Recommended Texts

3. Leedy, P. D., & Ormord, J. E. (2018). *Practical research: planning and design* (12th ed.). London: Pearson.
4. Creswell, J. W., & Creswell, J. D. (2018). *Research design quantitative qualitative and mixed methods approaches* (5th ed.). California: SAGE Publications.

Suggested Readings

1. Khan, J. A. (2008). *Research methodology*. Delhi: APH Publishing.
2. Walliman, N. (2005). *Your research project, a step by step guide for the first-time researcher* (2nd ed.). California: SAGE Publications.
3. Hess-Biber, S. N., & Leavy, P. (2004). *Approaches to qualitative research, a reader on theory and practice*. New York: Oxford University Press.
4. Laurel, B. (2003). *Design research, methods and perspectives*. London: The MIT Press.

ZOOL-6212 Principles and Kinetics of Toxicology 4(3+1)

Toxicology is a scientific discipline, overlapping with biology, chemistry, pharmacology and medicine that involve the study of the adverse effects of chemical substances on living organisms and the practice of diagnosing and treating exposures to toxins and toxicants. Toxicology is the science devoted to the study of the harmful effects produced by chemical compounds on living organisms and systems. Understanding toxicological effects of different chemicals on the biological systems help in designing safer chemicals, planning safer chemical synthesis, and ensuring that industrial processes employ safer, healthier, and sustainable chemistries. The principles of green chemistry provide a comprehensive framework to guide this vision by emphasizing a holistic, systems-based approach that acknowledges the inherent hazard associated with all molecules and products. Toxicology provides the theoretical and practical tools to profile the likely behavior of a molecule in living systems based on its physicochemical attributes using computational approaches, in vitro assays at the molecular and cellular levels, and information gained from in vivo testing in appropriate test organisms.

Contents

1. Introduction, Chemistry of toxicants, measuring toxicity and risk assessment
2. Toxicity testing methods, routes of exposure
3. Responses to varying doses of substances, time of exposure, the LD50 experiments, toxicity, hazards and risks. Toxicokinetics: introduction; pharmacokinetics and toxicokinetics
4. Absorption: the oral, respiratory and dermal route of exposure, distribution, elimination
5. Toxicokinetic models: mathematical models of elimination, absorption and bioavailability, contrasting kinetics of lipophilic substances
6. Biotransformation: introduction, primary biotransformation (phase I reaction) hydrolysis, oxidation, reduction
7. Secondary metabolism (phase II reaction) glucuridination, glutathione conjugation, acetylation and other, phase II reactions, factors influencing metabolism
8. Cellular sites of action, Introduction, interaction of toxicants with proteins
9. Effect of toxicants on enzymes

Practical

1. Study of biotoxicity assay for LC50
2. Study the effects of different teratogenic chemicals on the development of human/rat embryo

Recommended Texts

1. Stine, K. E., & Brown, T. M. (2015). *Principles of toxicology*. London: CRC press.
2. Marquardt, H., Schafer, S. G., Mcclellan, R., & Welsch, F. (2004). *Toxicology*. San Diego: Academic press.

Suggested Readings

1. Barile, F. A. (2013). *Principles of toxicology testing*. London: CRC Press.
2. Laurel, B. (2003). *Design research, methods and perspectives*. London: The MIT Press.

ZOOL-6213 Evolution & Principles of Systematics 4(3+1)

The course aims to provide extensive knowledge about origin of life and concepts about forces responsible for evolutionary changes. This study covers the importance and history of systematics with basic rules and regulations about the identification and naming of organisms. This course will also provide information about origin, classification and evolution of fauna. The students will be able to understand classification, philosophy of nomenclature, species concepts, phylogenetic inference and evolutionary perspectives of biodiversity. Moreover, the students will be able to understand the basic principles of evolution and systematics, and the inference of evolutionary patterns in the major animal groups. Students will be able to demonstrate evolutionary implications of animal diversity, nature and origin to life, systematic zoology, microtaxonomy and taxonomic categories. The practical section will enable the students to preserve invertebrate species and classify them up to class level, how to identify animal by the help of key and how to make keys of different types for identification of animals.

Contents

1. The nature and origin to life: evidences of evolution (molecular, embryological & paleontological).
2. Theories of Evolution: theories to explain the diversity of life - modern synthetic theory
3. Factors initiating elementary evolutionary changes (micro-evolution)
4. Role of isolation in evolution: factors of large evolutionary changes (macro/mega evolution)
5. Modern concept of natural Selection: levels, selection patterns
6. Action of natural selection leading to convergence, radiation, regression and extinction
7. Batesian mimicry, mullerian mimicry, sexual selection
8. Importance and applications of systematics: systematics as a profession and its future perspectives
9. History of taxonomy: systematics, basic terminology of systematics
10. Taxonomic characters: Kinds and weightage, microtaxonomy, taxonomic categories

Practical

1. Study of preserved invertebrate species and their classification up to class level.
2. Preparation of keys for the identification of specimens.
3. Methods of statistical analysis of samples from populations T-test, Analysis of variance etc.

Recommended Texts

1. Strickberger, M. W. (2012). *Evolution.* London: Jones & Barrett Publisher.
2. Mayer, E. (1994). *Principles of systematic zoology*. New York: McGraw-Hill.

Suggested Readings

1. Moody, P. A. (1989). *Introduction to evolution.* New York: Harper & Row Publishers.
2. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: theory and practice of phylogenetic systematics.* New York: Wiley-Blackwell.

ZOOL-6214 **Bioinformatics** **3(2+1)**

The course will provide an introduction to bioinformatics with a focus on fundamental bioinformatics problems and information on the tools used to compute solutions to those problems, and the theory upon which those tools are based. This involves algorithm, and storage/database development of genomics data. It also describes the different types of data found at the NCBI and EBI resources. This course has these main objectives i.e. to organize vast reams of molecular biology data in an efficient manner; to develop tools that aid in the analysis of such data; and to interpret the results accurately and meaningfully. The advent and rapid rise of bioinformatics has been due to the massive increases in computing power and laboratory technology in recent years. These advances have made it possible to process and analyze the digital information regarding DNA, genes and genomes. A student completing Bioinformatics course shall be able to apply it for problem-solving skills and to develop new algorithms and analysis methods.

Contents

1. Introduction to computers, software, hardware, operating systems
2. Bioinformatics: scope, useful websites, aims and bioinformatics tools
3. Biological databases: data acquisition, NCBI, major protein databases in the world, specialized databases, genome and organism databases, miscellaneous databases
4. Genome mapping: genetic and linkage mapping, physical mapping
5. Gene family, protein family, globin family as an example,
6. Data retrieval: searching sequence databases, FASTA format, retrieval of nucleotide/protein,
7. Primer designing, probe, qualities of primer, general rules and websites for primer designing
8. Sequence alignment: importance and significance of alignment, methods for sequence alignment,
9. BLAST: introduction and types, uses, algorithm , BLAST Score
10. Amino acid matrices: amino acids and their symbols, amino acid scoring matrices,
11. Multiple sequence alignment: introduction, tools for MSA, uses and importance

Practical

1. Introduction to NCBI, retrieving literature from NCBI and classification of an organism using NCBI
2. Retrieving FASTA sequence for nucleotide and protein
3. Retrieving disease gene information
4. Searching gene families, Primer designing, BLASTing a nucleotide / amino acid sequence

Recommended Texts

1. Selzer, P. M., Marhofer, R. J., & Kock, O. (2018). *Applied bioinformatics: an introduction*. Berlin: Springer Publishing.
2. Lesk, A. (2019). *Introduction to bioinformatics* (5^{th} ed.). Oxford University Press.

Suggested Readings

1. Rastogi, S. C., Mendiratta, N. & Rastogi, P. (2013). *Bioinformatics methods and applications: genomics, proteomics and drug discovery*. Dehli: PHI Publishing.
2. Krane, D. E. & Raymer, M. L. (2002). *Fundamental concepts of bioinformatics.* New Jersey: Benjamin Cummings

ZOOL-6215 **Seminar** **1(1+0)**

The major aim of the course is to develop the writing and presentation skills among the students. The course focuses on enhancing the capacity of students to conceive the concept and demonstrate it through different presentation softwares. We are living in a world with an abundance of information, but if you cannot assimilate that information in an easy-to-understand way, it becomes useless. With this course, students will develop the knowledge and skills to carry our accurate research, analyze information and put it into a particular format. This course will educate students on the fundamentals of this process, so they can achieve educational excellence and intellectual expertise. Academic work requires expert understanding of a given topic, and knowledge of how to prepare and structure the assignments, which includes: understanding, formatting and referencing styles, how to correctly cite sources, and the development of writing fluency and ability to effectively convey the message.

The students will be assigned current and advanced topics in the field of Zoology.

ZOOL-6216 Genetics 4(3+1)

Genetics, study of heredity in general and of genes in particular. Genetics forms one of the central pillars of biology and overlaps with many other areas, such as medicine, and biotechnology. Genetics is the study of the human genome and how genes are transmitted through generations. At a more practical level, an understanding of heredity is of critical importance in the prediction, diagnosis, and treatment of diseases that have a genetic component. Genetics is both an applied science than a fundamental science. Genetics arose out of the identification of genes, the fundamental units responsible for heredity. Genetics may be defined as the study of genes at all levels, including the ways in which they act in the cell and the ways in which they are transmitted from parents to offspring. Modern genetics focuses on the chemical substance that genes are made of, called deoxyribonucleic acid, or DNA, and the ways in which it affects the chemical reactions that constitute the living processes within the cell.

Contents

1. Introduction to genetics, the basic principles of inheritance (Mendelism)
2. Multiple alleles: blood groups, coat color in rabbits, genetics of Rh factor & erythroblastosis foetalis. Chromosomal basis and chromosomal theory of inheritance, aberrations & change.
3. Pedigree Analysis: Normal human chromosome complement; karyotyping,
4. Sex-determination and sex-linkage, sex influenced and sex limited traits,
5. Prenatal diagnosis: amniocentesis, choriovillus sampling, ultrasound, fetoscopy. genetic counselling,
6. Chromosome mapping: linkage, recombination, chromosome mapping in eukaryotes.
7. Molecular genetics: gene concept, genetics of viruses and bacteria, transposons, mutation and DNA repair molecular genetic analysis,
8. Regulation of gene expression in prokaryotes, eukaryotes, genetic basis of diseases, like cancer,

Practical

1. Drosophila culture techniques, salivary chromosomes, mutation induction in Drosophila ,
2. Human karyotyping from photographs & prepared slides
3. Preparation of human metaphase chromosomes from blood lymphocytes
4. Study of mitosis in onion root tip cells & meiosis in the testes of male grasshopper
5. Extraction of genomic DNA from WBC and separation of bio-molecules through electrophoresis
6. Study of blood group, quantitative traits & pedigree analysis in local population

Recommended Texts

1. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2018). *Concepts of genetics* (12th ed.). New Jersey: Pearson.
2. Krebs, J. E., Goldstein, E. S., & Kilpatrick, S. T. (2018). *Lewin's GENE-XII* (12th ed.). London: Jones & Bartlett Learning.

Suggested Readings

1. Snustad, D. P., Simmons, M. J., & Gardner, E. J. (2003). *Principles of genetics* (8th ed.). New York: John Wiley & Sons Ltd.
2. Tamarin, R. H. (2001). *Principles of genetics* (7th ed.). New York: McGraw-Hill.

ZOOL-6217 Zoogeography and Paleontology 3(2+1)

The objectives of the course are to provide information on the distribution of animals and their associations in the past and to rationalize their relationship in the present time; to impart knowledge and concepts of evolution mainly on the basis of fossil record and give understanding that fossil records also provide information about the distribution of animals in the past eras. After completion of this course students will be able to reconstruct the biological traits of extinct organisms, can interpret the modes of life of fossil organisms. The students will learn about Paleogeography focusing on theories of continental drift and plate tectonics, zoogeographical regions mainly faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian and Neotropical regions, Zoogeography of Pakistan and Geochronometry. The practical section will empower them with the knowledge of fauna of various zoogeographical regions and invertebrate fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.

Contents

1. Paleogeography: theories of continental drift and plate tectonics, pangea
2. Animal distribution, barriers and dispersal
3. Zoogeographical regions: boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaearctic, Nearctic, Oriental, Ethiopian, Australian, and Neotropical regions,
4. Zoogeography of Pakistan
5. The planet earth, history, age, shells of earth, atmosphere, hydrosphere, biosphere and lithosphere.
6. Rocks: igneous rocks, sedimentary rocks, metamorphic rocks.
7. Fossil and fossilization: fossil types, uses, nature of fossils, fossilization, invertebrates and vertebrates fossil, biostratigraphy, fossils of Pakistan, Paleontologically important areas of Pakistan.

Practical

1. Study of fauna of various zoogeographical regions.
2. Study of mold, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of fossils of coelenterates, trilobites, ammonite, brachiopods, molluscs and echinoderms.
4. Study of vertebrate fossils e.g. horse/elephant/camel/bovids.
5. Study and identification of igneous, sedimentary and metamorphic rocks
6. Map work for identification of various zoogeographical regions of the World.

Recommended Texts

1. Beddard, F. E. (2015). *A textbook of zoogeography*. Cambridge: Cambridge University Press.
2. Tiwari, S. K. (2006). *Fundamentals of world zoogeography.* Delhi: Sarup & Sons.

Suggested Readings

1. Michael, J. B. & Haper, D. A. T. (2009). *Paleobiology and the fossil record*. New York: Wiley & Blackwell.
2. Foote, M., & Millar, A. I. (2006). *Principles of paleontology*. New York:: W. H. Freeman & Co.
3. Ali, S. S. (1999). *Palaeontology, zoogeography and wildlife management*. Hyderabad: Nasim Book Depot.

ZOOL-6218 Biotechnology 4(3+1)

Biotechnology is technology that utilizes biological systems, living organisms or parts of this to develop or create different products. The most prominent area of biotechnology is the production of therapeutic proteins and other drugs through genetic engineering. For more than a decade, the biotechnology industry was dominated by recombinant DNA technology, or genetic engineering. This technique consists of splicing the gene for a useful protein into production cells such as yeast, bacteria, or mammalian cells in culture which then begin to produce the protein. Sometimes this means producing therapeutic proteins that augment the body's own supplies or that make up for genetic deficiencies, as in the first generation of biotech medications. This course has contents that cover expanded research into the development of traditional pharmaceuticals and monoclonal antibodies that stop the progress of a disease. Such steps are uncovered through painstaking study of genes (genomics), the proteins that they encode (proteomics), and the larger biological pathways in which they act.

Contents

1. Introduction: biotechnology and historical perspective, important events in the field of biotechnology
2. Genetics and biotechnology: genome, human genome, diversity of human genome
3. Short tandem repeats, nomenclature, inheritance & uses of STRs, allele, locus, genotype, phenotype. Polymerase chain reaction, principle, requirements, procedures and applications
4. Gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder
5. Biotechnology and legal issues: forensic DNA testing, principles, techniques, types and applications, Genetic engineering: introduction, steps, vectors and its types, plasmids and its types, pBR322, pUC19, restriction enzymes, screening, blue white screen, negative and positive control. Cloning, its types of cloning, cell cloning, molecular cloning, organism cloning, applications and uses

Practical

1. DNA Extraction, Quantification of DNA using gel electrophoresis and spectrophotometer
2. Amplification of DNA using PCR, PCR product measurement using gel electrophoresis
3. Gender typing of human and animal samples using PCR, Restriction fragment length polymorphism. Species identification of different animal samples using PCR and RFLP

Recommended Texts

1. Clark, D. B., & Pazdernik, N. J. (2015). *Biotechnology* (2nd ed.). Cambridge: Academic Cell.
2. Schmid, R. D., Schmidt-Dannert, C., & Hammelehle, R. (2016). *Biotechnology: an illustrated primer*. *New York:* Willey-Blackwell.

Suggested Readings

1. Brown, T. A. (2016).*Gene cloning and DNA analysis: An introduction* (7th ed.). New York: Willey- Blackwell.
2. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge: Cambridge University Press.

ZOOL-6219 Basic Human Genetics 4(3+1)

This course aims to provide understanding of basic concepts of genetics, providing a conceptual framework for future reference; provide understanding about the continuity of the life from one generation to other generation based on the mechanisms involving nucleus, chromosomes and genes. It develops the concept that continuity not only transfers the traits of the parents but also imparts variations that render the generations sustainable in changing environment. Understanding of probability concepts and using these concepts to solve problems will also be developed. The main goals of this subject are to accurately diagram and describe the processes of replication, transcription, translation, as well as predict the outcomes of these processes, to identify and describe the process and purposes of the cell cycle, meiosis, and mitosis and to describe what causes and consequences of DNA sequence changes and how cells prevent these changes, as well as make predictions about the causes and effects of changes in DNA.

Contents

1. Nucleic acids.
2. Genetic linkage: family method, somatic cell hybridization,
3. Deletion mapping and duplication mapping.
4. Introduction to human genome.
5. Karyotyping.
6. Patterns of transmission of single gene traits: Pedigree analysis and mode of inheritance
7. Genetic defects in prenatal development;
8. Oncogenes & cancer,
9. Congenital malformations.
10. Introduction to Human genome project.

Practical

1. Pedigree analysis.
2. Karyotyping of normal and abnormal human chromosomes.
3. Screening of metabolic and other disorders.
4. Problems solving on genetic counseling.
5. Orientation with different molecular techniques including PCR, RFLP

Recommended Texts

1. Strachan, T., & Read, A. P. (2003). *Human molecular genetics* (3rd ed.). Garland: Taylor & Francis.
2. Ehrlich, P. R. (2002). *Human natures: genes, cultures, and the human prospect* (1st ed.). London: Penguin Paper.

Suggested Readings

1. Relethford, J. H. (2001). *Genetics and the search for modern human origins*. New York: Wiley.
2. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2002). *Molecular biology of the cell* (4th ed.). New York: Garland Publishing Inc.

ZOOL-6220 Biodiversity and Wildlife 4(3+1)

The objective of this course is to enable the student to understand philosophy and significance of wildlife conservation; understand the wildlife management rules and regulations in Pakistan and to understand how national and international agencies are involved in conservation and management of wildlife. Students will be able to apply knowledge to solve problems related to wildlife conservation and management. They will learn about the biodiversity of amphibians, reptiles, birds and mammals, along with the wildlife and its distribution in different major eco zones of Pakistan. The major aims of the subject include knowing what type of wildlife exist in Pakistan and its biodiversity, moreover, how wildlife is being secured in Pakistan. After this course students will become able to participate in wildlife census. The practical section will cover the mammal's population census techniques, ecological indices and procedures for studying species richness, Simpson Index, Shannon and Weiner Function.

Contents

1. Biodiversity: definition, types, levels,
2. Status of biodiversity; importance
3. Natural resources and biodiversity: ecological aspects, impacts, loss of biodiversity,

Practical

1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population census techniques.
4. Mammal's population census techniques.
5. Study of wildlife habitats.

Recommended Texts

1. Kumar, U., & Asija, M. J. (2002). *Biodiversity: principles and conservation*. Ohio: Crescent News.
2. Starr, C., & Taggart, R. (2005). Biology: *The unit and diversity of life* (11th ed.). London: Cengage Learning.

Suggested Readings

1. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed). West Sussex: Wiley-Blackwell.
2. Bolen, E. G., & Robinson, W. (2002). *Wildlife ecology and management* (5th ed). London: Pearson.

ZOOL-6221 Comparative Developmental Biology 4(3+1)

The course aims to provide information on transmission of traits from the parents in their gametes, the formation of zygote and its development; impart detailed knowledge about cellular basis of morphogenesis, mechanisms of cellular differentiation and induction and provide understanding of the mechanisms of organogenesis, factors controlling growth and oncogenesis. Students will learn how developmental biology is having a significant impact on our understanding of modern molecular techniques in developmental biology and Uses of transgenic animals in developmental biology. The students will be able to understand and compare basic principles of embryology through understanding the embryonic adaptations with help of morphology and anatomy of embryos of different vertebrates. The practical section will enable them to go through study of prepared slides for the development of amphioxus, mammals, frog and chick isolation, identification and culture of various developmental stages.

Contents

1. Historical review of embryology.
2. Uses of modern molecular techniques in developmental biology.
3. Origin of germ cells (gametogenesis).
4. Spermatogenesis & oogenesis, structure and organization of male and female gametes.
5. Fertilization: chemistry of fertilization, molecular biology of fertilization, surface changes in the egg and sperm surface, In vitro fertilization (test tube technology).
6. Mono & Di-zygotic twinning, parthenogenesis, uses of transgenic animals in developmental biology, cleavage, blastulation, fate maps and their preparation, morphogenetic movements and gastrulation in amphioxus, mammals, chick and frog.
7. Stem cells technology and its uses in developmental biology.

Practical

1. Study of model eggs of invertebrates and vertebrates. Dactylography, and its uses in embryology.
2. Isolation, identification and culture of various developmental stages of *Ascaris lumbricoides* eggs from human/ *Neoascaris vituolarum* eggs from cattle dung (kept for 3 weeks at 240°C in desiccator) by using Telman's centrifugation technique.
3. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.

Recommended Texts

1. Gilbert, S. F. (2010). *Developmental biology* (9th ed.). New York: Sinauer Publishing Co.
2. Patten, B. N. (2004). *Foundation of embryology*. New York, London: McGraw Hill Books Company, Inc.

Suggested Readings

1. Oppenheiner, S. (2004). *Introduction to embryonic development* (4th ed.).New Jersey: Pearson Education.
2. Saddler, T.W. (2011). *Langmans Medical embryology* (Revised ed.). Philadelphia: Wolters Kluwer Health.

ZOOL-6222 Endocrinology 4(3+1)

The course is aimed to impart knowledge about endocrine glands, their anatomy, the hormones released from them and the physiological role of these hormones in body. Endocrinology involves the evaluation and management of disorders of the body's glands, hormonal secretions, and resultant changes in body metabolic activity. The course is designed to provide an understanding to structures and function of endocrine glands. It also provides an understanding of the common endocrine disorders, metabolic regulations, and metabolic abnormalities, and their management. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms of structure, function and its role in regulating metabolism, growth and reproduction, with reference to some disorders resulting from dysfunction. By the end of this course, the students should be able to examine and describe glands, determine hormonal impact and syndromes.

Contents

1. An overview of endocrinology: the endocrine system; type of hormones; endocrine and nervous system relationship, evolution of endocrine system.
2. Hypothalamus: hypothalamic hormones: origin, chemistry and actions;
3. Anterior pituitary: hypothalamic pituitary regulation, prolactin-growth hormone family, glycoprotein family, corticotrophins and other pro-opiomelanocortin peptides;
4. Posterior pituitary: release, regulation and actions of vasopressin and oxytocin.
5. Thyroid gland: anatomy and histology; formation, secretion & regulation of thyroid hormones;
6. Calciotropic and mineral metabolism hormones: parathyroid hormone, calcitonin and calciferols;
7. Pancreatic hormones and regulatory peptides of the gut: anatomy and histology;
8. Adrenal cortex:; physiological actions of corticoid hormones adrenal sex steroids.

Practical

1. Demonstration of endocrine glands (histology & ultrastructure) and associated structures in dissections, transparencies, computer projections etc.
2. Experiments to demonstrate physiological role & regulation of hormones of different glands;
3. Experiments to demonstrate functional diversity of hormones in different vertebrates.

Recommended Texts

1. Greenspan, F. S., & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Wilson, J. D., Foster, D. W., Kronenberg, H. M., & Larsen, P. R. (2008). *William's textbook of endocrinology*. Philadelphia: W.D. Saunders Company.

Suggested Readings

1. DeGroot, L. J., & Jameson, J. L. (2001). *Endocrinology (*4th ed.). Philadelphia: W.B. Saunders.
2. Gilbert, S. F. (2010). *Developmental biology* (9th ed.). New York: Sinauer Publishing Co.

ZOOL-6223 Entomology-I 4(3+1)

The course is designed to impart knowledge to students about morphology and body parts of the insects. The objective of the entomology undergraduate is to provide students with a broadly-based education in the science and practice of entomology. After this course, students can demonstrate an understanding of insect identification, structure, and function. It includes general characteristics of insects, relationship with other arthropods and evolutionary study of insects splitting up into different evolutionary lines. This subject also imparts knowledge about ecology of insects by learning carrying capacity, food chains, predation and competition, diapause insect population and community studies and insect communication. The practical section will enable the students to prepare permanent slides, distinguish the several body parts (antennae, mouth parts, wings, legs, terminal segments and genitalia) of insects; can study the different systems, especially digestive, reproductive of the insect and be able to address complex problems facing entomology.

Contents

1. General characteristics of insects. Relationship with other arthropods, different evolutionary lines,
2. Hard parts: general segmentation, tagmatosis and organization.
3. Cuticle: detailed structure, biochemistry, colors, cuticular outgrowths and appendages sclerotization.
4. Head: cephalization, sclerites, modifications. Antennae: modes of ingestion and types of mouth parts. Neck: sclerites. Thorax: sclerites: legs, their different modifications and functions.
5. Wings: origin; development, basal attachments, main veins and their branches, wing coupling.
6. Abdomen: secondary appendages and external genitalia,
7. Flight; types of flight, aerodynamics, fuels, endoskeleton; head, thorax and abdomen.
8. Soft parts: muscular system; basic structure, types of muscles; muscle contraction and its energetics,

Practical

1. Preparation of permanent slides of antennae, mouth parts, wings, legs, terminal segments & genitalia.
2. Digestive, reproductive system of cockroach, gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle, red cotton bug, wasp and honey bee.
3. Nervous system of cockroach & gryllus. Salivary glands of cockroach, cotton bug & honey bee.

Recommended Texts

1. Richards, O. W., & Davies, R. G. (1977). *Imm's general textbook of entomology* (Vol. 1; 10th ed.). London: Chapman & hall.
2. Chapman, R. F. (2013). *The insects: structure and function* (5th ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Wigglesworth, V. B. (2012). *The principles of insect physiology.* New York: Springer.
2. Peterson, P. G. (2018). *Elements of insect ecology.* London: Edtech Press.

ZOOL-6224 Entomology-II 4(3+1)

The main objective of the course is to develop knowledge about classification of insect orders and their economic importance. This subject provides students with a broadly-based education in the science and practice of entomology. After this course, students can classify the insects up to orders level. It also includes diagnostic characters of the insect orders, knowledge about insects of economic and medical importance and brief account of biological control, chemical control and integrated pest management. This subject also imparts knowledge about common sampling techniques in insect pest management, concept of economic levels, economic damage and economic boundary of insects. Moreover, some brief account on household pests and their management and knowledge of pests of cotton, rice and sugarcane will also be the part of learning. The practical section will enable the students to collect, preserve and identify insects up to families and can have core knowledge of entomology.

Contents

1. A general account including classification of insect orders: Collembola, Orthoptera, Dictyptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera.
2. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura, Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera, Zoraptera, Psocoptera, Mallophaga, Siphunculata, Thysanoptera, Neuroptera, Mecoptera, Tricoptera, Siphonaptera, Strepsiptera,
3. Insects of economic importance.
4. Brief account of biological control, chemical control and integrated pest management.
5. Common sampling techniques in insect pest management,
6. Concept of economic levels: economic damage, economic boundary and economic threshold.
7. Household pests and their management.
8. Knowledge of pests of cotton, rice, sugarcane.

Practical

1. Collection, preservation and identification of insects up to families
2. Identification up to species of a few pests of great economic importance with the help of keys/literature.

Recommended Texts

1. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6^{th} ed.). Long Grove: Waveland Press.
2. Richards, O. W., & Davies, R. J. (1977). *Imm's general textbook of entomology* (Vol-II, 10^{th}ed.). London: Chapman & Hall.

Suggested Readings

1. Metcalf, C. L., & Flint, W. P. (2018). *Destructive and useful insects: their habits and control*. Dehli: Agri Horti Press.

ZOOL-6225 Environmental Issues 4(3+1)

This course is designed to provide review of the different environmental subjects including ecological, conservation, pollution, resources, population and socioeconomic issues of Pakistan. To impart knowledge about management and planning issues using case studies. The environmental study prepares students for careers as leaders in understanding and addressing complex environmental issues from a problem-oriented, interdisciplinary perspective. In this subject students will learn about environmental and social impacts of growing population and affluence by addressing population problems, food production and its distribution, integrated pest management and several types of pollution with their impact on human life and their combating strategies. The learners will also have knowledge about major atmospheric changes due to acid deposition, global warming, greenhouse effect and ozone depletion. Energy sources and issues related to fossil fuel and nuclear power will also be discussed along with the alternate energy resources. In the end of this course students will be able to identify and analyze various environmental issues.

Contents

1. Human population: population explosion, environmental and social impacts.
2. Food production and its distribution: hunger, malnutrition and famine. Integrated pest management.
3. Water pollution: human impact on water resources, eutrophication, combating eutrophication.
4. Sewage pollution: sewage hazards and sewage managements.
5. Hazardous chemical pollution: nature of chemical risks, pollution sources and control.
6. Major atmospheric changes: acid deposition, global warming, greenhouse effect, ozone depletion.
7. Solid waste: landfills, incineration, management and solutions.
8. Energy resources: energy sources and uses; issues related to fossil fuel and nuclear power

Practical

1. Study of population with the help of the statistical data age profile, family size & educational status, Study of the types of the pesticides and their characteristics.
2. Study of the relationship between relative humidity and temperature of Lahore for a particular time. Estimation of total particulate matter in air by using air sampler.
3. Determination of Sodium and Potassium in various water samples using flame photometer.
4. Determination of Chromium, Lead and Copper in industrial effluent.

Recommended Texts

1. Botkin, D. B., & Keller, E. A. (2000). *Environmental science: earth as a living planet* (3rd ed.). New York: John Wiley & Sons Inc.
2. Wright, R. T., & Nebel, B. J. (2008). *Environmental science* (10th ed.). New Jersey: Pearson.

Suggested Readings

1. Bradbury, I. K. *(1999). The biosphere* (2nd ed.). New York: Wiley.
2. Ahmad, R. Z. (2000). *Pakistan- a descriptive atlas: a comprehensive geo-politics course* (1st ed.). Lahore: Feroze sons Pvt. Ltd.

ZOOL-6226 Fish Physiology and Breeding 4(3+1)

This course is formulated to provide sufficient knowledge about all physiological phenomena in fishes. The objective of this course is to provide practical information to obtain better growth of fishes during extensive or semi-intensive culture, to impart knowledge about breeding of most culturable freshwater fishes by manipulating reproductive and endocrinological aspects during natural season as well as off seasons. The course is adapted to a focus of fish physiology, breeding including other physiological processes in fishes as respiration, circulation, acid-base balance, osmoregulation and ionic regulation, swimming and buoyancy, sensory physiology, egg and larval physiology, digestion, energetics and growth, reproduction, fish health and diseases. In the end of the course the students will also have knowledge of fish migration (to nursery ground, to maturation grounds, freshwater to marine water and marine water to freshwater) and fish behavior (learning and memory, light response for maturation, courtship behavior, aquarium fish behavior).

Contents

1. Fish nutrition: digestive system, stomach less fishes, stomach fishes, digestion and absorption,
2. Feed, plant origin, animal origin, fresh food, dry concentrates, pelleted food
3. Transportation: blood cells, circulation, arterial & venous system, capillaries, transport of food.
4. Respiration: gills, lungs, skin, swim bladder, homeostasis
5. Excretion: kidneys, hypo-osmotic urine, hyper-osmotic urine, osmoregulation
6. Reproduction: testes and ovaries, maturation, egg and sperm, artificial fertilization of sex cells.
7. Breeding: natural, artificial, hormonal, temperature & photoperiod controlled induced breeding
8. Growth: extensive culture, semi intensive culture, intensive culture (due to only dry concentrates)
9. Fish health: water quality, hygiene of fish culture facilities, hygiene of equipment.
10. Diseases and their control: viral, bacterial, fungal, parasitic, protozoan, helminths & arthropods

Practical

1. Study of feeding modification and adaptation in fish. Study of gut contents.
2. Study of respiratory adaptation in fish.
3. Study of blood cells and their counts in normal and diseased fish.
4. Water quality parameters (DO, NH_3, hardness, alkalinity, turbidity, transparency, salinity).
5. Study of various forms of swim bladder as hydrostatic organ.

Recommended Texts

1. Kestin, S. C., & Warris, P. D. (2002). *Kestin farmed fish quality*. Oxford: Blackwell Science.
2. Saksena, D. N. (1999). *Ichthyology: recent research advances*. Dehli: Oscar Publications.

Suggested Readings

1. Stickney, R. R. (2016). *Aquaculture* (3rd ed.). Oxfordshire: CABI.
2. Maseke, C. (1987). *Fish aquaculture*. Oxford: Pergamon Press.

ZOOL-6227 Hematology 4(3+1)

This course provides knowledge about blood formation, morphology, physiology and biochemistry of blood cells, basic mechanisms and types. This course presents the functional morphology of blood cells (normal and abnormal), how important blood diseases manifest, and the approaches to diagnosis and treatment of blood and clotting diseases. It imparts knowledge about advanced techniques in studying serological and hematological techniques including blood coagulation. By the end of this course the student should be able to demonstrate an understanding of the components of human blood and characteristics, functions, abnormalities and disease states of each and can demonstrate proficiency in the skills necessary to perform blood cell counts, and evaluation of blood elements within stated limits of accuracy. After the laboratory practice they will be able to apply principles of safety, quality assurance and quality control in hematology, can compare and contrast hematology values under normal and abnormal conditions and can evaluate normal and abnormal cell morphology with associated diseases.

Contents

1. Blood formed elements and plasma.
2. Erythropoiesis and general aspects of anemia, hyper chromic anemia and iron overload and Iron deficiency anemia, Vitamin B12 deficiency anemia.
3. Megaloblastic anemia, hemolytic anemia and other meroblastic anemia.
4. Blood collection techniques. Anticoagulants.
5. Structure, types and genetic disorders of hemoglobin.
6. Leukopoiesis. General description of leukemias.

Practical

1. Blood smear of different vertebrates to compare the RBCs morphology.
2. Total erythrocyte and leucocyte counts.
3. Study of granulocytes and agranulocytes.
4. Differential leukocytes. Estimation of Hemoglobin. Study of erythrocytes sedimentation.
5. Comparison of blood counts of diseased (Anemia) and healthy individuals.

Recommended Texts

1. Hoffbrand, A.V., & Moss, P.A.H. (2002). *Essential hematology*. New York: Wiley.
2. Bain, B. J., Bates, I., & Laffan, M. A. (2016). *Dacie & Lewis practical haematology* (12th ed.). London: Elsevier Health Sciences.

Suggested Readings

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (2017). *Molecular biology of the cell*. New York: Garland Publishing Inc.
2. Cooper, G. (2018). *The cell: A molecular approach* (8th ed.). Oxford: Oxford University Press.

ZOOL-6228 Ichthyology 4(3+1)

This course is formulated to study the evolution and taxonomy of fish, to provide the knowledge regarding fish biology and to elaborate the anatomy and physiology of fish. The overarching goal of this course is to learn how the biological evolution process has shaped the existing taxonomic diversity and physiological variability of fishes. To achieve this goal, students will allow to survey fish diversity and examine the connections between anatomical traits and biological function as exemplified by living fish species. After this course students will be able to describe how the aquatic environment shapes all aspects of the biology of fish species, can explain how anatomy relates to function across major organ systems in fishes and can describe the basic function and organization of fish organ systems. The course focuses on physiological processes in fish including, respiration, circulation, acid-base balance, osmoregulation and ionic regulation, locomotion and energetics of swimming, swimming and buoyancy and digestion and control of gastro-intestinal motility in fish. Therefore, students will be provided an in-depth review of each topic in ichthyology.

Contents

1. Systematic position of fish in animal kingdom,
2. External features of fish, fish muscular system, locomotion and energetics of swimming.
3. Physiology of respiration and air breathing among fishes.
4. Cardiovascular system, blood and its circulation and hydro-mineral balance: osmoregulation, ionic regulation, stress responses, freezing resistance and acid-base balance.
5. Digestion and control of gastro-intestinal motility in fish.
6. Physiology of gas bladder: use of gas by the fish as a source of static lift.
7. Gas in the gas bladder: loss, retention and secretion of gas.

Practical

1. Study of classification of fishes and some selected fish species, fish habitats, fish fauna of Pakistan.
2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish reproduction, oocytes and aquaculture and food requirements
4. Study of environmental, ecological and economic importance of fishes

Recommended Texts

1. Lagler, K. F., Baradach, J. E., & Miller, R. R. (2009). *Ichthyology*. New York: John Wiley and Sons, Inc.
2. Moyle, P. B., & Cech, J. J. (2008). *Fishes: An introduction to ichthyology* (6th ed.). New Jersey: Prentice Hall.

Suggested Readings

1. David, H. (2003). *The physiology of fishes* (3rd ed.). Florida: CRC Press.
2. Smith, L. S. (2002). *Introduction to fish physiology* (2nd ed.). Washington: Argent Labs.

ZOOL-6229 Immunology 4(3+1)

The course aims to give understanding of the basic concepts of immunology and its importance in biological sciences, provide information about immunological mechanisms against different diseases and gives understanding of immunization, immunological tolerance etc. After this course the students will be able to understand immunobiology, immunophysiology and immunopathology. The course has brief account on natural and acquired immunity, active and passive immunity, antigens and elicitation of immune responses. The students will be able to describe immunological response and how it is triggered and regulated. This subject also focuses on detection and application of antigen-antibody reactions, antigen antibody interactions and monoclonal antibodies. Cellular basis of immune response will also be discussed in detail along with the immunological tolerance and autoimmunity. The students will be able to describe immunological response, their types and how these are triggered and regulated and students acquire knowledge for problem solving capacity about immune responsiveness.

Contents

1. Immunology: immunity: natural and acquired immunity, active and passive immunity.
2. Antigens: antigens and their types, antigenicity and immunogenicity, cell mediated and humoral: nature of antigens, genetic constitution of individuals and route of administration.
3. Immunoglobulins: theories of antibodies synthesis, types and antigen antibody interaction
4. Detection and application of antigen-antibody reactions: In vivo and in vitro reactions.
5. Monoclonal antibodies: importance, synthesis, isolation and applications.
6. Major histocompatibility complex: types and importance, diversity in MHC proteins.
7. Cellular basis of immune response: histological features of immune response.
8. Hypersensitivity: Immediate hypersensitivity, delayed type or cell mediated hypersensitivity.

Practical

1. Study of different types of leucocytes in: blood, bone marrow, spleen and thymus in mammals.
2. Estimations of total serum proteins, albumins and globulin concentrations in mammalian blood.
3. Differentiation of globulin proteins in blood serum of mouse by electrophoresis.
4. Diagnosis of immunoglobulin proteins by enzyme linked immunosorbent assay (ELISA).
5. Isolation of lymphocytes and resetting technique.

Recommended Texts

1. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). *Kuby's immunology* (8th ed.). New York: W. H. Freeman Company.
2. Delves, P. J., Martin, J. S., Burton, D. R., & Roitt, I. M. (2017). *Roitt's essential immunology* (13th ed.). New York: Wiley Blackwell.

Suggested Readings

1. Abbas, A., Lichtman, A., & Pilla, S. (2017). *Cellular and molecular immunology* (9th ed.). Amesterdam: Elsevier.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (1994). *Cellular and molecular immunology*. London: Elsevier Health Sciences.

ZOOL-6230 Integrated Pest Management 4(3+1)

The course aims to impart knowledge about approaches to control pest in an integrated manner. It will develop the understanding of multiple strategies to control various pests of human interest. This course will provide introduction, historical background and geographical distribution of various insect species along factors that makes them pest. Available biological pest control, their identification and distribution will be introduced through these learnings. Students will be given knowledge about biological features and varieties of biological mediators to control insect pests. Theoretical foundation of pest control will be highlighted. Moreover, it includes opportunities and challenges for insect pest control in developing countries, concept of economic threshold level and concept of classical biological control. Understanding about recent strategies which are in practice nationally or internationally to manage pests will be given to students. Several techniques which are commercially used for rearing of biological pest control agents including culturing of bacteria and virus will be familiarized.

Contents

1. Introduction. Approaches and objectives, past and present. Theoretical foundation of pest control.
2. Opportunities and challenges for insect pest control in developing countries.
3. Concept of economic threshold level. Economic injury level. Economic damage and boundary.
4. Major threats to the natural enemies. Ranking of natural enemies.
5. Concept of classical biological control.
6. Effects of different agronomic practices and habitat structure on the population dynamics of predators. Relationship of biological control to the sustainable agriculture.

Practical

1. Collection and identification of important pests and their enemies,
2. Techniques to culture and maintain selected natural enemies of insect pests in the laboratory and in the fields.

Recommended Texts

1. Bradford, A. H., & Howard V. C. (2008). *Theoretical approaches to biological control*. New York: Cambridge University Press.
2. DeBach, P. (1991). *Biological control by natural enemies* (2nd ed.). Cambridge: Cambridge University Press.

Suggested Readings

1. Dent, D. (2005). *Insect pest management* (2nd ed.). Oxfordshire: CABI.
2. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Long Groove: Waveland Press.
3. Van Driesche, R. G., & Bellows, T. S. Jr. (2012). *Biological control*. London: Springer Science & Business Media.

ZOOL-6231 Microbiology-I 4(3+1)

Microbiology is the study of microorganisms which include: bacteria, viruses, viroids, yeast, molds, protozoans, algae, fungi and other very small organisms. Microbiology is important because it helps us to understand and treat diseases. This course covers basic principles of microbiology and provides an introduction to the characterization and classification of microorganisms and cultivation of bacteria. Students are expected to gain a fundamental understanding of microbes including viruses, Bacteria, Archaea and eukaryotic microorganisms. After completion of the lecture component of the course, successful students will be able to understand morphology and fine structure of bacteria, cultural characteristics and microbial metabolism processes. It will also help students to recognize how microorganisms solve the fundamental problems their environments present. The laboratory practice can help them to study of bacteria, fungi and protozoa, staining techniques and can apply scientific method to collect, interpret, and present scientific data in microbiology and related fields.

Contents

1. The beginnings of Microbiology.
2. Microscopic examination of microorganisms.
3. Characterization and classification of microorganisms.
4. Morphology and fine structure of bacteria.
5. Morphology and fine structure of Protozoa
6. The cultivation of bacteria.
7. Pure cultures and cultural characteristics
8. Reproduction and growth of bacteria.
9. Microbial metabolism.

Practical

1. Study of bacteria, fungi and protozoa.
2. Staining of microorganisms: simple staining, negative staining.
3. Demonstration of special structures by stains; capsular stain, spore stain, metachromatic granule stain, acid fast stain, flagella stain.

Recommended Texts

1. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). New York: McGraw-Hill.
2. Pelczar, Jr., Chan, E. C. S., & Krieg, M. R. (2010). *Microbiology: application based approach.* London: McGraw Hill.

Suggested Readings

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). New Jersey: Pearson/Benjamin Cummings.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6232 Microbiology-II 4(3+1)

The course aims to develop knowledge about phylogeny of bacteria, their mode of nutrition and their diversity. The course will impart knowledge about phylogenetic relationship of the bacteria with other prokaryotes. Microbiology is important because it helps us to understand and treat diseases. This course covers basic evolutionary lineage of bacteria (proteobacteria). Students are provided fundamental understanding of phototrophic, chemo lithotrophic and methanotrophic proteobacteria, aerobic and facultative aerobic chemoorganotrophic proteobacteria and morphologically unusual proteobacteria. After completion of the lecture component of the course, successful students will be able to understand the structural similarities and differences among delta and epsilon proteobacteria, firmicutes, mollicutes and actinobacteria. It will also help students to appreciate the diversity of cyanobacteria and prochlorophytes and can recognize how microorganisms solve the fundamental problems their environments.

Contents

1. Bacterial physiology.
2. The phylogeny of bacteria, Phototrophic, chemo lithotrophic and methanotrophic proteobacteria,
3. Aerobic and facultative aerobic chemoorganotrophic proteobacteria,
4. Morphologically unusual proteobacteria,
5. Delta and epsilon proteobacteria,
6. Firmicutes, mollicutes and actinobacteria,
7. Cyanobacteria and prochlorophytes,
8. Chlamydia, the planctomycetes,
9. Verrucomicrobia, Flavobacteria and Acidobacteria,

Practical

1. Culturing of microorganisms: preparation and sterilization of culture media, broth culture, agar slope, agar slab, streak plates, pour plates.
2. Isolation and stock culturing of bacteria.
3. Quantitative plating method.
4. The turbidimetric estimation of microbial growth.

Recommended Texts

1. Madigan, M. T. (2009). *Brock biology of microorganisms* (12th ed.). New Jersey: Pearson/Benjamin Cummings.
2. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). New York: McGraw-Hill.

Suggested Readings

1. Pelczar, Jr., Chan, E. C. S., & Krieg, M. R. (2010). *Microbiology: application based approach.* London: McGraw Hill.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world.* London: Prentice Hall.

ZOOL-6233 Molecular and Clinical Endocrinology 4(3+1)

The course is designed to develop understanding of molecular mechanisms of hormone action, their molecular assessment and use of molecular techniques to treat endocrine disorders. The course of Molecular and Clinical Endocrinology aims to provide excellence in clinical care for all aspects of health and disease related to endocrine management like thyroid, adrenal, parathyroid, diabetes, pituitary, bone, obesity and lipid disorders. It also provides an understanding of the general mechanisms in molecular endocrinology, radioimmunoassay, immunoradiometric, immunochemiluminometric and radioreceptor assays and their statistical procedures. Furthermore, in all body cells, hormones influence the metabolism of nucleotides, proteins, lipids, carbohydrates, vitamins, water, and therefore, knowledge of endocrinology and metabolism is important. The students will study the endocrine system in terms functional pathology in endocrine glands, disorders of growth and puberty, endocrine hypertension and Polyendocrine syndromes. By the end of this course, the students should be able to examine and describe glands and can determine their hormonal impacts.

Contents

1. General mechanisms in molecular endocrinology:
2. Subcellular structure of cells secreting protein hormones; process of hormone secretion;
3. Recombinant DNA technology & molecular genetics in diagnosis & treatment of endocrine diseases.
4. Measurements of hormones: radioimmunoassay & their statistical procedures.
5. Mechanisms of action of hormones: hormone systems and intracellular communication;
6. Hormones acting at cell surface: properties of hormone receptor interaction, structure, biosynthesis and turnover of membrane receptors; hormones acting in transcription regulation:
7. Biochemistry and molecular interaction of steroid receptor, gene expression
8. Functional pathology: neuroendocrine disorder of gonadotrophin, prolactin, GH, corticotrophin.

Practical

1. Studies on recognition and response of receptors. Studies of disorders of pituitary.
2. Studies of thyroid status deficient & excess hormone function. Hormonal status i puberty & aging
3. Studies of type 1 & type 2 diabetes mellitus: Epidemiology, studies of management of the type 2.
4. Model studies of disorders of ovarian and testicular disorders, obesity and anorexia.

Recommended Texts

1. Greenspan, F. S., & Strewler, G. J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S., & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10th ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. DeGroot, L. J., & Jameson, J. L. (2001). *Endocrinology* (4th ed.). Philadelphia: W.B. Saunders.
2. Neal, J. M. (2000). *Basic endocrinology: an interactive approach.* London: Blackwell Science Inc.

ZOOL-6234 Ornithology 4(3+1)

The course will provide knowledge about bird diversity, avian anatomy, physiology and adaptations, bird behavior and socioeconomic and ecological importance. This course is an advanced undergraduate survey of ornithology. This means that students will learn about both science and birds at the same time. This course combines traditional zoology with an emphasis upon avian biology and diversity, and is delivered along with aspects of conservation management and practices. Students will learn about birds: how to identify them, what are the major characteristics and distinguishing features of the major groups of birds, and how birds function in a diversity of environments. However, this course will also cover a modern scientific approach by using birds as a means to uncover general biological principles that may apply to all living things. Students will acquire by the end of the course a new appreciation and knowledge of birds, additional understanding of biological concepts, and an improved ability to be an active scientist.

Contents

1. Introduction to ornithology, class Aves, taxonomy of birds up to orders, families and major species; Evolution of birds; biology of fossil bird's archaeopteryx, archaeornithes, neoornithes;
2. Morphology of bird, feathers, plumage; digestive system, anatomy, guts and feeding strategies;
3. Structure of bones; basic embryology of birds; internal anatomy of birds; systems physiology;
4. Blood circulatory, cardiovascular physiology, heart, blood cells and hemodynamics;
5. Respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption;
6. Urinary system, kidney physiology and production of solid or semisolid excreta,
7. Brain physiology and anatomy, special senses, olfaction, vision, taste;
8. Morphological and physiological adaptations of birds to flying, kind, mechanisms of aerodynamics;
9. Reproductive organs anatomy and physiology, egg laying and breeding seasons; brood parasitisim;

Practical

1. Identification characteristic &taxonomy of birds to families. Study of flying mechanic by model
2. Dissection sparrow, pigeon, myna. Anatomy of bones, skull, girdles, spine, vertebrae, feathers,
3. Study of gut contents of birds to understand feeding habits. Incubation of chicken eggs.
4. Bird stuffing & preservation of egg. Identification of bird species through feather & egg shells

Recommended Texts

1. Howell, S. N. G. (2010). *Peterson reference guide to molt in North American birds* .Amazon: Peterson Reference Guides.
2. Urfi, A. J. (2009). *Birds of India: a literary companion.* Oxford: Oxford University Press.

Suggested Readings

1. Rank, B. (2004). *Ornithology: ecology and evolution of Darwin's finches.* New York: Princeton/ W. H. Freeman.
2. Sibley, D. A., & Alfred, A. (2002). *Sibley's birding basics.* New York: New York Press.

ZOOL-6235 Physiological Systems and Adaptations 4(3+1)

This course gives details of physiological systems maintaining the homeostasis of animals. Inter-relations of the systems and regulatory features of the each system's function will be focused. The major goal of the course is to provide a course of study in mammalian, principally human, systems physiology, building on knowledge of basic physiological principles. Its contents mainly cover cardiovascular system, respiratory system, renal system, gastrointestinal system and osmoregulation. It also focuses on environmental challenges of temperature regulation like temperature and animal energetics, temperature relation of ectotherms, heterotherms and endotherms. Laboratory practice will enable the students to study of heart in prepared frogs, to study blood pressure in various physiological states, study of electrocardiograms and to determine the oxygen consumption in fish and mouse and effects of various factors affecting it. Physiological systems and adaptations also focus on how the metabolic, neuromuscular, cardiovascular, and respiratory systems respond to the demands of varying adaptations and it modifies these systems.

Contents

1. Cardiovascular System: blood and homeostasis; physiology of cardiac muscles; automaticity and rhythmicity in heart activity and cycle; electrocardiography; regulation; hemodynamics;
2. Arterial system; microcirculation and lymphatics; control of cardiac output;
3. Special circulations: cutaneous, skeletal, coronary, cerebral, fetal.
4. Respiratory System; pulmonary and bronchial circulations; mechanical aspects of breathing; transport of oxygen and carbon dioxide; regulation of ventilation; respiratory in extreme conditions.
5. Renal System: elements of renal function; tubular function in nephron; control of body fluid volume and osmolarity; potassium, calcium and phosphate homeostasis; role of kidney in acid-base balance.
6. Gastrointestinal System: gastrointestinal secretions and their control: salivary, gastric, pancreatic and liver; digestion, absorption of carbohydrates, proteins, lipids, vitamins, ions, water; motility.

Practical

1. Experiments on heart in prepared frogs; study of blood pressure in various physiological states;
2. Study of electrocardiograms; Blood coagulation study. Study of O_2 consumption in fish & mouse. Demonstration of respiratory volume and pulmonary function tests.

Recommended Texts

1. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *Eckert animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman & Company.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

Suggested Readings

1. Guyton, A. C., & Hall, J. E. (2015). *Textbook of medical physiology* (12th ed.).Philadelphia: W.B. Saunders Company.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

ZOOL-6236 Physiology of Coordination 4(3+1)

This course gives the details of nervous and hormonal coordination at molecular and cellular level in animals. The basic physiological aspects like biosynthetic, secretary and regulatory mechanisms of coordination will be focused in the course. It imparts knowledge about physiological mechanisms at cellular level, nervous coordination and hormonal control of physiology. At the end of the course students should have an enhanced knowledge and appreciation of mammalian physiology such as higher functions of nervous system including state of consciousness, learning, memory and adaptation of muscles for various activities. They will better comprehend the functions of important physiological systems including the cardio-respiratory, renal, reproductive and metabolic systems, can understand how these separate systems interact to yield integrated physiological responses to challenges.it will help them to understand the basics glands and their role in physiological coordination. The practical part will develop further practical biological skills introduced regarding physiology of coordination using various animal models.

Contents

1. Cellular membrane, transport; membrane potentials & signal-transduction pathways.
2. Nervous system: organization of nervous system; general sensory system; visual, auditory, vestibular and chemical sensory system; motor system with brainstem, learning, memory.
3. Muscle and movements: molecular basis of contraction; muscles activity on skeleton;
4. Endocrine system: General principles of endocrine physiology; hormones in homeostasis of metabolism; endocrine regulation of calcium and phosphate; parathyroid gland,
5. Hypothalamus and pituitary: Hypothalamic regulation of pituitary,
6. Pituitary gland hormone in physiological coordination;

Practical

1. Recording of action potentials on oscilloscope. Study of sciatic nerve action potential.
2. Demonstration of nervous system organization while studying brain, cranial nerve,
3. Spinal cord and spinal nerves. Experiments on sensory organs study. Experiments on characteristics of skeletal muscle contractions; Responses of intestinal muscles and effect of drugs.
4. Demonstration of endocrine glands in a mammal. Effect of hormones on glycemia and calcemia;

Recommended Texts

1. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *ECKERT Animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman and Company.
2. Bullock, J., Boyle, J., & Wang, M. B. (2001). *Physiology* (4th ed.). Philadelphia: Lippincott, Williams & Wilkins.

Suggested Readings

1. Guyton, A. C., & Hall, J. E. (2000). *Textbook of medical physiology* (12th ed.). Philadelphia: W.B. Saunders Company.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

ZOOL-6237 Physiology of Reproduction 4(3+1)

The course aims to provide knowledge about reproductive system and its role in the behavior of the animals. It will enable the students to develop the understanding about the role of sex hormone in sexual behavior and their interaction during development. The major objective of this course is to provide students with a sound coverage of human reproductive physiology within the framework of human body. This is achieved by first covering fundamentals of the structure and function of the male and female reproductive tracts, gametogenesis, fertilization, early embryogenesis, fetal development and preparation for birth, contraceptive methods and maternal adaptations to pregnancy. It particularly emphasize on the hormonal control of reproduction. This in turn provides an important foundation to consider sexual differentiation and development, contraception, infertility and current reproductive technologies. Finally, human reproductive behaviour and its implications to our future are considered in the light of our evolutionary history, culture and society.

Contents

1. Introduction, sex determination and differentiation: molecular aspects and chemical messengers
2. Hypothalamic – hypophysial gonadal axis in reproduction:
3. Hormonal and neural factors and their interaction in ovarian, testicular and reproductive functions;
4. The interactions in development, in estrous and menstrual cycle: the interactions in transitions from childhood to reproductive and post- reproductive states.
5. Reproductive behaviors: physiological basis of male & female sexual behavior; maternal behavior;
6. Endocrine basis of communication in reproduction and aggression; pheromone in mammalians
7. Rhythms in reproduction and pregnancy; fertilization, zygote transport and implantation.
8. Placental steroid and polypeptide hormones; recognition and maintenance of pregnancy; maternal metabolism gestation, hormonal mechanism in parturition.

Practical

1. Physiology & histology of segments of male and female reproductive tracts;
2. Recognition of spermatogenic cells, ovarian follicles and corpus luteum in gonads;
3. Study of hormonal mechanisms in super ovulation and implantation;

Recommended Texts

1. Evert, B. J., & Johnson, M. H. (2000). *Essential reproduction.* Oxford: Blackwell Science Inc.
2. Larsen, P. R., Kronenberg, H. M., Melmed, S., & Plonsky, K. S. (2003). *William's textbook of endocrinology* (10th ed.). Philadelphia: W.B. Saunders Company.

Suggested Readings

1. Knobil, E., & Neill, J. D. (2006). *The physiology of reproduction* (Vol.2). Houston: Gulf Professional Publishing.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

ZOOL-6238 Principles of Parasitology 4(3+1)

This course will Introduction to general parasitology, provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance knowledge about their pathology, host parasite relationship and control measures. Overall aim of the course is to provide students with knowledge concerning biological, epidemiological and ecological aspects of parasites causing diseases to humans, enable them to understand the pathogenesis, clinical presentations and complications of parasitic diseases, to establish knowledge regarding pathogenesis, clinical presentations and complications of parasitic diseases and to provide students with adequate knowledge about endemic parasites and national parasitic problems as well as re-emerging parasitic infection. By the end of the courses, students will be able to describe the world distribution of important parasitic infections and the epidemiologic principles and the effect of social and demographic patterns on parasitic disease and vulnerability and can describe molecular, biochemical and cellular mechanisms that occur in the body of humans infected with parasites

Contents

1. Introduction to parasitology. Relationship to other sciences, parasitology and human welfare.
2. Some basic definitions, principles and concepts. Parasite ecology and evolution.
3. Immunology and pathology. Susceptibility and resistance, innate defense mechanisms. Acquired immune response in vertebrates. Immunity in invertebrates.
4. Immunodiagnosis, pathogenesis of parasitic infections. Tolerance in the host-parasite relationship.
5. Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin,
6. Other flagellated protozoa, order Retortamonadita, Diplomonadida, Trichomonadida, Opalinida.
7. The Amoebas. Order Amoebida, order Schizopyrenida.
8. Phylum Apicomplexa, Gregarines, Coccidia and related organisms.
9. Phylum ciliophora, ciliated protistan parasites.

Practical

1. Preparation of temporary and permanent slides and identification of parasitic protozoan, helminthes & insects of medical and veterinary importance. Section cutting of the infected tissues.
2. Methods of collection, preservation and transportation of parasitic material & helminthes.

Recommended Texts

1. Roberts, L. S., & Janovy, J. Jr. (2005). *Foundations of parasitology* (7th ed.). Chicago/ London: W.M. Brown Publishers.
2. Urquhart, G. M., Hucan, J. L., Dunn, A. M., & Jennings, F. W. (2000). *Veterinary parasitology.* London: Longman Scientific and Technical publications.

Suggested Readings

1. Watson, J. M. (2014). *Introduction to animal parasitology*. London: Elsevier.
2. Cheesbrough, M. (2006). *Laboratory practice in tropical countries* (2nd ed.). Cambridge: Cambridge University Press.

MPhil
ZOOLOGY

ZOOL-7101 Advanced Animal Diversity 3 (3+0)

This course is about animal diversity, origin and evolution of various taxonomic groups. The diversity of animal life will be investigated in the phylogenetic context of both invertebrate and vertebrate animals. The taxonomy and evolution of the main classes of animals will be examined: morphology, biology, ethology (vertebrates) and physiology. This course will highlight structural and functional integration and looks at organizational patterns from an evolutionary point of view. Students will be able to describe the origin of multicellularity and adaptations necessary for increased size including the basic characteristics of each group and the evolutionary relationships among group members. Moreover, this course will provide insight into the fundamental principles of evolution, and how behavioral, anatomical and physiological adaptations of animals have evolved. Specializations and adaptations of animals to their environment will be investigated This course will be helpful in exploring the current theories in animal biology which attempt to explain the origins, functions and ecological significance of animals.

Contents

1. Animal diversity: definitions, overview
2. General and systematic characteristics of animals
3. Diagnostic characters of phyla and classes of Protista, protostomes, deuterostomes.
4. Evolutionary trends in animals
5. Origin and evolution: Protista, Metazoa, Bilateria
6. Origin and evolution: Platyhelminthes
7. Origin and evolution: Annelids,
8. Origin and evolution: Arthropods
9. Origin and evolution: Echinodermata
10. Origin and evolution: Cephalochordates and Urochordates
11. Origin and evolution: Chordates (with emphasis on the expression of HOX genes).
12. Evolution of jawed fishes
13. Origin of Amphibians,
14. Origin of Reptiles and Birds
15. Origin and evolution of Mammals
16. Methods of estimation of biodiversity

Recommended Texts

1. Hickman, C. P., Roberts, L. S., & Larson, A. (2002). *Animal diversity*. New York: The McGraw Hill.
2. Wilson, D. E., & Burnie, D. (2001). *Animal: the definitive visual guide to the world's wildlife.* London: Dorling Kindersley.

Suggested Readings

1. Miller, S. A., & Harley, J. P. (2016). *Zoology*. New York: McGraw-Hill
2. Kershaw, D. R. (Ed.). (2012). *Animal diversity*. New York: Springer Science & Business Media.
3. Hall, B., & Strickberger, M. W. (2008). *Strickberger's evolution.* Burlington: Jones & Bartlett Learning.

ZOOL-7102 Advances in Molecular Biology 3 (3+0)

This course is the explanation of the structure and function of molecules, including DNA and RNA, which allow genes to be expressed and be maintained from one generation to the next. Recent years have seen explosive advances in the study of DNA and molecular genetics, including gene cloning, sequencing and mapping. Developments in molecular biology have opened new areas of study and provided powerful techniques that are revolutionizing the pharmaceutical, health, and agricultural industries. The aim is to provide the students with a detailed understanding of the regulation systems for the expression of genes, the genetic nature of developmental pathologies, the different forms of human genetic defects contributing to disorders and of the pathways between the genotype and the phenotype. The key ideas and values of recombinant DNA technology and relevant uses and problems related to popular understanding will also be discussed. Students will also learn about genetic engineering, its application, and the ethical issues associated with its use.

Contents

1. Structural explanation of DNA
2. Concept of gene
3. Chromatin to chromosome structure and function
4. Molecular mechanisms DNA of replication.
5. Transcription and translation in prokaryotes and eukaryotes
6. Transcriptional and translational regulation of gene expression
7. Regulation of gene expression in prokaryotes (operon model and types with examples)
8. Regulation of gene expression in eukaryotes
9. Types of recombination
10. Mutations and chromosomal aberrations
11. DNA damage, repair and disrepair
12. Gene sequencing &Principles of Recombinant DNA technology
13. Role of Recombinant DNA Technology in economic development
14. Human Genome Project

Recommended Texts

1. Karp, G., Iwasa, J., & Marshall, W. (2019). *Karp's cell and molecular biology*: *concepts and experiments* (9th ed.). New York: Wiley.
2. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., & Watson, J. D. (2002). *Molecular biology of the cell*. New York: Garland.

Suggested Readings

1. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2019). *Concepts of genetics* (12th ed.). New York: Pearson Education, Inc.
2. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M., & Bretscher, A. (2007). *Molecular cell biology*. New York: W. H. Freeman Company.
3. Klug, W.S., Cummings, M.R., Spencer, C.A., & Palladino, M. A. (2015). *Concepts of genetics* (9th ed.). New York: Pearson Education, Inc.

ZOOL 7103 Animal Biotechnology 3 (3+0)

Animal biotechnology is a branch of biotechnology in which molecular biology techniques are used to genetically engineer (modify the genome of) animals in order to improve their suitability for pharmaceutical, agricultural or industrial applications. Animal biotechnology has been used to produce genetically modified animals that synthesize therapeutic proteins, have improved growth rates or are resistant to disease. The objective of this course is to introduce students to cutting edge biotechnologies that can be used for animal and human health and research. In this course students will analyze and discuss the primary literature on stem cells, cloning, large animal models for disease and development of therapies and treatments. In addition, the use of biotechnology for animal related issues such as food safety, disease control and biosecurity will be considered. A range of genetic, immunological and reproductive technologies will be introduced. The integration of these technologies to improve animal production, health and welfare will be explored.

Contents

1. Nuclear structure, organization, and function, DNA, proteins &chromatin structure
2. Central dogma, gene structure
3. Transcription, translation and regulation of gene expression
4. Transposons, retrotransposons, and retroviruses
5. Cloning Techniques: somatic cell nuclear transfer, embryo splitting
6. Nuclear Transplantation tools in genetic engineering, molecular cloning vectors
7. Genetic engineering guidelines & genetic engineering in aquaculture
8. Transgene delivery, detecting integration & expression of transgene.
9. Ethics: morality and animal biotechnology
10. Application of bio-security methods in various culture production
11. Molecular techniques in disease diagnosis
12. Human genome project
13. Principles of Immunology: antigens & immunoglobulins: immunotoxins
14. Immune system responses, lymphocytes& applications of ELISA.

Recommended Texts

1. Ranga, M. M. (2005). *Animal biotechnology*. Dehli: Agrobios.
2. Kettle, D. S. (1984). *Medical and veterinary entomology*. Kent: Croom Helm Ltd.

Suggested Readings

1. Banerjee, G. C. (2018). *A textbook of animal husbandry*. Oxford: IBH publishing.
2. Mettenleiter, T. C., & Sobrino, F. (Eds.). (2008). *Animal viruses: molecular biology*. Norfolk: Caister Academic Press.
3. Nagabhushanam, R. (Ed.). (2004). *Biotechnology of aquatic animals*. Florida: CRC Press.

ZOOL-7104 Applied Biostatistics 3 (3+0)

Applied Biostatistics provides the means to identify and verify patterns in this data and to interpret the findings in a public health context. Topics include the collection, classification, and presentation of descriptive data; the rationale of estimation and hypothesis testing; analysis of variance; analysis of contingency tables; correlation and the statistical control of confounding; sample size and power considerations; survival analysis. This course will also focus on the multiple regression modeling and multivariate analysis to cover multi-way analysis of variance, multiple linear regression, classification and regression trees, automated model search, model fit and diagnostic, experimental design and multivariate analysis (Principle component analysis and cluster analysis) with particular emphasis on applications in medicine and public health. Special attention is directed to the ability to recognize and interpret statistical procedures in articles from the current literature. The course will cover the theory and use of the most common meta-analytic methods Students will use the SPSS statistical package to analyze public health related data.

Contents

1. Descriptive statistics, types of data
2. Parametric and non-parametric tests, Z-test, T-test, assumptions of Z and T tests
3. Retrospective case-control studies, exact inference for the odds ratio
4. Assumptions of ANOVA, ANOVA models, Tukey's test, Duncan's tests, nested ANOVA
5. Factorial experiments & Repeated Measures
6. Correlation, Logistic regression, additional topics for logistic regression
7. Survival analysis, cox proportional hazards model, cox proportional hazards regression: assessment of assumptions
8. MANCOVA, estimation of space richness, diversity, evenness
9. Principal component analysis, correspondence analysis
10. Discrete data analysis
11. Meta-analysis

Recommended Texts

1. McGarigal, K., Cushman, S. A., & Stafford, S. (2013). *Multivariate statistics for wildlife and ecology research*. New York: Springer Science & Business Media.
2. Ludwig, J.A., & Reynolds, J. F. (1988). *Statistical ecology: a primer on methods and computing*. New York: John Wiley & Sons.

Suggested Readings

1. Manly, B. F., & Alberto, J. A. N. (2016). *Multivariate statistical methods: a primer*. Florida: CRC press.
2. Koricheva, J., Gurevitch, J., & Mengersen, K. (Eds.). (2013). *Handbook of meta-analysis in ecology and evolution*. New Jersey: Princeton University Press.
3. Rossi, R. J. (2009). *Applied biostatistics for the health sciences*. New Jersey: John Wiley & Sons.

ZOOL-7105 Classification of Insects and Pest Management (3+0)

The classification of insects can be complex but it is very important to group and identify insects so that they can be studied reliably. Insects, like all animals, are classified using a hierarchical system of classification. It is the coordinated use of pest and environmental information along with available pest control methods, including cultural, biological, genetic and chemical methods, to prevent unacceptable levels of pest damage by the most economical means and with the least possible hazard to people, property, and the environment. This course will provide knowledge to students about insect classification with its importance. Various insect orders and their principal features for identification of insects of agriculture and medical importance will be discussed. Ecological aspect of the course is also adequate to providing basic knowledge of insect population dynamics including factors regulating insect abundance, insect population prediction and monitoring systems. The course will also cover important areas such as insect behavior, communication, phylogeny and arthropod relations.

Contents

1. A general account including classification of insect orders: Collembola, Orthoptera, Dictyoptera, Isoptera, Hemiptera, Lepidoptera, Diptera, Hymenoptera, Coleoptera.
2. Only diagnostic characters of the remaining insect orders: Thysanura, Diplura, Protura
3. Ephemeroptera, Odonata, Plecoptera, Grylloblattoidea, Phasmida, Dermaptera, Embioptera,
4. Zapatero, Psocoptera, Mallophaga, Siphunculata, Thysanoptera, Neuroptera,
5. Meco- ptera, Tricoptera, Siphonaptera, Strepsiptera,
6. Insects of economic importance.
7. Brief account of biological control, chemical control and integrated pest management
8. Common sampling techniques in insect pest management
9. Concept of economic levels, economic damage and economic boundary

Recommended Texts

1. Pedigo, L. P., & Rice, M. E. (2014). *Entomology and pest management*. Long Grove: Waveland Press.
2. Richards, O. W., & Davies, R. G. (2013). *Imms' general textbook of entomology: classification and biology*. New York: Springer Science & Business Media.

Suggested Readings

1. Maredia, K. M., Dakouo, D., & Mota-Sanchez, D. (Eds.). (2003). *Integrated pest management in the global arena*. Oxford shire: CABI.
2. Dent, D. (2000). *Insect pest management*. Oxford shire: CABI.
3. Metcalf, R. L., & Luckmann, W. H. (Eds.). (1994). *Introduction to insect pest management* (Vol. 101). New Jersey: John Wiley & Sons.

ZOOL-7106 Comparative Vertebrate Anatomy 3 (3+0)

Comparative Vertebrate Anatomy is a course concerning the evolution of vertebrate's anatomy with changing environmental conditions. This course will explore how vertebrates originated, their characteristic anatomical and physiological features, how they developed, and how those features allow vertebrates to perceive their environment, locomotion, seek prey, avoid predators, maintain homeostasis and basically do everything an organism must do to live. Students will learn to appreciate that the vertebrate body is not simply a collection of static anatomy, but that the form and function of vertebrates is integrated into functional systems. This course will also introduce students to the groups of vertebrates and explores the anatomical evolution of vertebrates within the context of the functional interrelationships of organs and the changing environments to which vertebrates have adapted. An ideal entry point into the ways living creatures interact with their immediate physical world, we examine how the forms and activities of animals reflect the materials available to nature and consider rules for structural design under environmental forces.

Contents

1. Introduction and concepts
2. Methods of comparative biology and vertebrate diversity
3. Comparative anatomy of various body systems in vertebrate.
4. The outer organism – integument, acquiring food, dentition
5. Skeletal elements & the vertebrate axis: vertebral column
6. Vertebrate locomotion: girdles and limbs
7. Biomechanics: biological and physical design, walking & running, swimming, powered flight
8. Organismal respiration and circulation
9. Osmoregulation: concepts, organization and the vertebrate kidney
10. Nervous system: organization, functional integration
11. Sensing vibrations: lateral lines, hearing & vision

Recommended Texts

1. Hildebrand, M., & Goslow, G. (2001). *Analysis of vertebrate structure* (5th ed.). New York: Wiley.
2. Pough, F. H., Heiser, J. B., & McFarland, W. N. (1999). *Vertebrate life*. New Jersey: Prentice Hall.

Suggested Readings

1. Diogo, R., & Abdala, V. (2010). *Muscles of vertebrates: comparative anatomy, evolution, homologies and development*. Florida: CRC Press.
2. Kardong, K. V. (2006). *Vertebrates: comparative anatomy, function, evolution*. New York: McGraw-Hill.
3. Hyman, L. H., & Wake, M. H. (1992). *Hyman's comparative vertebrate anatomy*. Chicago: University of Chicago Press.

ZOOL-7107 Conservation Biology of Wildlife 3(3+0)

The wildlife faces a variety of threats that compromise their ability to survive and reproduce. Wildlife is forced to either adapt to life with humans or face extinction in the wake of industrial revolution, population growth and urbanization. The survival of every species of wildlife is critical to preserving earth's rich biodiversity and unique natural history. Managing wildlife populations and their habitats are the core areas of conservation biology. The goal of conservation biology is to analyze the effects of different threats (xenobiotics, chemicals, pesticides, hunting, invasive species, overexploitation, climate change, anthropogenic activities, predation and land use) that endanger the existence of wild animal populations. Reconstruction of local habitats, formation of protected areas, implementation of breeding programs in sanctuaries, monitoring of animal movements with satellite tracking and other remote techniques, survey of animal populations, conducting population assessments keeping in view the harms to wild animals and limiting the effects of environmental degradation, climate change and the loss of biodiversity are the key components of conservation biology.

Contents

1. Introduction to conservation biology
2. Biodiversity: species diversity, ecosystem diversity, genetic diversity, functional diversity
3. Global patterns and drivers of biodiversity
4. Genetic concepts and tools to support wildlife populations
5. Genetic variation and fitness in wildlife populations
6. Threats to biodiversity: mass extinction and global changes, ecosystem degradation and loss
7. Overexploitation, deforestation, fragmentation and reduction in wildlife habitats, climate change
8. Introduction of exotic species, inbreeding and outbreeding depressions, loss of genetic variability
9. Environmental fluctuations, factors limiting the population size
10. Human factors, economic factors, politics and actions
11. Historical precedent of wildlife conservation in Pakistan
12. Current scenario of wildlife conservation in Pakistan
13. Species level, community and ecosystem conservation, ex-situ conservation

Recommended Texts

1. Mills, L. S. (2012). *Conservation of wildlife populations: demography, genetics, and management*. New Jersey: John Wiley & Sons.

2. Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sunderland: Sinauer Associates.

Suggested Readings

1. Hunter Jr, M. L., & Gibbs, J. P. (2006). *Fundamentals of conservation biology*. New Jersey: John Wiley & Sons.
2. Cardinale, B., Primack, R., & Murdoch, J. (2019). *Conservation biology* (1st ed.). Sunderland: Sinauer Associates.
3. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed). West Sussex: Wiley-Blackwell.

ZOOL-7108 Economic Zoology 3 (3+0)

It is a specialized branch of zoology which deals with animal world that is associated with the economy, health and welfare of humans. It includes culturing animals for mass production for human use and to control or eradicate animals that are injurious to man directly or indirectly. This course deals with the topics in a scientific way, the multidisciplinary nature of Economic Zoology has been given due importance incorporating topics like sericulture, lac culture, apiculture, poultry, fisheries, parasitology and dairy science. In this course the students will learn about Aquaculture, Poultry and Animal husbandry, Parasitism in relation to man, insects in relation to man that will include productive insects, insect pest & vectors of human diseases. This course offers students an understanding of experiential learning on the methodology of fish culture, sericulture and apiculture. It will also provide information about economic aspects of culturing animals.

Contents

1. Parasitic protozoans and their role in human welfare, soil protozoans and their role in agriculture.
2. Sponge culture and its importance in industry.
3. Concept of Coral reef and its significance.
4. Helminths as human and animal parasites.
5. Nematodes- parasitic roundworms of animals and plants.
6. Vermiculture industry
7. Household insects, apiculture, lac culture, sericulture, prawn culture, insects of
8. Commercial value and stored grain pests.
9. Economic importance of amphibian, reptiles and birds
10. Poultry, Piggery
11. Dairy industry
12. Wool industry.

Recommended Texts

1. Ravindranathan, K.R. (2017). *A text book of economic zoology*. Delhi: Wisdom Press.
2. Islam, A. (2016). *A textbook of economic zoology*. Delhi: I. K. International Publishing House Pvt. Ltd.

Suggested Readings

1. Ahsan, J., & Sinah, S.P. (2010). *A hand book of economic zoology*. Delhi: Chand Publishing.
2. Jabde, P. V. (2005). *Text book of applied zoology*. Delhi: Discovery Publishing House.
3. Shukla, G. S., & Upadhyay, V. B. (1998). *A textbook of economic zoology*. Delhi: Rastogi Publication.

ZOOL-7109 Environmental Science 3 (3+0)

Environmental Science is focused on a holistic understanding of earth systems in order to learn from the past, comprehend the present and influence the future. Environmental Science is an unusual academic discipline in that it requires scientific knowledge about the natural world, as well as an understanding about ways in which humans interact with the natural world. Course will examine effects of human actions on the environment, and the means by which policies, regulations, and decisions influence human actions. It will also examine human behavioral, cultural, and sociological interactions that affect the environment. This course is designed around three core themes-understanding of environmental issues, investigations of environmental changes & impacts and prediction and mitigation of environmental issues. This course examines environmental issues through many lenses, including ecology, economics, ethics and policy analysis. This course also explores laws and regulatory policies governing to water and air pollution, land use and hazardous waste at national and international levels.

Contents

1. Definition, principles and scope of environmental science.
2. Physico-chemical and biological factors in the environment.
3. Concept of major and trace elements, classification of trace elements, human use, trace elements and health.
4. Air Pollution: natural and anthropogenic sources of pollution.
5. Primary and secondary pollutants, transport and diffusion of pollutants and effects of pollutants
6. Water Pollution: Types, sources and consequences of water pollution. Water quality standard.
7. Soil Pollution: Analysis of soil quality. Soil Pollution Control.
8. Industrial waste effluents and heavy metals, their interactions with soil components.
9. Soil micro-organisms and their functions,
10. Degradation of different insecticides, fungicides and weedicides in soil.
11. Noise Pollution: Sources of noise pollution, measurements of noise and Indices
12. Effect of meteorological parameters on noise propagation.
13. Noise exposure levels and standards. Noise control and abatement measures.
14. Impact of noise on human health.

Recommended Texts

1. Smith, T. M., Smith, R. L., & Waters, I. (2012). *Elements of ecology*. San Francisco: Benjamin Cummings.
2. Chiras, D. D. (2011). *Environmental science*. Burlington: Jones & Bartlett Publishers.

Suggested Readings

1. Newman, E. I. (2008). *Applied ecology and environmental management*. New Jersey: John Wiley & Sons
2. Molles, M. (2015). *Ecology: concepts and applications.* New York: McGraw-Hill Education.
3. Phalen, R. F., & Phalen, R. N. (2011). *Introduction to air pollution science: a public health perspective*. Burlington: Jones & Bartlett Publishers.

ZOOL-7110 Modern Techniques in Zoological Research 3(0-3)

A variety of instruments and techniques are used in biological studies, some of them are quite complex in nature. Scientific progress is directly related to the advancement in techniques and modern instruments. An understanding of these techniques and their application is essential for reading the zoological research literature, developing skills as a researcher and appreciating the goals, current limitations and future potential of modern zoological research. This course is designed to teach to do zoological research. Course will acquaint students with techniques employed in zoological research at the molecular, cell, tissue, whole organism and population levels. There is one main basic facet to this task. The laboratory exercises and instructions aim to teach students some of the most important, cutting edge, most often used generally applicable in short important zoological research methods and techniques. Such equipment, methodology and/or analysis will serve students wherever they go to do research in the future. This course is designed to set a foundation for student's future research/laboratory experiences.

Contents

1. Different staining techniques
2. Animal preservation techniques
3. Sampling techniques
4. Mass Spectrometry
5. Working with and fractionating mammalian cells
6. Separation / partitioning techniques: Gas and liquid chromatography
7. Antibody and fluorescence based techniques
8. PCR
9. Microtome
10. Gene sequencing
11. DNA / Protein Extraction, electrophoresis and initial characterization of proteins and nucleic acids.

Recommended Texts

1. Nelson, D. L., Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. New York: Macmillan.
2. Spangler, B. D. (2002). *Methods in molecular biology and protein chemistry*. New Jersey: John Wiley & Sons.

Suggested Readings

1. Nelson, D. L, Lehninger, A. L., & Cox, M. M. (2008). *Lehninger principles of biochemistry*. New York: Macmillan.
2. Wilson, P. D., Wilson, K., & Walker, J. (2000). *Principles and techniques of practical biochemistry*. Cambridge: Cambridge University Press.

ZOOL-7111 Recombinant DNA Technology 3(3+0)

It is an interdisciplinary subject that encompasses the sciences of Molecular Biology, Biomedicine as well as the genomic, proteomic, transcriptomic and metagenomics applications. Recombinant DNA technology is a technique which changes the phenotype of an organism (host) when a genetically altered vector is introduced and integrated into the genome of the organism. So, basically, the process involves introducing a foreign piece of DNA into the genome, which contains our gene of interest. This gene, which is introduced, is the recombinant gene and the technique is called the recombinant DNA technology. The course has been designed to acquaint the student with the fundamental techniques of genetic engineering; manipulation of DNA in vitro, transformation techniques, library construction and screening methods, expression systems and host-vector systems. Recent applications of recombinant DNA technology in the analysis of biological processes, diagnosis of human diseases, isolation of human genes, DNA finger printing, gene therapy and the development of commercial products are also covered. The course has 3 major components: techniques used in the generation of recombinant molecules, application of recombinant technology to diagnostics and therapeutics and genetically modified organisms. The discussion of potential ethic concerns of genome manipulations will also be included in the course

Contents

2. An outline of DNA cloning experiment; southern and northern blotting
3. Potentials of recombinant DNA technology; PCR; production of proteins
4. Plasmid vectors, bacteriophage, expression vectors, other vectors
5. Construction of genomic and c-DNA libraries,
6. Screening methods for gene libraries
7. Joining of DNA fragments to vectors, cohesive and blunt end ligation, adaptors, and linkers
8. Tissue culture techniques; transgenic organisms and gene therapies
9. Restriction fragment length polymorphisms and disease detection (e.g. cystic fibrosis)
10. Human genome project
11. Stem cells and therapeutic cloning; social considerations.

Recommended Texts

1. Khan, F. A. (2020). *Biotechnology fundamentals* (3rd ed.). Florida: CRC Press.
2. Ratledge, C., & Kristiansen, B. (Eds.). (2006). *Basic biotechnology*. Cambridge: Cambridge University Press.

Suggested Readings

1. Brown, T. (2010). *Gene cloning and DNA analysis: an introduction*. New Jersey: John Wiley & Sons.
2. Primrose, S. B., & Twyman, R. (2009). *Principles of gene manipulation and genomics*. New York: Wiley.
3. Howe, C. J. (2007). *Gene cloning and manipulation*. Cambridge: Cambridge University Press.

ZOOL-7112 Advances in Immunology 3(3+0)

The focus of course is on the immune system in disease situations where faulty B and T cell interactions are involved. Central topics are allergy, autoimmunity and cancer immunology. Furthermore, attempts to manipulate the immune response will be described. The course will integrate general immunology and cell biology, with a focus on antigen presentation. Students will be acquainted with understanding of lymph node microanatomy and know how B and T cells encounter antigen and develops in different locations, will know antigen presentation and autophagy on a detailed molecular level. This course will clear understanding of students about the cellular and molecular basis for autoimmune disease and allergies, basic knowledge of tumor immunology and the development of novel recombinant antibodies for treatment of cancer and autoimmune disease. The topics that will be covered include: innate and acquired immune responses; cellular and molecular mechanisms of immunity; antigen processing and presentation; tissue-specific immune responses; immune-mediated pathologies; and vaccination.

Contents

1. Molecular mechanism of innate & acquired immunity, TLRs and their role in Immunity.
2. Role of phagocytes in immunity, phagocytosis and role of antimicrobial and cytotoxicity mechanisms.
3. Mechanism of activation of B lymphocytes, accessory molecules in activation of B cells.
4. Mechanism of activation of T lymphocytes, General description of activation of T cells
5. Role of accessory molecules in activation of T cells.
6. Role of dendritic cells and regulatory T cells (T regs) in health and disease,
7. Signaling through immune system receptors, signaling pathways in B cells activation, signaling pathways in T cell activation, TLRs signaling pathways.
8. Organization and expression of immunoglobulin genes,
9. mechanism of variable regions DNA rearrangement
10. Generation of antibody diversity.

Recommended Texts

1. Punt, J., Stranford, S., Jones, P., & Owen, J. A. (2018). *Kuby's immunology* (8th ed.). New York: W. H. Freeman Company.
2. Delves, P.J., Martin, J. S., Burton, D. R., & Roitt, I.M. (2017). *Roitt's essential immunology* (13thed.). New York: Wiley Blackwell.

Suggested Readings

1. Abbas, A., Lichtman, A., & Pilla, S. (2017). *Cellular and molecular immunology* (9th ed.). Amesterdam: Elsevier.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (1994). *Cellular and molecular immunology*. London: Elsevier Health Sciences.

ZOOL-7113 Advances in Reproductive Technology 3(3+0)

Advanced reproductive technology includes medical procedures used primarily to address infertility. This subject involves procedures such as in vitro fertilization, intracytoplasmic sperm injection (ICSI), cryopreservation of gametes or embryos, and/or the use of fertility medication. When used to address infertility, advanced reproductive technology may also be referred to as fertility treatment. Advanced reproductive technology mainly belongs to the field of reproductive endocrinology and infertility. This course will clear the understanding of students about urinary human FSH, stimulation strategies for complex IVF patients programming the cycle with oral contraceptives antecedent to the use of antagonists, physiology to clinical success, micro-dose GnRH for the stimulation of low responders. The role of GnRH antagonist in the management of poor responders, alternative approaches to ovarian stimulation and triggering of ovulation, role of LH in stimulation protocols for ART, role of hMG-HP in stimulated cycles for ART, ovulation induction surgical approaches.

Contents

1. Advent of medically assisted reproductive technologies (MART), The endocrinology of ART,
2. Classification of infertility
3. Stimulation strategies: ovulation induction, hyper stimulation, urinary human FSH
4. Alternative approaches to ovarian stimulation and triggering of ovulation,
5. Role of LH & hMG-HP in stimulation protocols for ART
6. Art procedures: vaginal oocyte retrieval, (GIFT), (ZIFT), fallopian tube sperm perfusion
7. Fundamentals of sperm processing techniques, human oocyte and embryo cryopreservation.
8. *In Vitro* Maturation: future clinical applications, sperm separation, molecular biology applied to ART
9. Third party reproduction: Gestational surrogacy, oocyte donation, oocyte-sharing
10. Implantation: pathophysiology of implantation failure in IVF
11. Cryopreservation of oocytes and embryos, cryopreservation of human spermatozoa
12. The male factor, male infertility, isolated teratozoospermia,
13. ICSI or IUI, hormone substitution in male infertility

Recommended Book

1. Patel, H. N., & Esteves, C. S. (2019). *Advances in assisted reproductive technologies*. Dehli: Jaypee Brothers.
2. Gautam, N. A., Rita B. D., Rubina, M., & Bruno, L. (2003). *The art and science of assisted reproductive techniques (ART)*. London, New York: Taylor and Francis.

Suggested Readings

1. David K. G., Ariel, W., Colin, M., & Howles, Z. S. (2001). *Text book of assisted reproductive techniques laboratory and clinical perspectives*. Martin Dunitz: Taylor & Francis.
2. Gautam, N. A., Rita, B., Das, R. M., & Bruno, L. (2003). *The art and science of assisted reproductive techniques (ART)*. London, New York: Taylor and Francis.

ZOOL-7114 Analysis of Development 3 (3+0)

This course covers the fundamental aspects of development, from the molecular to the organismal levels. Some of the topics covered include: Determination of cell fate: cell-autonomous specification and induction cell-cell interactions and signal transduction, regulation of gene expression and gene regulatory networks, axis specification, patterning of tissues & organs, morphogenesis. Students will be able to understand the theme of development as a phenomenon of differential gene regulation, manipulation of embryos of different vertebrate classes, analysis of fetal organ twinning, conjoined twins, preservation of vital germplasm, cryopreservation of gametes and embryos, biobanking and bio–repository.Stages of embryogenesis, morphogenesis, pattern formation and differentiation of developing organisms will be examined. They will also become aware of how various changes in developmental pathways can play a role in human and animal health. Developmental mechanisms, especially at a molecular level, will be examined for differences and commonality among development of embryos of different vertebrate classes. Course will also touch on important issues related to stem cell research, regenerative medicines, animal and embryonic cloning.

Contents

1. Manipulation of embryos of different vertebrate classes.
2. Microsurgical techniques and fetal manipulations, In utero surgeries.
3. Analysis of fetal organ twinning, conjoined twins.
4. In vitro fertilization and embryo transfer techniques.
5. Preservation of vital germplasm
6. Cryopreservation of gametes and embryos
7. Biobanking and bio–repository.
8. Stem-cells therapy
9. Regenerative medicine.
10. Animal and embryonic cloning.

Recommended Texts

1. Carlson, B. M. (2018). *Human embryology and developmental biology*. London: Elsevier Health Sciences.
2. Moore, K., Persaud, T.V.N., & Torchia, M. (2016). *The developing human: clinically oriented embryology* (10^{th} ed.). London: Elsevier/ Saunders.

Suggested Readings

1. Schoenwolf, G. C., Bleyl, S. B., Brauer, P. R., & Francis-West, P. H. (2014). *Larsen's human embryology*. London: Elsevier Health Sciences.
2. Sadler, T. W. (2012). *Langman's medical embryology* (Vol. 12). Philadelphia: Wolters Kluwer.
3. Shumway, W. (2002). *Introduction to vertebrate embryology*. Dehli: Daya Books.

ZOOL-7115 Applied Microbiology 3(3+0)

Applied Microbiology is an interesting and dynamic field where basic knowledge of micro-organisms is applied to human health, industry, agriculture and the environment. The course focuses on how micro-organisms interact with the environment, how to detect causal micro-organisms of diseases and spoilage, and how micro-organisms can be employed to produce valuable products for society, such as antibiotics, fermented foods and drinks, and alternative fuels. The course is a job providing in nature after its completion. This course will also provide an overview of the diversity of microorganisms and their metabolic activities such as the microbial products of major social, economic and environmental importance. Students will learn about: host-microbe interactions, Resistance and immunity, Air, food and water-borne human infections, Human contact diseases, Infectious diseases of animals, Microbiology of food, milk and milk products. Microbial activity measurements, assess the use of microbes as tools in biotechnology and can describe microbial biochemical pathways and relate them to important industrial processes.

Contents

1. Control of microorganisms: fundamentals of control by physical and chemical agents
2. Antibiotics and other chemotherapeutic agents.
3. Environmental microbiology**:** microbiology of air.
4. Aquatic microbiology. Soil microbiology. microbiology of domestic water and sewage.
5. Industrial microbiology**:** scope of industrial microbiology in food production, control of insects, human therapy, petroleum, mining and bioremediation.
6. Biotechnology and its role in modern human comforts.
7. Microbial ecology: microorganisms in aquatic habitats, deep-sea & terrestrial environments
8. Hydrothermal vents, rumen microbial ecosystem, microbial leaching,
9. Biogeochemical cycles; trace metals and mercury,
10. Biodegradation of xenobiotic.

Recommended Texts

1. Jacquelyn, G. B., & Laura, J.B. (2015). *Microbiology principles and explorations* (9th ed.). New Jersey: John Wiley & Sons Inc.,
2. Eugene, W. N., Denise, G., Anderson, M. T., Nester, C., Roberts, E., & Nancy, N. (2008). *Microbiology: a human perspective* (6th ed.). New York: McGraw Hill Higher Education.

Suggested Readings

1. Alfred, B., & Heidi, S. (2015). *Benson's microbiological applications laboratory manual in general microbiology* (13th ed.). London: McGraw Hill.
2. Pelczar Jr., Chan, E.C.S., & Krieg, M.R. (2001). *Microbiology* (5th ed.). New York: McGraw Hill.

ZOOL-7116 Aquaculture and Fisheries 3 (3+0)

Fisheries and aquaculture are the theory and practice of cultivating marine and freshwater algae and animals for food. The industry also provides opportunity in the development of chemical and pharmaceutical products, scientific research, species population restoration, food safety and sustainability, and the production of ornamental plants and animals. Currently, culture of aquatic biota for direct consumption, stock enhancement, or other purposes is the fastest growing and most diverse sector of livestock production. The purpose of this course is to develop an understanding of commonly used culture systems, to become familiar with the fundamentals of fish and shellfish husbandry, and to gain an appreciation of aquaculture's roles in natural resource management, the human food supply, and the global economy. Students will gain an understanding of the key aspects of producing food in aquatic environments and develop scientific skills in experimental design and technical aspects applied in aquaculture.

Contents

1. Introduction to fisheries and aquaculture, national and international trends.
2. Fish morphology and diversity in size and shape.
3. Distribution of fishes in Pakistan, commercial fishes, marine and freshwater.
4. Types of ponds, planning construction and pond preparation.
5. Pond fertilization, application
6. Food and feeding habits of fishes, feeding types, artificial and natural fish food, artificial fish feed.
7. Fish habitat, ecology and extant of distribution, water quality parameters and their effects on fish health and production.
8. Biotic parameters of ponds, lakes, rivers, and impacts on fish growth. Induced breeding.
9. Fish diseases and their control.
10. Fishing gears, fishing techniques, fishing communities.
11. Fish preservation, processing transportation and marketing.

Recommended Texts

1. Lovrich, G., & Thiel, M. (2020). *Fisheries and aquaculture*. Oxford: Oxford University Press, Incorporated.
2. Gibert, G. (2019). *Novel development in aquaculture and fisheries science*. New York: Callisto Reference.

Suggested Readings

1. Sharma, O. P. (2009). *Handbook of fisheries and aquaculture*. Dehli: Agrotech Publishing Academy.
2. Stickney, R. R. (2009). *Aquaculture: an introductory text*. London: CABI Publishing
3. Pillay, T. V. R., & Kutty, M. N. (2005). *Aquaculture: principles and practices*. New York: Blackwell Science Limited.

ZOOL-7117 Behaviour of Spiders 3(3+0)

This course is about biology of spiders, their morphological and physiological characteristics, range of behaviours and activities performed by them. Spiders are commonly thought as appropriate behavioural models due to the concept that they have small brains and show innate and frequently consistent behaviour. This course will introduce students to the interesting domain of spiders, their biology, their intelligent behaviours like deception, and methods of communications to their relatives and various strategies for self-defense. The course highlights how spiders show amazing mental abilities, changing their behaviour to suit their situational needs and provide care to their young ones. This course unravels the considerable intra-specific as well as intra-individual variability and plasticity in different behaviours ranging from foraging and web building skills to communication, silk production, self-defense and courtship. Students will be able to understand the structure, functions, ecological associations, intelligent abilities and behavioural adaptations in spiders at the completion of this course.

Contents

1. Introduction: Spider biology
2. Foraging behaviour
3. Web building behavior
4. Anti-predator behavior
5. Communication
6. Deception
7. Mating behaviour and sexual selection
8. Group living in spiders
9. Cooperative breeding
10. Coloniality
11. Plasticity
12. Learning and cognition

Recommended Texts

1. Herberstein, M. H. (Editor). (2011). *Spider's behaviour- flexibility and versatility*. New York: Cambridge University Press.
2. Wolfgang, N. (2013). *Ecophysiology of spiders.* London: Oxford University Press.

Suggested Readings

1. Viera**,** C., & Gonzaga, M. O. (2017). *Behaviour and ecology of spiders*. Switzerland: Springer International Publishing AG.
2. Foelix, R. (2011). *Biology of spiders* (3rd ed.). New York: Oxford University Press.
3. Barth**,** F. G. (2002). *A spider's world: senses and behavior*. New York, Berlin, Heidelberg: Springer.

ZOOL-7118 Behavioural Ecology 3(3+0)

The course comprises of fundamental features of behavioural ecology. Specific emphasis will be put on various behavioural mechanisms adapted by animals in an evolutionary perspective. In this context topics discussed include interaction between individual interests, social behaviours, life history, and also the role of behavioural ecology in conservation biology. Furthermore, this course provides information about various inter and intraspecific interactions, how competition and cooperation within and among species affects evolutionary suitability. The aim of this course is to understand the evolutionary basis of animal behaviour due to ecological pressures. When we discuss adaptations we are referring to changes brought about during evolution by the process of natural selection. Students will study about the ecological factors that induce behavioral adaptations in this course. Students will be able to learn in this study how to critically evaluate theories and models for sexual selection, foraging, and life history strategies, sociality, predation, speciation, personality, communication and to integrate knowledge of ecology, evolution and behavior.

Contents

1. Natural selection, ecology and behavior
2. Testing hypotheses in behavioral ecology
3. Economic decisions and the individual
4. Predator verses prey
5. Evolutionary arms races
6. Competing for resources
7. Living in groups. Social behaviours: altruism to spite
8. Cooperation, Altruism
9. Conflict in the social Insects.
10. Sexual selection, sperm competition and sexual conflict
11. Mating systems

Recommended Texts

1. Nicholas, B. D., John, R. K., & Stuart, A. W. (2012). *An introduction to behavioral ecology* (4th ed.). Oxford, UK: Willy-Blackwell, John Willy and Sons Ltd Publications.
2. Goodenough, J., McGuire, B., & Jakob, E. (2009). *Perspectives on animal behavior*. New York: John Wiley & Sons.

Suggested Readings

1. Danchin, E.L., Giradeau, A., & Cezilly, F. (2008). *Behavioral ecology: An evolutionary perspective on Behavior*. Oxford: Oxford University Press.
2. Dugatkin, L. A. (2001). *Model System in behavioral ecology. Integrating conceptual, theoretical, and empirical approaches.* New Jersey: Princeton University Press.
3. Dugatkin, L. A. (2012). *Principles of animal behavior*. New York: W.W. Nortan & Co.

ZOOL-7119 Biological Insect Pest Control 3(3+0)

Use of pesticides is globally disliked due to their environmental and health effects and the scientists are focusing on the use of safer pest control strategies including Biological Pest Control. This course will provide introduction, historical background and geographical distribution of various insect species along factors that makes them pest. Available biological pest control, their identification and distribution will be introduced through these learnings. Students will be given knowledge about biological features and varieties of biological mediators to control insect pests. Ecological and behaviourial characteristics of pest as well as biological control will be highlighted. Pest control methods include predation, parasitism, herbivory and additional natural tools, but characteristically depend on dynamic human management. Understanding about recent strategies which are in practice nationally or internationally to manage pests will be given to students. Several techniques which are commercially used for rearing of biological pest control agents including culturing of bacteria and virus will be familiarized.

Contents

1. Pest management: history and recent developments, general aspects of biological pest control, national and international significance and scope.
2. Morphological features, Identification, habitats and distribution of biological pest control agents.
3. Parasitoids: Hymenoptera, Diptera, Strepsiptera other insect orders.
4. Predators: Insects (Coleoptera, Neuroptera, Hemiptera, Odonata, Lepidoptera, Thysanoptera), invertebrates and vertebrates.
5. Biology of Biocontrol agents: Trichogramma, Ichneumonids, Braconids, Tachinids and Chalcids.
6. Rearing techniques for following biocontrol agents:
7. Parasitoids: *Trichogramma spp., Chelonusblackburni, Braconbrevicornis, Meteorusdichomeridis, Copidosomakoehleri, Campoletischlorideae*.
8. Predators: Lady bird beetle: *Cryptolaemusmontrouzieri*, Hemipterans, lace wing: *Crysoperlacarnea, Menochilus sp.*, dragonflies, toad, shrews and guppy fish.
9. Bacteria: *Bacillus thurienginesis* and Viruses: Nuclear Polyhedrosis Virus (NPV).

Recommended Text

1. Abrol, D.P. (2013). *Integrated pest management: current concepts and ecological perspective.* California: Academic Press.
2. Sathe T.V. (2013). *Recent trends in biological pest control*. Dehli: Daya Publishing House.

Suggested Readings

1. Patil, V.J., & Sathe, T.V. (2003). *Insect predators and pest management*. Dehli: Daya Publishing House.
2. Sathe, T.V., & Bhoje, P.M. (2000). *Biological pest control*. Dehli: Daya Publishing House.
3. Srivastava, K.P. (2010). *Text book of applied entomology* (3rd ed.). Dehli: Kalyani Publishers.

ZOOL-7120 Biology of Birds and Mammals in Pakistan 3(3+0)

Birds and mammals represent a great diversity of species that are widely distributed across the globe and carry out a variety of functions in the earth's ecosystems. The biology of these animals is the underlying factor allowing the success of birds and mammals in dynamic ecosystems. Being winners in the evolution, birds and mammals have shown exceptional rate of success. They have diversified into many types of environments with more species number than any other vertebrate group. A group of many mammals, with the scientific name of Boreoeutheria, has diversified about seven times faster than expected, beginning about 110 million years ago. Modern birds have diversified about nine times faster than expected, starting about 103 million years ago. Avian physiology has multiple unique features. Birds have unique biological systems allowing flight, migration, production of large yolky eggs, and maintenance of high body temperature and high blood concentrations of glucose together with care of young. Mammals, on the other hand, nourish their young ones with the milk; possess hair, muscular diaphragm, enucleated red blood cells and direct attachment of lower jaw with skull via a hinge. Except for the monotremes (an egg-laying order of mammals comprising echidnas and the duck-billed platypus), all mammals are viviparous, they bear live young.

Contents

1. Origin, evolution and life history of birds in Pakistan
2. Classification of avifauna of Pakistan
3. Characteristics, structure
4. Reproduction and development in birds
5. Behavior and population regulation in birds
6. Birds: general ecology, geographical distribution
7. Migration and orientation in birds
8. The mammalian fauna of Pakistan, introduction and classification
9. Behavior and population regulation in mammals
10. Ecological distribution, status and relationships of mammals
11. Species accounts of mammalian and avifauna of Pakistan
12. Endangered birds and mammals of Pakistan
13. Scientific and economic importance of mammalian and avifauna in Pakistan

Recommended Texts

1. Gill, F.B., Prum, R.O., & Robinson, S. K. (2019). O*rnithology* (4th ed.). New York: W. H. Freeman.
2. Feldhamer, G. A., Merritt, J. F., Krajewski, C. Rashlow, J. L., & Stewart, K. M. (2020). *Mammalogy: adaptation, diversity, ecology* (5th ed.). Baltimore: Johns Hopkins University Press.

Suggested Readings

1. Grewal, B., Sen, S., Singh, S., Devasar, N., & Bhatia, G. (2017). *A photographic guide to the birds of India, Pakistan, Nepal, Bhutan, Sri Lanka and Bangladesh.* New Jersey: Princeton University Press.
2. Grimmett, R., Roberts, T. J., Inskipp, T., & Byers, C. (2008). *Birds of Pakistan*. London: A&C Black.
3. Roberts, T. J. (2006). *Field guide to the large and medium-sized mammals of Pakistan*. Oxford: Oxford University Press.

ZOOL-7121 Cellular and Molecular Physiology 3(3+0)

This study is based on the understanding how molecular and cellular processes give rise to complex physiologic functions in a living body. This course provides the study of molecular structure and function, molecular interactions and cell signalling through simple to complex cellular phenotypes. The course provides details how molecular machines can be the cause of physiological processes and how these mechanisms are regulated. The idea behind this kind of approach is that the whole of a living system can be understood by studying its individual parts, identifying the subset of genes and proteins that function in physiological context or malfunction to trigger disease. The course emphases on the diverse modules of molecular machines that facilitate movement, change molecular states, or stimulate membrane transport, in addition to their mechanisms of action. Focus is maintained on molecular structure and physiology of cellular compartments in addition to chromatin, proteomics, pharma informatics and drug designing.

Contents

1. Compartmental diversity within the cell and its maintenance.
2. Molecular mechanisms of vesicular transport, maintenance of compartment identity.
3. Bioenergetics: cellular metabolisms. Energy transformations.
4. Molecular motors: P - loop NTPase super family, myosins, kinesin & dynein, A rotary motor (in bacteria).
5. Signal transduction pathways in cell: G-proteins, cyclic AMP, Ca^{-2} as messenger, protein kinases
6. Ionic basis of membrane excitability: Ionic channels, electrical properties of membrane
7. Control of gene expression: organization of gene, role of gene regulatory proteins, role of DNA-binding proteins, chromatin structure & control of gene expression.
8. Garbage disposal unit inside the cell: lysosomes, peroxisomes
9. Cell and defense: cellular basis of immunity, SER and biotransformation.(Biotics & xenobiotics)
10. Cell renewal: By simple duplication, by stem cells, by pluripotent stem cells,
11. Cell death: apoptosis Type I, apoptosis Type II
12. Genomics and evolution: principles of genome annotation
13. Proteomics and drug designing: Conceptual models of protein structure, three dimensional structure classification and protein function, structural alignment, pharma-informatics & drug designing.

Recommended Texts

1. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M., & Bretscher, A. (2016). *Molecular cell biology* (8th ed.). New York: W. H. Freeman Company.
2. Karp, G., Iwasa, J., & Marshall, W. (2019). *Karp's cell and molecular biology*: *concepts and experiments* (9th ed.). New York: Wiley.

Suggested Readings

1. Alberts, B., Bray, D., Lewis, J., Raff, M., Roberts, K., &Watson, J.D. (2017). *Molecular biology of the cell*. New York: Garland Publishing Inc.
2. Cooper, G. (2018). *The cell: A molecular approach* (8th ed.). Oxford: Oxford University Press.

ZOOL-7122 Clinical Teratology 3(3+0)

Exposures that can induce permanent structural or functional anomalies in an exposed embryo or fetus are called teratogenic, while teratology is the detailed study of those factors that exhibit teratogenic potential under certain conditions. This study is focused on the congenital malformations and abnormalities of physiological development due to exposure to teratogens. The students will be provided details of various types of teratogens, their source, structure and mode of induction of teratogenicity. Students will be provided extensive knowledge about genetic and environmental factors that produce congenital malformations in order to be able to understand differences between inherited, acquired, and so-called multifactorial malformations. Early development also has an influence on age related diseases, so age related effects of teratogens will be discussed in this course. Furthermore, familiarity with the knowledge of possibility of investigating, and treating, fetuses by drugs, genetic engineering or intra-uterine surgery will be provided to learners.

Contents

1. Teratogenesis: environmental assaults on human development.
2. Teratogenic agents: retinoic acid, hydroflourocarbons
3. The degradation products used as refrigerants
4. Drug abuse as heroin, alcohol, tobacco and cannabis
5. Heavy metals,
6. Pathogens: *Rubella, Toxoplasma gondii, Treponema pallidum* (Syphilis bacterium)
7. Endocrine disruptors: diethylstilbestrol; nonylphenol; bisphenol A
8. Testicular dysgenesis and declining sperm counts.
9. Developmental biology and future of medicine:
10. Germ-line gene therapy,
11. Stem cell therapy and regeneration therapy.

Recommended Texts

1. Gilbert, S.F. (2018). *Developmental biology* (11th ed.). Massachusetts: Sinauer Associates.
2. Moore, K., Persaud, T.V.N., & Torchia, M. (2016). *The developing human: clinically oriented embryology* (10th ed.). New York: Elsevier,Saunders.

Suggested Readings

1. Carlson, B.M. (2018). H*uman embryology and developmental biology* (6th ed.). New York: Elsevier.
2. Bedard, P.L., & Cardoso, F. (2008). Recent advances in adjuvant systemic therapy or early-stage breast cancer, *Ann Oncol.*19 (5), pp. 122– 127
3. National Academies USA. (2009). *Understanding stem cells*: An overview of the science and issues from National Academies USA.

ZOOL-7123 Concepts of Toxicology 3(3+0)

Toxicology is a discipline, which in combination with biology, chemistry and pharmacology, deals with the study of the adverse effects of chemical substances on living organisms. Students through this learning became able to study basic concepts of toxicology as they are applicable to the disturbances of environmental agents, e.g. chemicals or metals for human health. It imparts knowledge about the distribution, cellular penetration, metabolic conversion, and elimination of toxic agents, as well as the fundamental laws governing the interaction of foreign chemicals with biological systems. It provides information about molecular, cellular and pathophysiological reactions resulting from exposure to chemical agents related to human health. It elucidates how to identify underlying susceptibility factors which contribute to the ability of chemicals to provoke bioeffects which contribute to human disease. This course defines the chemical properties and the biological processes which control the toxicokinetics of chemical agents of public health importance, explain the significance of biotransformation reactions.

Contents

1. Introduction to principles of toxicology: types, nomenclature, applications of toxicology.
2. Classification of toxic agents according to use: pesticides, food additives, therapeutic drugs
3. Sources of toxins: botanical, environmental.
4. Effects of chemicals: general classification, chemical allergies, mutagenic and carcinogenic
5. Biochemical properties, exposure: route: oral, intranasal, inhalation, dermal and parenteral
6. Accumulation: dose-response relationship, criteria for measurement
7. Toxic kinetics: pharmacokinetics: toxicology testing,
8. Absorption: ionic and non-ionic principles, Henderson- Hassel bach equation,
9. Distribution: fluid compartments, plasma protein binding, lipids, liver and kidney, blood-brain barrier,
10. Biotransformation: principles of detoxification, biochemical pathways, enzyme systems,
11. Elimination: urinary excretion, fecal, pulmonary, mammary gland secretion, other secretion
12. Descriptive animal toxicology: correlation with human exposure,
13. Animal welfare and US animal welfare act,
14. Chemicals: selection of chemicals, route of administration, species differentiation: selection of appropriate animal species, methodologies.

Recommended Books

1. Carson, B. L. (2018). *Toxicology biological monitoring of metals in humans*. USA: CRC Press.
2. Frank, C. Lu., & Sam Kacew. *Lu's basic toxicology: fundamentals, target organs, and risk assessment*. USA: Informa Healthcare.
3. Karen, E. S., & Thomas, M. B. (2015). *Principles of toxicology*. USA: CRC Press.

Suggested Books

1. Schafer, S.G, Dawes, R., Elsenhans, B., Forth, W., Schumann, K. *Metals "in" toxicology* edited by Hans M., Siegfried, G. S., Roger, M., & Frank, W. (1999). San Diego, London, Boston, New York: Acadmic Press.
2. Barile, F. A. (2013). *Principles of toxicology testing*. Florida: CRC Press.

ZOOL-7124 Fish Nutrition 3(3+0)

The course will provide an introduction to the various food components, nutritional impact on growth, development, reproduction, health and quality of farmed fish. Familiarity of nutritional necessities, the formation of diet regimes, and suitable feed managing practice is necessary for the rearing of any animal species that is cultured intensively. The course will deliver an overview to the various food constituents, nutritional impact on growth, development, reproduction, health and quality of farmed fish. This involves learning about the fish's digestive system and the different nutrient's digestion, absorption, metabolism and biochemical function. The course content highlights the physiological features of nutrition and the response of fish to diet in relative to other environmental factors and to the genetic background of the fish. The course illustrates particular techniques used in experimental studies in fish nutrition. The course also covers relevant undesirable substances in feed that can be a challenge for the health and for the seafood product produced.

Contents

1. Bioenergetics; introduction, energy utilization and requirements
2. Digestible, urinary, branchial and metabolizable energy
3. Recovered energy and its use in growth and reproduction
4. Vitamins; introduction, water-soluble vitamins and fat soluble vitamins
5. Amino acids and proteins; qualitative and quantitative requirements of amino acids
6. Methods of amino acid requirement determination
7. Protein requirements and methods of determination
8. Lipids; fatty acids and dietary energy, sources of lipids for feed formulations.
9. Minerals; essential minerals and their requirements for finfish.
10. Intermediary metabolism; metabolic circuitry and control mechanisms
11. Carbohydrate, protein and amino acid metabolism.
12. Diet formulation and manufacture; introduction
13. Feed ingredients, diet formulation, manufacturing and storage.

Recommended Texts

1. Jain, N. (2018). *Practical manual on fish nutrition and feed technology*. Dehli: Daya Publishing House.
2. Lee, C. S., Linn, C., Gatlin, D. M., & Webster, C. D. (2015). *Dietary nutrients, additives, and fish healt*h. New Jersey: Wiley Blackwell.

Suggested Readings

1. Halver, J. E., Ronald, W. H., & Dniel, M. H. (2004). *Fish Nutrition* (4th ed.). New York: Academic Press.
2. Hepher, B. (2010). *Nutrition of pond fishes*. Cambridge: Cambridge University Press.
3. National Research Council (NRC). (2011). *Nutrient requirements of fish and shrimp*. Washington D.C: National Academic Press.

ZOOL-7125 Medical Biotechnology 3(3+0)

The course focus on medical applications of biotechnology, tools used to analyze a variety of biological samples, as well as for health care applications in diagnostics and drug development. The student will be provided with in-depth knowledge about scientific methodologies used for comprehensive analyses of biological systems, and their applications for advanced health care or medical investigation. Medical Biotechnology is the use of sensational advances in molecular and cell biology to medicine, agriculture, and the environment. Through modern technologies such as genetic engineering, biotechnology is modeling different aspects of medicine (cancer, vaccines, therapy and diagnosis of genetic diseases), food production (transgenic plants), and industry (bioremediation). The course curriculum is designed to deliver step wise information regarding various technicalities part of genetic engineering, cell culture, DNA cloning and many more. Further, emphasis is maintained on the use of biotechnology in medical field as gene therapy, mapping of genetic diseases and production of molecular pharmaceutical products.

Contents

1. Introduction to the medical biotechnology: its role and interdisciplinary pursuit
2. The principles of cloning DNA in medical biotechnology: strategies and tools
3. The enzymology of *in vitro* DNA recombination,
4. Vectors for cloning, synthesis of DNA for cloning, determination of base sequence in DNA
5. Reaching the gene via mRNA and protein, synthesis of complete gene, reporter genes,
6. Recombinant virus genes, (brief account), gene cloning techniques for mammalian cells
7. Methods of transfection: liposomes, direct transformation, microinjection.
8. Gene expression. Expression of mammalian genes in prokaryotic and eukaryotic systems
9. Basic techniques of animal cell culture and their applications, transgenic animals
10. Molecular techniques for rapid diagnosis of diseases: Gene therapy
11. Medical biotechnological approach to study various types of diseases (infectious and genetic)
12. Other mutations, a molecular basis for inherited disease, mapping a genetic disease
13. Applied medical biotechnology: drug targets: vaccines and antibodies, preparation and usage
14. Biosafety regulation & management: genetically engineered microbes and environment

Recommended Texts

1. Lanza, R.P., Langer, R., & Vacanti, J. (2013). *Principles of tissue engineering* (4th ed.). California: Academic Press.
2. Primrose, S.B., & Twyman, R. M. (2006). *Principles of gene manipulation and genomics* (7th ed.). New Jersey: Wiley Blackwell.

Suggested Readings

1. Hartwell, L.H., Hood, L., Goldberg, M.L., Reynolds, A.E., Silver, L.M., &Veres, R.C. (2010). *Genetics: from genes to genomes* (4th ed.). New York: McGraw-Hill Publishing.
2. Griffiths, A. J. F., Wessler, S.R., Lewontin, R.C., & Carroll, S. B. (2015). *Introduction to genetic analysis* (11th ed.). New York: W.H. Freeman and Company.
3. Ratledge, C., & Kristiansen, B. (2006). *Basic biotechnology* (3rd ed.) New York: Cambridge University Press.

ZOOL-7126 Medical Parasitology 3(3+0)

This curriculum provides core theoretical aspects of medical parasitology, covering the protozoan and metazoan parasites of humans and the vectors which transmit them. Students will gain familiarity with common protozoan and helminth parasites of humans as well as some related parasites of livestock and companion animals related to medical parasitology. The study will highlight various types, ecology and physiology of vectors responsible for transmission of parasitic diseases. This course provides students with an understanding of parasitic infections of humans including the biology of parasites, understanding of parasitism, epidemiology, pathogenesis, treatment, and prevention of various medically important parasitic infections. Students come to know about the problems in parasitology, including clinical, public health and biological issues and the roles of parasites and of infectious diseases on the ecology and evolution of their hosts. Extensive knowledge about diagnosis, treatment and control of parasitic infections in humans and in veterinary animals will be provided.

Contents

1. Symbiosis to parasitism: parasite, host, community;
2. Malaria; biological aspects; immunological and patho-physiological aspects in malaria
3. Leishmaniasis: disease spectra and immunopathology of Chagas' disease
4. Opportunistic pathogens: Toxoplasmosis; Intestinal protozoa: amoebiasis and Giardiasis;
5. Schistosomiasis: hepatosplenic, intestinal and urinary schistosomiasis;
6. Fascioliasis; Echinococcosis;
7. Cerebral and generalized cysticercosis
8. Ascariasis and visceral larva migrans
9. Intestinal nematodiasis: immunological mechanisms of worm expulsion
10. Cytokines: their roles in parasitic diseases
11. Lymphatic filariasis: causes, symptoms, diagnosis and treatment
12. Trichinosis; causative agent, clinical manifestation, diagnosis and treatment
13. Significance of eosinophilia in helminthiasis
14. Parasite-host interaction: molecular to cellular level

Recommended Texts

1. Roberts, L.S., & Janovy, J. Jr. (2009). *Foundations of parasitology* (8th ed.). Bostan: McGraw Hill, Publishing.
2. Sastry, A. S., & Bhat, S. (2019). *Essentials of medical parasitology* (2nd ed.). Dehli: Jaypee Brothers Medical Publishers.

Suggested Readings

1. Strickland, G. T. (1984). *Hunter's tropical medicine* (6th ed.). Philadelphia: Saunders
2. Janeway, C.A., &Travers, P. (2001). *Immunobiology.* New York: Garland Science.

ZOOL-7127 Physiology of Homeostasis 3(3+0)

The curriculum in this course provides an integrated knowledge and understanding of the major principles of homeostasis involved in the maintenance of health. Homeostasis is the body's effort to keep a constant internal environment. This adjusting of physiological systems within the body is called homeostatic regulation. Physiological interactions between the nervous system and the endocrine system maintain homeostasis and health. This course describes the main components of the endocrine, digestive, renal and nervous systems and demonstrates knowledge of how they contribute to the maintenance of homeostasis. Themes in this course include the functions of the central and peripheral nervous systems; the roles of endocrine glands and the hormones they secrete; the gastrointestinal tract in providing nutrition to the body; and the renal system in the regulation of fluid and ion levels. Learning of molecular and physiological mechanisms responsible for the stability in internal environment will be ensured through this course.

Contents

1. Homeostasis control systems: feed-back, feed forward
2. Non physiological homeostatic mechanisms.
3. Acclimatization, strategies, adaptations
4. Regulatory devices, behavioral responses
5. Thermoregulation: Strategies, adaptations,
6. Importance of temperature to animal physiology
7. Classification of temperature regulation
8. Heat exchange interactions between animals and the environment,
9. Ectotherms & Endotherms: control of body temperature in endotherms,
10. Comparison of ectothermy with endothermy.
11. The body fluids of animals.
12. The principles of osmosis: osmo-confirmers, regulatory strategies,
13. Osmotic responses of animals under changing environmental conditions.

Recommended Texts

1. Moyes, C.D., & Schulte, P. (2014). *Principles of animal physiology* (2nd ed.). New Jersey: Pearson publishers.
2. Hill, R.W., Wyse G. A., & Anderson, M. (2012). *Animal physiology* (3rd ed.). Sunderland: Sinauer Associates, Inc.

Suggested Readings

1. Guyton, A. C. (2006). *Textbook of medical physiology* (11th ed.). Philadelphia: Elsevier Saunders.
2. Ian Kay. (1998). *Introduction to of animal physiology*. Oxford: Bios Scientific Publishers.

ZOOL-7128 Protozoans Parasitology 3(3+0)

Protozoa is an informal term for single-celled eukaryotes, either free-living or parasitic, which feed on organic matter such as other microorganisms or organic tissues and debris. These one-celled animals are found worldwide in most habitats. Most species are free living, but all higher animals are infected with one or more species of protozoa. Infections range from asymptomatic to life threatening, depending on the species and strain of the parasite and the resistance of the host. This course is designed to give a broad overview of general human and animal parasitology, with respect to the types of parasites, nature of parasitism, advantages and disadvantages of parasitism. It will cover the biology, parasitism and pathogenesis of the parasitic protozoans and arthropod vectors that cause significant transmission of human and animal diseases. This subject covers how each parasite establishes infection in their hosts, how it spreads between hosts, and the pathogenesis of disease. Current approaches to control and to treat parasitic disease will be addressed.

Contents

1. History and classification of Protista. Host parasites interactions
2. Systematics, biology, pathology and control of parasitic protozoa
3. Protozoa of medical and veterinary importance.
4. Morphology, life cycle, pathogenesis, diagnosis and control of Trypanosoma,
5. Morphology, life cycle, pathogenesis, diagnosis and control of Leishmania
6. Morphology, life cycle, pathogenesis, diagnosis and control of Trichomonas, Histomonas,
7. Morphology, life cycle, pathogenesis, diagnosis and control of Giardia, Entamoeba, Eimeria,
8. Morphology, life cycle, pathogenesis, diagnosis and control of Isospora, Toxoplasma,
9. Morphology, life cycle, pathogenesis, diagnosis and control of Sarcocystis, Plasmodium
10. Morphology, life cycle, pathogenesis, diagnosis and control of Haemoprotaus, Babesia,
11. Morphology, life cycle, pathogenesis, diagnosis and control of Theileria, Balantidium
12. Morphology, life cycle, pathogenesis, diagnosis and control of Anaplasma.

Recommended Texts

1. Robert, L. S., & Janory, J. Jr. (2002). *Foundations of parasitology*. London: W. M. C. Brown Publishers.
2. Chang, T.C. (1996). *General parasitology* (2nd ed.). New York, London: Academic Press.

Suggested Readings

3. Walochnik, J., & Duchene, M. (2016). *Molecular prarsitology: Protozoan parasites and their molecules*. Dehli: Springer- Verlag Wien.
4. Heinz, M. (2016). *Human parasites* (1st ed.). Cham: Springer International Publishing.

ZOOL-7129 Reproductive Endocrinology 3(3+0)

Reproductive endocrinology is the study that imparts knowledge about fundamental pathways regulating reproductive health of an individual. Curriculum provides detailed information about the structure and functioning of the hormone-secreting glands that mediate various processes of the body including reproductive growth, development and fertility. Students will be familiarized with the role of endocrine input at various stages of life including sex differentiation at embryonic level, neuroendocrine mediators at pubertal level and maintained regulation of fertility and reproductive health through whole life. Curriculum is designed to have all relevant information required about complications related to reproduction and fertility mediated through endocrine glands disorders in both men and women. In women, these may include diseases of the fallopian tube, endometriosis, repeated pregnancy loss, uterine myomas, uterine abnormalities and other reproductive endocrine disorders. Men also face reproductive and fertility complications, which may result from disorders such as erectile dysfunction or priapism, decreased sperm count etc.

Contents

1. Endocrine aspects of sex differentiation in male and female foetus
2. Hypothalamus and pituitary structure and secretions.
3. Role of Hypothalamic-pituitary-gonadal axis and its regulation.
4. Ovarian function: gametogenesis, steroidogenesis and its regulation
5. Testicular function: gametogenesis, steroidogenesis and its regulation
6. Steroid hormones: biosynthesis and physiological actions.
7. Endocrinology of puberty
8. Endocrine regulation of pregnancy.
9. Endocrinology of lactation.
10. Endocrine disorders in males (few examples)
11. Endocrine disorders in females (few examples)

Recommended Texts

1. Wilson, J.D., Foster, D.W., & Larson, P.R. (1998). *Williams textbook of endocrinology*. Philadelphia: W.B. Saunders.
2. Strauss, J.F., Barbieri, R. L., & Gargiulo, A.R. (2018). *Yen & Jaffe's reproductive endocrinology: physiology, pathophysiology, and clinical management* (8th ed.). Amsterdam: Elsevier.

Suggested Readings

1. Wilson, J.D., Foster, D.W., & Larson, P.R. (1998). *Williams textbook of endocrinology*. Philadelphia: W.B. Saunders.
2. White, B.A, & Porterfield, S.P. (2013). *Endocrine and reproductive physiology* (4th ed.). Amsterdam: Elsevier/Mosby.

ZOOL-7130 Statistical Ecology 3(3+0)

Statistical ecology is a new scientific discipline that has developed promptly in response to advances in different academic fields globally. Statistical ecology deals with the development of new methodologies for analyzing ecological data. The course focuses on learning the fundamentals of probability distributions as models of animal abundance, models of demographic processes and evolutionary dynamics. Advanced statistical models and techniques are often needed to provide robust analyses of the available data offered in the life sciences by focusing on the mathematical statistics theory underlying the methods used in ecological and evolutionary analyses. The curriculum explains basic and fundamental concepts of probability and statistical inference in ecology, basic probability distributions to model and employ basic elements of statistical inference in ecology by means of mathematical statistics results. Learners will became aware about basic and advance statistical tools and their applications though this course on ecological data by the help of specific software.

Contents

1. Introduction to ecological parameters,
2. Experiments and experimental design in ecology
3. Review of ANOVA, assumptions of ANOVA, ANOVA models, mixed model ANOVA, nested ANOVA,
4. Factorial experiments & repeated measures, linear regression and multiple regression,
5. MANOVA, estimation species richness, diversity evenness.
6. Principal component analysis, corresponding analysis, discriminate functional analysis,
7. Cluster analysis, redundancy analysis,
8. Concept of niche overlap and resource partitioning
9. Distribution models, intraspecific association, intraspecific covariant,
10. Association analysis, non-linear ordinations, resemblance function,
11. Quadrate-variance methods and distance methods.

Recommended Texts

1. Ludwig, J.A., & Reynold, J.F. (1988). *Statistical ecology: A primer on methods in computing.* New York: John Wiley and Sons.
2. Ewens, W. (2004). *Mathematical population genetics 1- theoretical introduction.* New York: Springer Verlag.

Suggested Readings

1. Pielou, E.C. (1984). *The Interpretation of ecological data: a primer on classification and ordination.* New Jersey: Wiley- Inter-science.

ZOOL-7131 Vascular Biology 3(3+0)

The course provides detailed knowledge about the formation of blood vessels from progenitors or stem cells and about the interaction of the blood vessels at the tissue, cellular and molecular level. The communication of blood vessels with blood and tissues will be discussed with special reference to the pathophysiology of common vascular diseases as cardiovascular, cerebro- vascular disorders and the effect of toxicants on the circulation. The curriculum elucidate various responses of endothelial and smooth muscle cells to injury, growth and proliferation of vascular cells, endothelial dysfunction in hypertension and cardiomyopathy, roles of vasoactive mediators in mammalian cell function, and signal transduction in vascular endothelial cells. Effect of macromolecules like lipids and lipoproteins in circulation and the relevant immune responses will be shared with the students. Importance of blood vessels for normal physiological states including reproduction, wound healing as well as in disease conditions as cancer and venous thrombosis will be highlighted.

Contents

1. An introduction and overview of Vascular Biology,
2. Cardiovascular development/morphogenesis,
3. Vascular stem cells and progenitors
4. Structural anatomy of blood vessels
5. Endothelial cells their structure and characters, and dysfunction
6. Endotheilal cell signaling.
7. Interaction between leukocytes and endothelial cells.
8. Vasculogenesis, angiogenesis, Signaling pathways, Forms of vascular expansion,
9. Inhibition of angiogenesis,
10. Lymphatic vessels, lymphangiogenesis.
11. Extracellular matrix interactions,
12. Smooth muscle cell structure, signaling: function and dysfunction
13. Mechanosensing and signal transduction in the vessel wall
14. Epidemiology and genetics of cardio- and cerebrovascular disease, Venous thrombosis
15. Lipids and lipoproteins in vascular biology, Atherosclerosis, immunity, and inflammation

Recommended Texts

1. Hunt, B.J., Poston, L., Schachter, M., & Halliday, A.W. (Eds). (2002). *An introduction to vascular biology. From basic sciences to clinical practice* (2nd ed.). Cambridge: Cambridge University Press.
2. Krams, R., & Back, M. (Eds). (2017). *The ESC textbook of vascular biology* (1st ed.). Oxford: Oxford University Press.

Suggested Reading

1. Ribatti, D. (Ed). (2015). *Vascular morphogenesis. Methods and protocols* (1st ed.). New York: Springer.
2. Tharp, G., & Woodman, D. (2002). *Experiments in physiology* (8th ed.). London: Prentice Hall.

ZOOL-7132 Vector Biology 3(3+0)

Vector is an organism that does not cause disease itself but spreads infection by conveying pathogens from one host to another. The curriculum of course covers the principles of transmission of human and animal pathogens by insects, mites and ticks, arthropod biology with special attention to biological properties of vectors and their interactions with pathogens. Topics about environmental, biological and genetic drivers of transmission and how these are impacted by the social, political and economic climate will also part of course. In addition, the course will provide basic components of arbopathogen disease cycles and principles of pathogen transmission dynamics with specific examples. Students came to know about biological and genetic conditions and mechanisms leading to evolution of resistance in arthropods and the pathogens they vector, methods to manage the development of resistance and ecological components of arthropod-borne disease transmission. Furthermore, familiarity about emerging pathogens, vector genetics, traditional and next generation control strategies will be given to the learners.

Contents

1. Introduction to vectors: classification of vectors.
2. Biological and mechanical vector,
3. Human vectors and Animal vectors, their adaptations and pest management.
4. Vector borne diseases – Insect transmitted diseases.
5. External morphology of insects: types of mouthparts, antennae, wings and legs.
6. Life cycle of Housefly: types of metamorphosis in insects.
7. Introduction to mosquitoes: mosquito life cycle, mosquito feeding behavior.
8. Anopheles, Aedes and Culex.
9. Sand files, bugs – human bugs, lice & fleas.
10. Malaria: Parasites, causes, symptoms, diagnostics and treatment. Plasmodium life cycle.
11. Dengue & Filariasis - causes, symptoms, diagnostics and treatment.
12. Blue tongue virus, sleeping sickness.
13. Synthetic drugs: treatment of malaria, filariasis & dengue.
14. Biological treatment for Dengue. Nano-drug delivery system.
15. Vector control – Integrated vector control program. Chemical, physical and botanical control.
16. Synthesis of metal nanoparticles for insect vector control.

Recommended Books

1. Mike, S. (2008). *Medical entomology for students*. Cambridge: Cambridge University Press.
2. Chapman, R.F. (1998). *The insects: structure and function*. Cambridge: Cambridge University Press.

Suggested Readings

1. Eldridge, B.F., & Edman, J.D. (2003). Medical entomology: a textbook on public health and veterinary problems caused by arthropods. Amsterdam: Springer.
2. Tyagi. B.K. (2008). Vector-borne diseases: epidemiology and control. Basel: Scientific Publishers

ZOOL-7133 Wildlife of Pakistan 3(3+0)

Regional background information about zoogeographic influences upon animal distribution across the main ecological zones of Pakistan is the core area of this subject. The course outlines introduction, current and past status, distribution of animals, theories, practices, and issues of wildlife and its management in Pakistan. The mountainous areas embracing the Himalayan, Karakorum and Hindukush Ranges are rich in fauna and flora, compared to other parts of the country because of inaccessibility. The Himalayan foothills and the Pothohar region, including the Salt Range and Kala Chitta Range, are covered with scrub forests, which have been reduced to scanty growth in most places. Vast Indus flood plains have been cleared of natural vegetation to grow crops. Very little wildlife habitat has been left untouched. Little vegetative cover, severity of climatic conditions and the great thrust of grazing animals on the deserts have left wild animals in a precarious position. The main threats to wild animals include, the competition with domestic livestock, increasing human interference, the construction of roads, and hunting. Establishment of protected areas is crucial to conservation of existing biodiversity.

Contents

1. Biodiversity and wildlife in context of its services
2. Wildlife prior to establishment of Pakistan and current status of wildlife
3. Vegetative zones and associated wildlife in Pakistan
4. Important biodiversity eco regions in Pakistan
5. Provincial biodiversity of Pakistan
6. Wildlife rules and regulations in Pakistan
7. Protected areas of Pakistan: Marine protected areas, land protected areas
8. National parks
9. Game reserves
10. Wildlife sanctuaries
11. Ramsar sites and wetlands
12. Major threats to wildlife of Pakistan
13. Endangered fauna of Pakistan
14. Role of national organizations in conservation and management of wildlife

Recommended Texts

1. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed.). West Sussex: Wiley-Blackwell.
2. Bolen, E.G., & Robinson, W. (2002). *Wildlife ecology and management* (5th ed.). London: Pearson.

Suggested Readings

1. Roberts, T.J. (1977). *Mammals of Pakistan* (1st ed.). London: Ernest Benon Ltd.
2. Roberts, T. J. (1991). *The birds of Pakistan, regional studies and non-Passeriformes* (1st ed.). Oxford: Oxford University Press.
3. Roberts, T. J. (1992). *The birds of Pakistan, Passeriformes: pittas to buntings* (1st ed.). Oxford: Oxford University Press.

PhD
ZOOLOGY

ZOOL-8101 Clinical Immunology 3(3+0)

Clinical immunology is the study of diseases caused by disorders of the immune system (failure, aberrant action, and malignant growth of the cellular elements of the system). It also involves diseases of other systems, where immune reactions play a part in the pathology and clinical features. The field of clinical immunology has evolved from serological testing for the presence of antibodies to infectious agents to a multifaceted discipline that utilizes some of the traditional techniques in addition to many newer more sensitive assay systems. It is involved with evaluation of the immune system of patients and the ability of the immune system to respond to antigenic stimuli. Assays developed to target specific parts of the immune system enable the clinical immunology specialist not only to determine if a patient has normal immune responsiveness but also to target those parts of the immune system that are suspect of inadequate function. Current technologies have created expanded opportunities to diagnose infectious, autoimmune, and allergic diseases with new tools. Development of new methodology has allowed for an expanded understanding of the intricate mechanisms of immune cell interactions allowing for the insight into basic principles of immune defenses.

Contents

1. Immuno-diagnostic techniques and their applications
2. Radioimmune assay, ELISA, immuno-precipitation, immuno-fluorescence, western blotting, hybridoma technology
3. Production of monoclonal antibodies and their applications
4. Vaccines, active and passive immunization
5. Polysaccharide vaccines, toxoid vaccines, antigen vaccines, DNA vaccines, recombinant vector vaccines, synthetic peptide vaccines
6. Hypersensitivity reactions, gel and combs classification, IgE mediated (type 1) hypersensitivity
7. Antibody mediated (type ii) hypersensitivity, immune complex mediated (type iii) hypersensitivity, TDTH mediated (type IV) hypersensitivity
8. Immune response to infectious diseases
9. Immuno deficiency diseases, primary immuno deficiencies
10. Defects in lymphoid lineage, SCID, immune disorders involving thymus and selective deficiencies of Ig classes
11. Secondary immunodeficiencies: AIDS
12. Auto immunity organ, specific auto immune diseases, systemic auto immune diseases, treatment of auto immune diseases, immuno suppressive therapy
13. Cancer and immune treatment of auto immune system

Recommended Texts

1. Virella, G. (2019). *Medical immunology* (7th ed.). New York: CRC Press.
2. Punt, J., Stranford, S. A., Jones, P. P., & Owen, J. A. (2019). *Kuby immunology* (8th ed.). New York: W. H. Freeman Company.

Suggested Readings

1. Delves, P.J., Martin, J. S., Burton, D. R., & Roitt, I.M. (2017). *Roitt's essential immunology (essentials)* (13th ed.). New Jersey: Wiley Blackwell.
2. Rich, R. R., Fleisher, T. A., Shearer, W. T., Schroeder Jr, H. W., Frew, A. J., & Weyand, C. M. (2018). *Clinical immunology: principles and practice* (5th ed.). Philadelphia: Elsevier.

ZOOL-8102 Wildlife Conservation and Management 3(3+0)

Wildlife conservation and management is the practice of protecting wild species and their habitats in order to allow managers to gather information about the status of threatened species and to measure the effectiveness of management strategies. Wildlife conservation has evolved into a science, but its goal remains essentially the same: to ensure the wise use and management of renewable resources. Wildlife management is interdisciplinary that deals with protecting endangered and threatened species and subspecies and their habitats, as well as the non-threatened game species. The wildlife management program emphasizes both applied and basic research in wildlife ecology, management, education and extension. Wildlife management takes into consideration the ecological principles such as carrying capacity of the habitat, preservation and control of habitat, reforestation, predator control, re-introduction of extinct species, capture and reallocation of abundant species and management of "desirable" or "undesirable" species. *Wildlife protection and management* also involves wildlife protection adhering to international convention on restricting trade of endangered species.

Contents

1. Introduction to wildlife conservation and management: a comparative approach
2. Historical precedent of wildlife conservation in Pakistan
3. Current scenario of wildlife conservation in Pakistan
4. Types of wildlife conservation and management
5. Philosophy and significance of wildlife conservation
6. Major challenges faced during wildlife conservation
7. Biodiversity and sustainability of wildlife.
8. Role of national and International agencies involved in conservation and management of wildlife in Pakistan
9. Convention on international trade in endangered species (CITES)
10. Role of protected areas in wildlife conservation and management
11. Importance and role of modern conservation strategies in wildlife conservation and management
12. Population genetics, extinction, restoration ecology, management, and conservation policy. Conservation through population and ecosystem management.
13. Conservation and management of wildlife: wildlife as unaltered source, concept and process of wildlife conservation, wildlife management, conservation and management, modes of wildlife conservation

Recommended Texts

1. Mills, L. S. (2012). *Conservation of wildlife populations: demography, genetics, and management* (2nd ed.). West Sussex: Wiley-Blackwell.
2. Primack, R. B. (2014). *Essentials of conservation biology* (6th ed.). Sunderland: Sinauer Associates.

Suggested Readings

1. Bolen, E.G. (2002). *Wildlife ecology and management* (5th ed.). London: Pearson.
2. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management* (3rd ed.). West Sussex: Wiley-Blackwell.

ZOOL-8103 Human Genetics 3(3+0)

Human genetics is the study of the human genome and how genes are transmitted through generations. Human genetics encompasses a variety of overlapping fields including: classical genetics, cytogenetics, molecular genetics, biochemical genetics, genomics, population genetics, developmental genetics, clinical genetics and genetic counseling. At a more practical level, an understanding of human heredity is of critical importance in the prediction, diagnosis, and treatment of diseases that have a genetic component. Human genetics is more an applied science than a fundamental science. One benefit of studying human genetic variation is the discovery and description of the genetic contribution to many human diseases. This is an increasingly powerful motivation in light of our growing understanding of the contribution that genes make to the development of diseases such as cancer, heart disease, and diabetes. The desire to develop medical practices that can alleviate the suffering associated with human disease has provided strong support to basic research. Many basic biological phenomena have been discovered and described during the course of investigations into particular disease conditions. Human genetics has blossomed from an obscure biological science and explanation for rare disorders to a field that is profoundly altering health care for everyone.

Contents

1. Human genome map
2. Impact of human genes on health
3. Fundamentals of cells and chromosomes, patterns of inheritance, karyotyping
4. Gene regulation and epigenome
5. Oncogenes and cancer, normal chromosomes, congenital malformations
6. Metabolic variation and diseases: in-born errors of metabolism, errors in transport system, inherited variations
7. Genetic linkage: family method, somatic cell hybridization, deletion mapping and duplication mapping
8. Eugenics, twin studies
9. Human genome project objectives and goals
10. Human population genetics
11. Human evolutionary genetics
12. Comparative genomics and genome evolution
13. Evolutionary insights into genetic diseases

Recommended Texts

1. Lewis, R. (2017). *Human genetics: concepts and applications* (12th ed.). Pennsylvania: McGraw Hill Higher Education.
2. Lewis, R. (2016). *Human genetics: the basics* (2nd ed.). Oxford shire: Routledge.

Suggested Readings

1. Jobling, M., Hollox, E., Kivisild, T., & Tyler-Smith, C. (2013). *Human evolutionary genetics: origins, peoples & disease* (2nd ed.). New York: Garland Science.
2. Samuelsson, T. (2019). *The human genome in health and disease: a story of four letters* (1st ed.). New York: Garland Science.

ZOOL-8104 Molecular Physiology 3(3+0)

The course attempts to provide the knowledge about how molecular mechanisms can be the cause of physiological processes and how these mechanisms are regulated. Whole of a living system can be understood by studying its individual parts, identifying the subset of genes and proteins that function in physiological context or malfunction to trigger disease. As science and technology rapidly develop, there are more and more tools to intervene and more and more parameters to be measured. Currently, we are able to study the expression of thousands of genes or hundreds of proteins at a time by high-through-put microarray technologies, providing a far more detailed molecular snapshot of life inside normal and abnormal cells. The ultimate goal of molecular physiology is to create new knowledge about the function and interactions of living cells, the cellular and molecular basis for dysfunction, and ultimately provide the basis for the development of new clinical treatment strategies to combat disease.

Contents

1. Overview of resting membrane, action potential and synaptic transmission, structure and mechanisms in ion channels
2. Biosynthesis of neurotransmitters; Neurotransmitters action at synaptic receptors
3. Neurosecretions and neurotransmitters in higher nervous system
4. Molecular mechanisms in transduction of sensory stimuli into impulse, photochemistry and transduction of photoreceptor, color vision
5. Overview of endocrine glands, their hormones and roles, chemistry and biosynthesis of hormones of adenohypophysis, thyroid, parathyroid, endocrine pancreas, adrenal medulla and steroidogenic tissue. Metabolism of thyroid and steroidogenic tissues
6. Structure of hormone receptors, mechanisms of action of a protein/peptide, a steroid and thyroid hormone, hormonal regulation of metabolism
7. Molecular basis of muscular contraction, molecular interaction at neuromuscular level, molecular structure of cilia and flagella and mechanisms in movements
8. Atomicity and rhythmicity of myogenic heart, regulation of cardiac activity, humeral regulation of circulation, vasoconstriction and vasodilatation
9. Exchange of respiratory gases, chemical regulation of respiration
10. Nature formation of various nitrogenous waste products, glomerular filtration, reabsorption, and secretion mechanisms, concentration of urine
11. Regulation of digestive secretions, digestion and absorption of nutrients, molecular mechanisms in adaptation to temperature extremes

Recommended Texts

1. Hall, E.J. (2020). *Guyton and hall textbook of medical physiology* (14th ed.). Philadelphia: Elsevier.
2. Widmaier, E., Raff, H., & Strang, K. (2018) *Vander's human physiology* (15th ed.). Pennsylvania: McGraw-Hill Education.

Suggested Readings

1. Moyes, C. D., & Schulte, P. M. (2015). *Principles of animal physiology* (3rd ed.). San Francisco: Pearson.
2. Randall, D., Burggren, W., & French, K. (2001). *Eckert animal physiology; mechanisms and adaptations* (5th ed.). New York: W. H. Freeman and Company.

ZOOL-8105 Molecular Endocrinology 3(3+0)

This is an interdisciplinary course that need concepts of cell structure, cell physiology, Biochemistry, mechanisms of enzymes and receptors activities, system and organ physiology, gene action, transcriptional, translational activities and post transcriptional and translational processing of mRNAs and proteins as a prerequisite. The course will provide a deeper insight into the nature and distribution of endocrine tissues and glands, the diverse chemical nature of hormones (proteins, peptides, organic amines, amino acid derivatives and steroids). Study of the mechanisms and processes and control of the biosynthesis of various hormones is also involved. Additionally, the mechanisms of storage and release of various hormones will also be explained. Moreover, the structure of cell surface and cytoplasmic hormone receptors and various mechanisms of hormone action are also be explained in detail. Furthermore, the metabolism of various hormones will also be introduced. The course also includes an in-depth preview of diverse techniques employed in assays of different hormones.

Contents

1. General mechanisms in molecular endocrinology
2. Study of the cellular structures involved and the synthesis, storage, processing and release of proteinaceous hormones
3. Transcription factors involved in endocrine systems
4. Recombinant DNA technology and molecular genetics in diagnosis and treatment of endocrine diseases
5. Measurements of hormones and hormone receptors: radio-immunoassay, immunoradiometric, immunochemiluminometric and radioreceptor assays and their statistical methods and procedures.
6. Mechanisms of action of hormones
7. Hormone systems and intracellular communication
8. Surface and cytoplasmic hormone receptors
9. Hormones acting at cell surface: properties of hormone receptor
10. Interaction, structure, biosynthesis and turnover of membrane receptors
11. Hormones mediated gene regulation, transcription regulation
12. Biochemistry and molecular interaction of steroid receptor, gene expression, messenger RNA stability and metabolism in hormone action

RecommendedTexts

1. Gardener, D. G., & Shobak, D. (2018). *Greenspan's basic and clinical endocrinology* (10th ed.). New York: McGraw-Hill Publishers.
2. Melmed S. (2019). *Williams textbook of endocrinology* (14th ed.). Amsterdam: Elsevier.

Suggested Readings

1. Melmed, S., Polonsky, K., Larsen, P.R., & Kronenberg, H. (2015). *Williams textbook of endocrinology* (13th ed.). Amsterdam: Elsevier.
2. Guyton, A.C., & Hall, J.E. (2020). *Textbook of medical physiology* (14th ed.). Amsterdam: Elsevier.
3. DeGroot, L.J., & Jameson, J.L. (2001) *Endocrinology, volume 1-3* (4th ed.). Philadelphia: Saunders.

ZOOL-8106 Molecular Entomology 3(3+0)

This subject provides a broad perspective on the molecular biology of insects and a specific focus on aspects relating to the transmission of insect-borne diseases. It also provides an introduction to insect physiology, developmental biology, genomics and molecular evolution and ecology. Arthropods are so amazingly diverse, and of course their genetics are, too. The world has so much to learn from insects: chemistry, sensory processing, niche utilization, damage avoidance and remediation, and mechanical design. The subject is tailored to help formulate adequate strategy to fast track application of entomology in addressing research questions and provide solutions to be used for development of viable products, maintain environmental diversity and add value to the quality of life. Students will be exposed to theoretical and practical aspects of insect systematics, population genetics, genome organization, physiology, diversity, pathology, biotechnology and toxicology, with emphasis on molecular aspects. This course aims to train and equip students with current knowledge, skills and techniques that can be used in entomological research spur development.

Contents

1. Introduction, insect genomes, nucleus, chromosomes, DNA and RNA
2. Gene structure and function; gene transcription and translation; concept of introns and exons;
3. Central dogma of molecular biology
4. Polymerase chain reaction (PCR), gene cloning and sequencing,
5. Restriction analysis, gene libraries
6. Insect polyphenism
7. DNA for insect species identifications and insect population diversity
8. DNA for phylogenetic analysis and construction of phylogenies
9. Role of miRNAs in insect life
10. RNA interference and neuropeptide signaling
11. Gene knock-ins and knock-outs by RNA interference
12. RAPD, RFLP and PCR-RFLP
13. Linkage and chromosomal mapping, genes regulatory processes, mutagenesis
14. Molecular basis of insect functions (insect behavior, insecticidal resistance)
15. DNA and protein sequence alignments and use of bioinformatics tools
16. Sequencing, assembly and analysis of insect genome
17. Cis-regulatory modules in insects
18. Bioinformatics analysis of epigenetic modifications

Recommended Texts

1. Gilbert, L. I., Iatrou, K., & Gill, S. S. (2005). *Comprehensive molecular insect science* (1st ed.). Oxford: Pergamon, Elsevier.
2. Hoy, M. A. (2018). *Insect molecular genetics: an introduction to principles and applications* (4th ed.). Massachusetts: Academic Press, Elsevier.

Suggested Readings

1. Brown, S. J., & Pfrender, M. E. (2018). *Insect genomics: methods and protocols* (1st ed.). New Jersey: Humana Press.
2. Hall, B.G. (2011). *Phylogenetic trees made easy: a how-to manual* (4th ed.). Sunderland: Sinauer Associates.
3. Hoffmann, K. H. (2014). *Insect molecular biology and ecology* (1st ed.). Florida: CRC press.

ZOOL-8107 Biological Toxicology 3(3+0)

Toxicology is a scientific discipline, overlapping with biology, chemistry, pharmacology, and medicine, that involves the study of the adverse effects of chemical substances on living organisms and the practice of diagnosing and treating exposures to toxins and toxicants. Toxicology is the science devoted to the study of the harmful effects produced by chemical compounds on living organisms and systems. Understanding toxicological effects of different chemicals on the biological systems help in designing safer chemicals, planning safer chemical synthesis, and ensuring that industrial processes employ safer, healthier, and sustainable chemistries. The principles of green chemistry provide a comprehensive framework to guide this vision by emphasizing a holistic, systems-based approach that acknowledges the inherent hazard associated with all molecules and products. Toxicology provides the theoretical and practical tools to profile the likely behavior of a molecule in living systems based on its physicochemical attributes using computational approaches, in vitro assays at the molecular and cellular levels, and information gained from in vivo testing in appropriate test organisms.

Contents

1. Reproductive toxicology and teratology
2. Cytotoxicity and infertility, interference with hormonal control
3. Effects of toxicants on development, teratogens and teratogenesis
4. Effects of dose exposure level and timing of exposure, examples and mechanism of teratogenity
5. Respiratory toxicology: general principles for the effects of toxicants on the respiratory system
6. Immediate response to respiratory toxicants, free radical induced damage, the irritant response
7. Delayed and cumulative response to toxicants
8. Cardiac toxicology: effects of toxicants, arrhythmias, cardiomyopathies, myocardial infarction
9. Effects of toxicants on the vascular system, atherosclerosis, vascular spasm and blood pressure
10. Effects of toxicants on blood; anemias, hemolysis and effects on hemoglobin
11. Neurobiological toxicants, blood-brain barrier
12. Effects on electrical conduction, synaptic function, axonopathies
13. Myelinopathies, direct effects on neurons, excitotoxicity, other neurotoxicants
14. Hepatic toxicity: types of toxicant induced injury; fatty liver, necrosis and apoptosis, cirrhosis
15. Response to liver injury
16. Renal toxicology: effects on the system, damage to glomerulus, proximal and remainder of the tubule.

Recommended Texts

1. Lee, B. M., Kacew, S., & Kim, H.S. (2017). *Lu's basic toxicology: fundamentals, target organs, and risk assessment* (7th ed.). Florida: CRC press.
2. Stine, K.E., & Brown, T.M. (2015) *Principles of toxicology* (3rd ed.). Florida: CRC Press.

Suggested Readings

1. Barile, F.A. (2013) *Principles of toxicology testing* (2nd ed.). Florida: CRC Press.
2. Klaassen, C. (2019). *Casarett and Doull's toxicology: the basic science of poisons* (9th ed.). New York: McGraw-Hill Education.

ZOOL-8108 Research Methodology and Report Writing 3(3+0)

The practical utility of research study depends heavily on the way it is presented to those who are expected to act on the basis of research findings. Research report is a written document containing key aspects of research project employing different methodologies and statistical tools. Research reports are recorded data prepared by researchers or statisticians after analyzing information gathered by conducting organized research, typically in the form of surveys or qualitative methods. Reports usually are spread across a vast horizon of topics but are focused on communicating information about a particular topic and a very niche target market. The primary motive of research reports is to convey integral details about a study for relevant scientists and policy makers to consider while designing new strategies. A research report is a reliable source to recount details about a conducted research and is most often considered to be a true testimony of all the work done to garner specificities of research.

Contents

1. Research methodology: meaning of research, objectives of research, significance of research
2. Research design: needs and features of good research design, types of research designs
3. Basic principles of experimental designs, design of experiments
4. Sampling designs: census and sample surveys, different types of sample designs
5. Data collection: primary and secondary data and methodologies to collect data
6. Hypothesis: definition, testing of hypothesis, procedures of hypothesis testing
7. Parametric and non-parametric tests for testing of hypothesis, limitations of tests of hypothesis
8. Biostatistics: correlation, regression, `t' test; chi -square test, `f' test, ANOVA, probit analysis
9. Statistical softwares: SAS, SPSS, minitab, stata, excel
10. Computational biology and bioinformatics
11. Biological databases, NCBI, Pubmed, Genbank, protein databases, information retrieval
12. Report / thesis writing: identification, selection and scope of research problems
13. Methods of literature collection and review
14. Planning and execution of investigation
15. Preparation and presentation of research papers for journals, conferences
16. Preparation of short communications and review articles

Recommended Texts

1. Singh, Y. K. (2006). *Fundamental of research methodology and statistics*. Delhi: New Age International.
2. Flick, U. (2015). *Introducing research methodology: a beginner's guide to doing a research project* (2nd ed.). California: SAGE Publications.

Suggested Readings

1. Selvin, S. (2003). *Biostatistics: how it works* (1st ed.). London: Pearson Education.
2. Elston, R. C., & Johnson, W. (2008). *Basic biostatistics for geneticists and epidemiologists: a practical approach* (1st ed.). New Jersey: John Wiley & Sons.
3. Triola, M. M., & Triola, M. F. (2017). *Biostatistics for the biological and health sciences* (2nd ed.). London: Pearson Education.

ZOOL-8109 Advanced Analytical Techniques 3(3+0)

This multi-dimensional course of study will help students to learn the sophisticated analytical techniques involved in biomedical and Zoological studies researches. The students will be able to understand the basic mechanisms involved and the applications of the techniques involved in handling, storage and analyses of the biological samples such as microbes, live and fixed human and animal tissues, extraction, storage handling and analyses of biomolecules like DNA, RNAs, Proteins, Hormones, Enzymes etc. TH students will also learn various microscopic (compound, Electron, florescent and confocal), cell and tissue imaging, immune-fluorescent, histological, hematological, serological, biochemical, pathological and immunological techniques of research in detail. Additionally, various chemical techniques involve in the analyses and assays of various bioactive compounds like hormones, enzymes, DNA, RNA and proteins will also be introduced. Furthermore, the separation techniques like chromatographic and electrophoretic techniques, fluorescent techniques such as spectrophotometry, Imaging techniques like NMR and centrifugation techniques will also be introduced.

Contents

1. UV spectroscopy/separations, quantitative infrared spectroscopy, flame atomic absorption spectroscopy, direct potentiometry
2. Spectrofluorimetry: determination of fluid volumes by dye dilution techniques
3. TLC: drug monitoring techniques
4. Column techniques: separation of transition metal cations
5. Gas chromatography
6. High performance liquid chromatography
7. Principles of IR-spectrometry and its use for compound identification; understanding of the working mechanism of the basic components of spectrometric and mass spectrometric instrumentation
8. Amino acid sequencers, balances, bioreactors, blotting apparatus, centrifuges
9. DNA sequencers
10. Electroporation instrument
11. Isoelectric focusing apparatus, lyophilizer
12. Microarray technology
13. Microscopy. Microtomy
14. Nuclear magnetic resonance instrument, principles and application

Recommended Texts

1. Katoch, R. (2011). *Analytical techniques in biochemistry and molecular biology.* Berlin: Springer Science & Business Media.
2. Rouessac, F., & Rouessa, A. (2000). *Chemical analysis: Modern instrumentation, methods and techniques.* Oxford: John Wiley & Sons.

Suggested Readings

1. DeLoos-Vollebregt, M.T.C. (2004). *Spectrometrische analysetechnieken*. Berlin: Bohn Stafleu Van Loghum.
2. Douglas, A., Skoog, F., Holler. J., & Nieman, T. A. (1997). *Principles of instrumental analysis* (5th ed.). San Francisco: Brooks Cole.

ZOOL-8110 Advanced Cell and Molecular Biology 3(3+0)

This is dynamic coursed deals with the study of prokaryotic and eukaryotic cells. Subcellular membrane bound and non-membranous organelles like mitochondria, smooth and rough endoplasmic reticulum, ribosomes, lysosomes, peroxisomes, glyoxysomes etc. The details of molecular structure and functions of plasma membrane and endomembrane system are also included. This study also includes the intracellular movement and transport of materials as well as the exocytosis (cell secretions and excretions) and endocytosis (phagocytosis, pinocytosis, active transport and bulk transport of materials). The study of the molecular basis of life, the structure and flow of information form nucleus (Gene structure, regulation, mutations, whole genome analysis) to the cytoplasm (the structure of DNA, chromatin and chromosome DNA replication, transcription, post transcriptional processing including posttranscriptional addition of cap and tail RNA, splicing mechanisms, storage and translation of RNAs, protein synthesis and the post translation processing of the protein molecules, transcriptional and translational control mechanisms) and cellular replication processes (the cell cycle, mitosis and meiosis) are also included in this course of study.

Contents

1. Introduction, difference between prokaryotes and eukaryotes, physico-chemical properties of protoplasm
2. Ultra-structure, chemical composition and functions of cell wall, cell membrane, cellular organelles (mitochondria, endoplasmic reticulum, golgi apparatus, lysosome, glyoxysome, nucleus, ribosomes, etc.) cytoskeleton
3. Chemical composition and molecular structure of chromosomes, cell cycle and apoptosis, cell reproduction, signal transduction
4. Cell culture, *E. coli* and yeast as representative prokaryotic and eukaryotic models for molecular differentiation.
5. Chromosome structure and function molecular mechanism of replication
6. Transcription and translation, transcriptional and translational regulation of gene expression. regulation of gene expression in prokaryotes and eukaryotes
7. Types of recombination, mutations and chromosomal aberrations, DNA damage and repair, gene sequencing
8. Principles of recombinant DNA technology, role in economic development
9. Human genome project, stem cell research

Recommended Texts

1. Karp G., Iwasa, J., & Marshall, W. (2016). *Karp's cell and molecular biology* (8th ed.). New York: Wiley.
2. Clark, D. P., Pazdernik, N. J., & McGehee, M. R. (2019). *Molecular biology* (3rd ed.). San Diego: Academic Press.

Suggested Readings

1. Plopper, G., Sharp, D., Sikorski, E., & Lewin. B. (2013). *Lewin's cells* (3rd ed.). Massachusetts: Jones and Bartlett Publishers, Inc.
2. Lodish, H., Matsudaira, P., Berk, A., Ploegh, H., Scott, M., Kaiser, C. A., Krieger, M., & Bretscher, A. (2007). *Molecular cell biology*. New York: W. H. Freeman Company.
3. Watson J. D. (2004). *Molecular biology of the gene*. Singapore: Pearson Education.

ZOOL-8111 Advances in Insect Biology and Pest Management 3(3+0)

Insects are extraordinarily adaptable creatures, having evolved to live successfully in most environments on earth, including deserts and the Antarctic. The only place where insects are not commonly found is the oceans. If they are not physically equipped to live in a stressful environment, insects have adopted behaviors to avoid various stresses. Insects possess an amazing diversity in size, form, and behavior. It is believed that insects are so successful because of protective shell or exoskeleton, small size, and ability to fly permitting escape from enemies and dispersal to new environments. Being small they require only small amounts of food and can exist in very small niches or spaces. Insect populations also possess considerable genetic diversity and a great potential for adaptation to different or changing environments. This makes them formidable pests of crops, able to adapt to new plant varieties as they are developed or rapidly become resistant to insecticides employed for pest control. One of the pest management techniques gaining popularity is biological control due to its eco-friendliness. Biological control is a form of pest control that uses living organisms (parasitoids, predators, or herbivorous arthropods) to suppress pest density to lower levels.

Contents

1. Reproductive system of insects, basic histomorphology, heterogeneity among insect orders
2. Viviparous insects. Factors regulating parthenogenesis
3. Polymorphism with special reference to homoptera, isoptera and hymenoptera
4. Abiotic & biotic factors in biology, abundance & distribution of insects
5. Interspecific and intraspecific interactions, insect migration & pest outbreak
6. Insect life table and its application methods of assessing insect pest/populations
7. Chemical control of Insect Pests: classification of insecticides, modes of action of insecticides
8. Mechanism of insecticide resistance: Chitin inhibitors and their efficacy in pest management
9. Recent trends in pesticide application technology
10. Biological control: dynamics of prey-predator and host parasite/parasitoid interactions
11. Genetic and semi-chemical bases of insect pest control
12. Neurohormone, juvenile hormone and ecdysteroids in insect pest management
13. Integrated Pest Management (IPM)
14. Ecological basis of IPM towards pesticide application
15. Recent trends in IPM

Recommended Texts

1. Abrol, D.P. (2013). *Integrated pest management: current concepts and ecological perspective* (1st ed.). San Diego: Academic Press.
2. Schowalter, T.D. (2016). *Insect ecology: an ecosystem approach* (4th ed.). San Diego: Academic Press.

Suggested Readings

1. Chapman, R. F., Simpson, S.J., & Douglas, A.E. (2012). *The insects: structure and function* (5th ed.). Cambridge: Cambridge university press.
2. Gullan, P. J., & Cranstan, P. S. (2014). *The insects: an outline of entomology* (5th ed.). New jersey: Wiley-Blackwell.

ZOOL-8112 Advances in Wildlife 3(3+0)

Looking outside one's window can give students an appreciation for nature, and this subject greatly widens the view in terms of wildlife of the world and Pakistan. The subject begins with information on animal habitats and then shifts the focus to species in different ecoregions. Research in wildlife conservation and management often focuses on the life histories of mammals, birds, and other terrestrial organisms, as well as their interrelationships with each other, with humans, and with the physical environment. Ecological information of this kind is used by wildlife managers and scientists to identify factors that influence survival and productivity of species of management concern, and to develop strategies for maintaining species diversity, improving conditions for declining and endangered species, managing populations that are hunted, mitigating for human-caused damage to terrestrial systems, and coordinating with other resource managers to maintain environmental quality. This subject brings together the principles of ecology, population biology, wildlife conservation and management and examines wildlife in context of ecosystems and threats that endanger wild animals.

Contents

1. Overview and fundamental concepts
2. Wildlife populations
3. International conventions and their role in wildlife conservation
4. Ecoregions of the world
5. Biodiversity hotspots in South Asia
6. Vegetative zones and associated wildlife in Pakistan
7. Important biodiversity eco regions of the world and Pakistan
8. Introduction of protected areas and their importance
9. Types of protected areas (national parks, sanctuaries, game reserves, ramsar sites)
10. Current status of protected areas in Pakistan
11. Decline in the biodiversity and threats to wild animal populations
12. Climate change and wild animals. Management of protected areas in Pakistan
13. Dimensions of wildlife management and conservation
14. Role of national and International NGOs in wildlife conservation in Pakistan
15. Current trends in conservation and management of wildlife
16. Restoring wild and threatened populations. Wildlife rules and regulations

Recommended Texts

1. Mills, L.S. (2012). *Conservation of wildlife populations: demography, genetics and management* (2nd ed.). Oxford: John Wiley & Sons.
2. Primack, R.B. (2014). *Essentials of conservation biology* (6th ed.). Sunderland: Sinauer Associates.

Suggested Readings

1. Hosetti, B. B., & Venkateshwarlu, M. (2001). *Trends in wildlife biodiversity, conservation and management.* Delhi: Daya Publishing House.
2. Fryxell, J. M., Sinclair, A. R., & Caughley, G. (2014). *Wildlife ecology, conservation, and management*. Oxford: John Wiley & Sons.
3. Dasmann, R. F. (1981). *Wildlife biology*. Oxford: John Wiley & Sons.

ZOOL-8113 Applied Genetics 3(3+0)

Applied Genetics is directed at changing the genomes of organisms, to increase their utility to humans. Techniques are derived from cytogenetics, molecular biology, and Mendelian and quantitative genetics. Genetic techniques are used in medicine to diagnose and treat inherited human disorders. Knowledge of a family history of conditions such as cancer or various disorders may indicate a hereditary tendency to develop these afflictions. Cells from embryonic tissues reveal certain genetic abnormalities, including enzyme deficiencies that may be present in newborn babies, thus permitting early treatment. Agriculture and animal husbandry apply genetic techniques to improve plants and animals. Breeding analysis and transgenic modification using recombinant DNA techniques are routinely used. Various industries employ geneticists. Biotechnology, based on recombinant DNA technology, is now extensively used in industry. Designer lines of transgenic bacteria, animals, or plants capable of manufacturing some commercial product are made and used routinely.

Contents

1. Essentials of a gene
2. Nucleic acids and DNA
3. Plant and animal viruses (DNA and RNA) and their importance in molecular biology
4. Tumor viruses, retroviruses, conjugation
5. Gene mapping. Transformation and transduction
6. Integration of viral DNA, consequences of integration
7. Transposition: transposable elements
8. Detection of transposition in bacteria, types of bacterial transposons, modes of transposition
9. Genetic phenomena mediated by transposons
10. Transposable elements & gene expression in prokaryotes and eukaryotes
11. Genetic transformation (all kinds)
12. Regulation of simple and complex transcription unit
13. Advances in genetics
14. Molecular techniques viz. Southern, Northern and Western blotting
15. PCR, RFLP, AFLP's, RAPDs, micro-satellites, SNPs
16. Genetic engineering, Recombinant DNA technologies

Recommended Texts

1. Pierce, B. A. (2016). *Genetics: a conceptual approach* (6th ed.). London: W. H. Freeman.
2. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular biology of the gene* (7th ed.). San Francisco: Pearson Education.

Suggested Readings

1. Hartwell, L., Goldberg, M. L., Fischer, J. A., & Hood, L. E. (2017). *Genetics: from genes to genomes* (6th ed.). New York: McGraw-Hill.
2. Klug, W. S., Cummings, M. R., Spencer, C. A., Palladino, M. A., & Killian, D. (2019). *Concepts of genetics* (12th ed.). San Francisco: Pearson Education.
3. Brooker, R. J. (2014). *Genetics: analysis & principles* (5th ed.). Pennsylvania: McGraw-Hill Education.

ZOOL-8114 Applied Reproductive Physiology 3(3+0)

The advances in animal and human reproduction science has not only resolved various issues related to human reproduction but also it provided the animal breeders and farm keepers to increase animals' reproduction efficiency as well as productivity in terms of increased productivity of farm house products like milk and meat production. It is now possible to keep the semen frozen for indefinite that has relieved the farm houses to keep males for breeding made it possible to transport semen even through the continents for the breeding purpose. In this course of study, students will learn the semen cryo-preservation, sexing and analysis protocols the artificial insemination, in-vitro fertilization and embryo culture and transfer technologies. The student will also learn the concepts and applications of endocrinology of female reproductive cycles, pregnancy, parturition and lactation. Applications of hormones on the ovulatory, pregnancy maintenance, inducing labor and milk letdown reflex will also be explained to the students.

Contents

1. Male reproductive system anatomy, production, storage and transport of spermatozoa in male reproductive duct system
2. The role of epididymis, seminal vesicles and prostate in male fertility
3. Female reproductive system, study of the anatomical parts of female reproductive system, endocrine role and responsibilities of ovaries, ovarian hormonal release patterns, follicular growth, ovulation, capacitation of spermatozoa in the female reproductive tract and fertilization
4. The birth control- natural, artificial means, the role of environmental components in infertility, aging and reproductive senescence
5. Cyclic uterine and vaginal responses, pregnancy parturition and lactation.
6. Developments during pregnancy, biology of uterine endometrium and myometrium and the cervix.
7. Prenatal Diagnostic tests- advantages and disadvantages.
8. Endocrinology of pregnancy and parturition, control of parturition, physiology of lactation
9. Reproductive Technology: artificial insemination, semen analysis sperm preparation for ICSI, In vitro fertilization (IVF), cryopreservation, HY antigen and sex determination
10. Pheromones and reproduction: signaling, chemical communications
11. Endocrinology and reproduction: pituitary hormones, thyroid metabolic hormones, male sex hormones, female sex hormones, pregnancy and neonatal physiology

Recommended Texts

1. Plant, T. M., & Zeleznik, A. J. (2015). *Knobil and Neill's physiology of reproduction, volume 1* (4th ed.). San Diego: Academic Press.
2. Plant, T. M., & Zeleznik, A. J. (2015). *Knobil and Neill's physiology of reproduction, volume 2* (4th ed.). San Diego: Academic Press.

Suggested Readings

1. Jones, R. E., &Lopez, K. H. (2014). *Human reproductive biology* (4th ed.). San Diego: Academic Press.
2. Devis, A., Blakely, A., & Kidd, C. (2001). *Human physiology*. Livingstone: Harcourt Publishers.
3. Elder, K., & Dale, B. (2000). *In vitro fertilization* (2nd ed.). Cambridge: Cambridge University Press.

ZOOL-8115 Aquaculture System Management 3(3+0)

This subject involves development and application of best management practices to improve commercial aquaculture farming through the use of a structured and systematic approach vital for operations and business management. The role of different stakeholders and institutions, reflect wide range of factors and issues relevant to modern aquaculture development. The systems approach recognizes this diversity of influences on aquaculture development, and is a multifactorial and multidisciplinary approach. It uses an understanding of how aquaculture systems operate to analyze how different factors affect aquaculture and develop solutions to problems that are identified. This analytical approach has been shown to contribute to identification of key researchable issues, development of better management solutions, improvement of business efficiency, and design and testing of new aquaculture systems, as well as to more effective extension and education. Key factors to be understood in the functioning of a farming system are the technologies of production and social, economic and environmental aspects. At the technology level, feeds, feed additives and fertilizers, water quality, seed quality and availability, chemotherapeutants and other chemicals, disposal of wastes that may adversely affect human health and/or the environment, and food safety of aquaculture products all require consideration.

Contents

1. Brief history of aquaculture, scope and importance of commercially important organisms
2. Mussel resources and their distribution
3. Seed production- natural collection and artificial production
4. Induced spawning and rearing, different culture methods, harvesting and processing
5. Prawn culture, pearl culture, induced pearl formation
6. Pisciculture: different types of fish ponds, pond maintenance and improvement liming
7. Fresh water fish culture: cultivable species, major carps, exotic carps, gouramy, tilapia
8. Composite fish culture, paddy cum fish culture
9. Brackish water fish culture: *mugil, chanos, etroplus*
10. Ornamental fish culture: biology, artificial breeding and rearing techniques of gold fish, cichlids
11. Fish preservation, processing: chilling, freezing, freeze drying, salting, smoking and canning
12. Fish byproducts, fish meal, fish oil, fish protein concentrate
13. Isinglass, fish manure, fin rays, chitin chitosan, biochemical and pharmaceutical compounds.
14. Fish diseases—bacterial, viral, fungal and other pathogens of fishes

Recommended Texts

1. Kurian, C.V., & Sebastian, V.O. (2002). *Prawn and prawn fisheries in India.* Delhi: South Asia Books.
2. Huet, M. (1986). *Text book of fish culture: breeding and cultivation of fish* (2nd ed.). London: Fishing News Book ltd.

Suggested Readings

1. Davison, A. (2019). *Recirculating aquaculture systems: a guide to farm design and operations* (1st ed.). Independently published.
2. Boyd, C.E., & G.S. Tucker. (1998). *Pond aquaculture water quality management* (1st ed.). New York: Springer.

ZOOL-8116 **Bacterial Genetics** **3(3+0)**

This course is about mechanisms of heritable information in bacteria, their chromosomes, plasmids, transposons and phages. Techniques that have enabled this discipline are culture in defined media, replica plating, mutagenesis, transformation, conjugation and transduction. The genetics of bacteria is very different from that of higher organisms. Firstly, bacteria are generally haploid, with one copy of each gene on a single circular chromosome. Secondly, gene transfer in bacteria is normally unidirectional. That is, a donor cell transfers genes to a recipient cell rather than two cells sharing genetic information to generate progeny as in higher organisms. Gene transfer in bacteria occurs by one of three major mechanisms. Transformation is gene transfer by naked DNA without the involvement of cell contact. Transduction is gene transfer by DNA packaged inside virus particles. Again no contact between living bacterial cells is involved. Conjugation does involve cell contact. Plasmids, and sometimes bacterial chromosomes, are transferred between two cells during bacterial mating. Recently it has become possible to artificially synthesize whole bacterial chromosomes and re-introduce them into the corresponding bacterial cells. This opens the way for improved genetic engineering of bacteria.

Contents

1. DNA and genes, nucleic acid structure and function
2. Mutation and variation
3. DNA replication and its control, dichotomous replication in prokaryotes
4. Regulation of gene expression, transcriptomes
5. Protein synthesis - mRNA translation: genetic code - non universality, codon usage
6. Genetics of bacteriophages, plasmids
7. DNA mutagenesis and mutagenic agents, repair and mutation suppression
8. Genetic recombination: generalized recombination, site specific recombination
9. Genomic plasticity: transposons
10. Gene transfer mechanisms and their role in evolution
11. Transformation, transduction, conjugation and cross-phylogenic transfer
12. Gene mapping by conjugation and transduction, circular chromosomal maps of bacteria
13. DNA cloning
14. Bioinformatics and proteomics
15. Genetic modification: exploiting the potential of bacteria

Recommended Texts

1. Snyder, L.R., Peters, J.E., Henkin, T.M., & Champness, W. (2014). *Molecular genetics of bacteria* (4th ed.). Washington, DC: ASM Press.
2. Snyder, L.A.S. (2020). *Bacterial genetics and genomics* (1st ed.). Florida: CRC Press.

Suggested Readings

1. Dale, J. W., & Park, S.F. (2013). *Molecular genetics of bacteria* (5th ed.). New Jersey: John Wiley & Sons.
2. Trun, N., & Trempy, J. (2004). *Fundamental bacterial genetics* (1st ed.). Oxford: Blackwell Science.
3. Davis, R. W., Botstein, D., & Roth, J.R. (1980). *Advanced bacterial genetics: a manual for genetic engineering*. New York: Cold Spring Harbor Laboratory.

ZOOL- 8117 **Biology of Aging** **3(3+0)**

Ageing is a phenomenon of get old with the passage of time. Infect ageing starts with the beginning of life of an individual. In the life span a human being passes through irreversible developmental changes that are seen and named as neonate, infant, baby, toddler, crawler, preschool, kindergarten, schoolboy or schoolgirl, pubertal, colligate, adult, post-adult, old or aged. These all developmental stages are the consequence of cellular and metabolic changes that occur in our bodies and consequently leads to death. The study of all the biological processes, event and changes and the environmental factors influencing these biological processes are to be studied in this course of reading. Additionally, the study of possible remedies that can ease-out the miseries old age- such as the study and research on the dietary and nutritive, immunomodulatory, antioxidative, organ regenerative and anti-ailment substances like that of vitamins, antibiotics etc. are also fall in the domain of this course of study. Furthermore, the role of regenerative medicine and stem cell therapies as possible means of anti-ageing drives are explained in detail.

Contents

1. Aging at whole animal level: pathobiology- influence of age on life expectancy
2. Abnormal cell growth (neoplasia) and aging
3. Nutrition and aging
4. Physiological stress of exercise, environmental stress and aging at tissue level and organ level
5. Neuronal and autonomic aspects of aging
6. Aging in salivary glands
7. Aging of reproductive systems
8. Immunity and aging
9. Aging at cellular level
10. Cell division and the cell cycle
11. Cell longevity
12. The cellular basis for biological aging
13. Cellular transformation and *in vivo* aging
14. Aging at molecular level: damage by free radicals to macromolecules
15. Macromolecular metabolism during aging
16. Metabolic changes and their significance in aging
17. Lipid peroxidation and antioxidants

Recommended Texts

1. Fillit, H. M., Rockwood, K., &Young J.B. (2016). *Brocklehurst's textbook of geriatric medicine and gerontology* (8th ed.). London: Elsevier.
2. Robert A. (2006). *The biology of aging: observations & principles* (3rd ed.). Oxford: Oxford University Press.

Suggested Readings

1. Kanungo, M.S. (2010). *Genes and aging.* Cambridge: Cambridge University Press.
2. Guarente, L. P., Partridge, L., & Wallace, D. C. (2008). *Molecular biology of aging.* New York: CSHL Press.

ZOOL-8118 **Bio Pesticides** **3(3+0)**

Biopesticides have been broadly defined to include biochemical pesticides (pheromones and other attractants), microbial pesticides, and pesticides resulting from genetic manipulations. Biopesticides are largely microbial pathogens of the pest in need of control which can be processed and marketed in the same way as chemical pesticides and some have enjoyed considerable success in crop protection systems. Biopesticides are considered safer alternatives to chemical pesticides in pest management. Numerous biopesticides are commercially available for managing arthropods. Environmental safety concerns have resulted in increased demand for biopesticides Biopesticides have been adopted worldwide either singly or in combination with conventional pesticides. Pesticide pollution continues to be a problem in agriculture, and the extensive use of chemical pesticides has depleted soil resources, increased pest resistance, and impacted food quality, often with serious effects in different parts of the food chain. The development of nanobiopesticides has been largely in relation to plant-derived and microbial-derived products. Nanotechnology holds promise for further improving the efficacy of biopesticides through particle size reduction as well as delivery of toxins.

Contents

1. Pests, pesticides and biopesticides: pest problems in agriculture
2. Insecticides resistance, insect resurgence, pesticide poisoning, contamination of food commodities, effect on non-target organisms
3. Biological control agents: predators and parasitoids
4. Biological control approaches, augmentation, conservation, integrated biological control
5. Microbial control: introduction, historical perspective
6. Bacterial pathogens: *Bacillus thuringiensis*, *Bacillus spaericus*,
7. Viral pathogens: baculovisus
8. Fungal pathogens and protozoan pathogens
9. Botanical pesticides: introduction, historical perspective, promising plant
10. Major botanical pesticides, insecticidal phytochemicals
11. Behavior and physiology affecting phytochemicals, Hormonal mimics and antagonists
12. Pest resistance to phytochemicals
13. Biological origin of IPM concept
14. IPM: a paradigm shift, biotechnological approaches
15. Sustainable pest management

Recommended Texts

1. Nollet, L. M. L., & Rathore, H. S. (2015). *Biopesticides handbook* (1st ed.). Florida: CRC Press.
2. Anwer, M.A. (2017). *Biopesticides and bioagents: novel tools for pest management* (1st ed.). Oakville: Apple Academic Press.

Suggested Readings

1. Hall, F.R., & Menn, J.J. (1999). *Biopesticides: use and delivery*. New Jersey: Humana Press.
2. Bailey, A., Chandler, D., Grant, W., Grant, W.P., Greaves, J., Prince. G., & Tatchell, M. (2010). *Biopesticides: pest management and regulation*. Oxfordshire: CAB International.
3. Koul, O. (2019). *Nano-biopesticides today and future perspectives* (1st ed.). San Diego: Academic Press.

ZOOL-8119 Clinical Endocrinology 3(3+0)

The endocrine system is assemblage of glands that secrete hormones into the circulatory system which regulate different body processes such as development, growth, metabolism, blood pressure, sexual health and maturity, and including many other functions. Endocrinology provides the normal anatomical and physiological aspects of the endocrine system as well as its diseases, secretions and conditions that impact hormonal imbalance. The endocrine system can be influenced by different internal and external conditions such as stress, aging, some disease, pregnancy or environmental factors. Clinical endocrinology provides the knowledge about underlying mechanisms behind irregular secretion and modified action of hormones and the resulting impacts on health or behavior of an individual. Moreover, students will be provided familiarity with various techniques used for the diagnosis of hormonal levels in laboratories. In addition, the learners became aware about different therapeutic tools which can be used to control hormonal disorders including hormonal therapy or medicinal treatment.

Contents

1. Functional pathology in endocrine glands
2. Pituitary disorders: prolactinomas, acromegaly, Cushing's syndrome
3. Diabetes inspidus, hypo- and hyper-tonic syndromes
4. Neuroendocrine disorder of gonadotrophin, prolactin, growth hormone, corticotrophin regulation
5. Thyroid diseases of excess and deficient hormones and autoimmunity
6. Disorders of adrenal cortex: hypo and hyper function
7. Disorders of adrenal medulla: hypo and hyper function
8. Disorders of ovarian function and hormonal therapy
9. Abnormalities of testicular functions and hormonal therapy
10. Fuel homeostasis: glucose homeostasis and hypoglycemia
11. Diabetes mellitus; disorders of lipoprotein metabolism
12. Eating disorders: obesity, anorexia nervosa and bulimia nervosa
13. Development and growth: disorders of growth and puberty
14. Endocrine hypertension
15. Polyendocrine syndromes
16. Hormones and cancers: hormones effect on tumors, breast and prostate cancer
17. Endocrine therapy; humoral manifestation of malignancy
18. Geriatric endocrinology: endocrine and associated metabolism in aging: specifically, thyroid, glucose and calcium homeostasis

Recommended Texts

1. Gardner, D. G., & Shoback, D. M. (2017). *Greenspan's basic and clinical endocrinology* (10th ed.). New York: McGraw-Hill Education.
2. Melmed, S. (2019). *Williams textbook of endocrinology* (14th ed.). Amsterdam: Elsevier.

Suggested Readings

1. Greenspan, F.S., & Strewler, G.J. (2002). *Basic and clinical endocrinology* (5th ed.). London: Prentice Hall International Inc.
2. Rees, A., Levy, M., & Lansdown, A. (2017). *Clinical endocrinology and diabetes at a glance.* London: Wiley-Blackwell.
3. Neal, J.M. (2002). *Basic endocrinology: an interactive approach.* London: Blackwell Science.

ZOOL-8120 Comparative Developmental Biology 3(3+0)

Comparative developmental biology is an interactive course of study that explains how the single cell formed at fertilization transforms in to a complete individual through the various phases of embryonic changes. It employs the comparative study of the events of development in diverse animal groups. The events of development are to be studied at all the levels of organization starting from the molecular, and genetic levels through the events of fertilization and differentiation bring about changes at the tissue, organ, anatomical and the morphological levels. The fascinating events of gametogenesis (spermatogenesis, oogenesis), molecular role and control of fertilization, twining, pregnancy, development of placenta, prenatal and postnatal developments, parturition, pre-pubertal and adolescent changes and the events involved in ageing are also to be discussed in detail. Biotechnological advancements of assisted reproductive technologies (semen cryo-preservation, artificial insemination, in vitro fertilization and embryo transfer techniques and the introduction to the stem cell technology) are also to be taught appropriately.

Contents

1. Historical review of embryology
2. Uses of modern molecular techniques in developmental biology
3. Origin of germ cells (gametogenesis)
4. Spermatogenesis
5. Oogenesis
6. Structure and organization of male and female gametes
7. Fertilization: chemistry of fertilization
8. Molecular biology of fertilization, surface changes in the egg and sperm surface
9. *In vitro* fertilization (test tube technology)
10. Mono- & di-zygotic twinning
11. Parthenogenesis
12. Uses of transgenic animals in developmental biology
13. Cleavage, blastulation
14. Fate maps and their preparation
15. Morphogenetic movements and gastrulation in amphioxus, mammals, chick and frog
16. Stem cells technology and its uses in developmental biology
17. Embryonic adaptations (fetal extra-embryonic membranes) and placentation, umbilical cord, parturition (birth) and its stages
18. Regeneration and regenerative powers of vertebrates
19. Aging

Recommended Texts

1. Gilbert, S.F. (2018). *Developmental biology* (11th ed.). Sunderland: Sinauer Associates.
2. Webster, S., & de-Wreede, R. (2016). *Embryology at a glance* (2nd ed.). New Jersey: Wiley-Blackwell.

Suggested Readings

1. Gilbert, S. F. (2010). *Developmental biology* (9th ed.). New York: Sinauer Publishing Co.
2. Patten, B.N. (2004). *Foundation of embryology*. New York: McGraw-Hill Books Company.

ZOOL-8121 Economic Importance of Amphibians and Reptiles 3(3+0)

Amphibians and reptiles represent a great diversity of species that are widely distributed across the globe and carry out a variety of functions in the earth's ecosystems. The two groups are similar in some respects; for example, species from these two classes occupy close habitats, are ectotherms, and are similarly vulnerable to habitat degradation, disturbance, pollution of the environment and introduction of exotic species. these groups play a key role in energy flow and nutrient cycling in both aquatic and terrestrial environments, in addition to helping control pest populations and potentially acting as pollinators and seed dispersers. Human welfare depends directly or indirectly on the services provided by ecosystems. Amphibians and reptiles represent a high proportion of global species diversity and include species that are widely distributed throughout the world and play a variety of roles that benefit humans. Reptiles and amphibians are important components of ecosystems serving as predators and as key food sources for many species. Reptiles have even been described as keystone species. Determining the economic loss suffered as a result of herpeto-faunal extirpations is an important first step in understanding the value of reptiles and amphibians and requirements for effective mitigation.

Contents

1. Herpeto-faunal diversity of Pakistan
2. General characteristics, natural history, ecology and life histories
3. Distribution, identification, families, phylogeny and evolution of amphibians
4. Biodiversity, decline and conservation (global and regional)
5. Amphibians as ecological indicators
6. Diseases of salamander, captive breeding, endangered and invasive species
7. Importance of amphibians
8. Reptiles: general characteristics, natural history, ecology and life histories
9. Distribution, and identification of reptiles of Pakistan
10. Families, phylogeny and evolution of turtles, crocodiles, lizards and snakes of Pakistan
11. Snakes identification and distribution
12. Diseases of snakes, captive breeding, endangered and invasive species of Pakistan

Recommended Texts

1. Vitt, L. J., & Caldwell, J. P. (2013). *Herpetology: an introductory biology of amphibians and reptiles* (4th ed.). London: Academic press.
2. Sharif M.K. (2006). *The amphibians and reptiles of Pakistan*. Florida: Krieger Publishing Company.

Suggested Readings

1. Sharif M.K. (2002). *A guide to the snakes of Pakistan, volume 16.* Frankfurt am Main: Edition Chimaira.
2. Masroor, R. (2012). *A contribution to the herpetology of northern Pakistan.* Ohio: Society for the Study of Amphibians and Reptiles.

ZOOL-8122 General Microbiology 3(3+0)

Microbiology is the study of microorganisms which include: bacteria, viruses, viroids, yeast, molds, protozoans, algae, fungi and other very small organisms. Microbiology is important because it helps us to understand and treat diseases. This course covers basic principles of microbiology and provides an introduction to the diversity, physiology, morphology, genetics, ecology, applications and pathogenicity of microbes. Students are expected to gain a fundamental understanding of microbes including viruses, Bacteria, Archaea and eukaryotic microorganisms. After completion of the lecture component of the course, successful students will be able to understand the structural similarities and differences among microbes and the unique structure/function relationships of prokaryotic cell and can recognize how the underlying principles of epidemiology of disease and pathogenicity of specific microbes affect human health. It will also help students to appreciate the diversity of microorganisms and microbial communities and recognize how microorganisms solve the fundamental problems their environments present. The laboratory practice can help them to apply scientific method to collect, interpret, and present scientific data in microbiology and related fields.

Contents

1. Introduction and scope
2. Microbial evolution, systematics and taxonomy, nomenclature and Bergey's manual
3. Morphology and structure of bacteria
4. The cultivation of bacteria: choice of media, conditions of incubation
5. Reproduction and growth of bacteria: normal growth cycle of bacteria, the plate count method, membrane-filter count, turbidimetric method
6. Bacteriophages and phages of other protists, replication of bacteriophage
7. Viruses of animals and plants: effects of virus infection on cells. Cancer and viruses.
8. Pure cultures and cultural characteristics
9. Eukaryotic microorganisms: algae: biological and economic importance of algae; characteristics of algae, lichens.
10. Fungi: importance of fungi; morphology; physiology and reproduction, cultivation of fungi
11. Protozoa: classification, ecology and importance of protozoa
12. Prokaryotic diversity bacteria
13. Mycoplasmas, actinomycetes, mycobacterium, filamentous actinomycetes

Recommended Texts

1. Madigan, M. T., Bender, K. S., Buckley D. H., Sattley, W. M., & Stahl, D. A. (2019). *Brock biology of microorganisms* (15th ed.). London: Pearson.
2. Benson, H.J. (1994). *Microbial applications (complete version) laboratory manual in general microbiology*. London: WMC Brown Publishers.

Suggested Readings

1. Madigan, M. T., & Martinko, J. M. (1997*). Brock biology of microorganisms.* London: Prentice-Hall.
2. Stainier, R.Y., Ingraham, J.L., Wheelis, M.L., & Painter, R.R. (1986). *The microbial world*. London: Prentice Hall.

ZOOL-8123 Insect Physiology 3(3+0)

Insect physiology includes the physiology and biochemistry of insect organ systems. Although diverse, insects are quite similar in overall design, internally and externally. Hormones pervade insect physiology. Much of the early success in insect physiology was derived from studies on insect hormones particularly those responsible for metamorphosis. Both development and the daily lives of insects are regulated by the actions of hormones. Insect tissues produce steroid hormones, peptide hormones, and biogenic amines. Recent advances in insect physiology provide evidence that epigenetic mechanisms operating before and after transcription contribute to the transgenerational inherited transcriptional reprogramming of immunity-related genes in insects, ultimately providing mechanisms for the evolution of resistance to parasites. Air and water chemistry affects insect physiology. Oxygen supply is critical to survival, but may be limited under certain conditions. Airborne or dissolved chemicals can affect respiration and development. Soil or water pH can affect exoskeleton function and other physiological processes. Changes in concentrations of various chemicals, especially those affected by industrial activities, affect many organisms, including insects.

Contents

1. Classification of insects: external morphology, types of mouth parts, antenna, legs and wings
2. Systems physiology: anatomy, physiology and biochemistry
3. Digestive system
4. Respiratory system
5. Circulatory system
6. Excretory system
7. Reproductive system
8. Neuro-endocrine physiology of insects: hormones and behaviors and pheromones and behavior
9. Embryonic development: formation of the embryo - stages of embryonic development,
10. Parthenogenesis, polyembryony, viviparity and oviparity
11. Physiology of metamorphosis: types with examples, complete and incomplete metamorphosis
12. Physiological development of various organs
13. Physiology of sense organs.
14. Beneficial and harmful insects. Insects pest of agriculture (Rice, cotton and groundnut)
15. Sericulture, Apiculture and Lac culture

Recommended Texts

1. Whitfield, J. B., Doyen, J. T., Purcell, A. H., & Daly, H. V. (2013). *Daly and Doyen's introduction to insect biology and diversity* (3rd ed.). Oxford: Oxford University Press.
2. Chapman, R.F., Simpson, S.J., & Douglas, A.E. (2012). *The insects: structure and functions* (5th ed.). Cambridge: Cambridge University press.

Suggested Readings

1. Klowden, M.J. (2013). *Physiological systems in insects* (3rd ed.). New York: Academic press.
2. Richards, O. W., & Davies, R. G. (1997). *Imms' general textbook of entomology, volume 1: structure, physiology and development*. London: Chapman and Hall.
3. Richards, O. W., & Davies, R. G. (2013). *Imms' general textbook of entomology, volume 2: classification and biology*. Berlin: Springer Science & Business Media.

ZOOL-8124 Medical Microbiology 3(3+0)

This course aims to provide knowledge of medical microbiology which includes microorganisms, diagnosis, disease causation, and treatment of pathogens to advanced practical training and major significance to public health. It covers biology of bacteria, viruses and other pathogens related with infectious diseases in humans. The structure of the course is based on presenting the fundamentals of microbiology to include structures, morphology and classification of bacteria, viruses, fungi and parasites. The students will be introduced to the pathogenesis of the various infectious agents. The course will also cover some topics related to community health, including the modes and sources of infections as well as prevention of these infections. In addition, students will develop the knowledge, specialist practical skills and critical awareness needed to pursue a career in medical microbiology. Moreover, the students will be able to evaluate methods used to identify infectious agents in the clinical microbiology lab and will be able to describe the epidemiology of infectious agents including how infectious diseases are transmitted.

Contents

1. Antimicrobial agents, mode of action
2. Bacterial pathogens and associated diseases
3. Infective syndromes and diagnostic procedures
4. Strategy of antimicrobial therapy
5. Prophylactic immunization
6. *Staphylococcus aureus* skin and wound infections
7. *Streptococcus,* sore throat, scarlet fever
8. Glomerulo-nephritis, *Streptococcus pneumoniae, S. viridans* (Halitosis)
9. Pneumococcus, respiratory infections
10. *Neisseria meningitidis, Neisseria gonorrhoeae, Anthrax bacillus, Bacillus anthracis, Clostridium tetani, C. perfringens (Gas gangrene), C botulinum,*
11. *Listeria monocytogenes, Cornyebacterium diphtheriae,* Diphtheria
12. *Mycobacterium tuberculosi, M. leprae, Pseudomonas aeruginosa*
13. *Brucella: Bordetella pertussis, Legionella pneumophila,*
14. *Escherichia coli, Salmonella typhae, Shigella*

Recommended Texts

1. Goering, R., Dockrell, H., Zuckerman, M., & Chiodini, P. (2018). *Mims medical microbiology and immunology* (6th ed.). Amsterdam: Elsevier.
2. Anderson, D., Salm, S., & Allen, D. (2015). *Nester's microbiology: a human perspective* (8th ed.). New York: McGraw-Hill.

Suggested Readings

1. Ryan, K., Ray, C. G. Ahmad, N., Drew, W. L., & Plorde, J. (2010). *Sherris medical microbiology* (5th ed.). Washington DC: McGraw-Hill Publishers.
2. Jacquelyn, G.G. (2001). *Microbiology principles and explorations.* New Jersey: Wiley John & Sons Inc.

ZOOL-8125 Physiology of Endocrine Coordination 3(3+0)

Coordination is the property of connectivity among the body organs of an animal/ human being. It is generally needed to bring harmony among the body organs to make the body capable to respond appropriately to the internal and external changes and thus to survive as a single unit. Endocrine coordination involves the synthesis and secretion of various hormones and the metabolic, growth and developmental changes and the physiological homoeostasis. This course of reading will introduce the students about the anatomical positions of various endocrine glands and tissues in the body; the biochemistry, synthesis, storage, secretion, mode of action and the biological role of different hormones produced and secreted by these tissues and organs. The hormonal control over reproductive biology- development of reproductive system, sex related changes, gametogenesis, pregnancy, parturition, lactation, nurture the young ones and the behavioral patterns are to be studies in detail. The molecular mechanisms of hormone action will also be introduced

Contents

1. General principles of endocrine physiology, hormones in homeostasis of metabolism, endocrine regulation of metabolism of calcium and phosphate, parathyroid gland, calcitonin and cholecalciferol
2. Hypothalamus and pituitary: hypothalamic regulation of pituitary, pituitary gland hormone in physiological coordination
3. Thyroid gland: functional anatomy, biosynthesis, regulation and roles in physiological functions, mechanism of thyroid hormones action
4. Adrenal cortex: hormones biosynthesis, physiological roles and control; adrenal medulla: hormones biosynthesis, physiological roles, and hypothalamic-pituitary-adrenocortical axis, adrenal medulla and sympathetic nervous system together integrate responses to stress; endocrine function of kidney, heart and pineal gland
5. General reproductive mechanisms
6. Energetics of reproduction; functional anatomy, synthesis and regulation of gonadal steroids, secretary pattern of gonadal steroid at different stage of life
7. Male reproduction: roles of androgen, biology and regulation of spermatogenesis, male puberty;
8. Female reproduction: roles of ovarian steroids, biology and regulation of oogenesis, female puberty, cyclic changes
9. Adaptations in gestation, parturition, lactation and menopause.

Recommended Texts

1. Stanfield, C. L. (2016). *Principles of human physiology* (6th ed.). San Francisco: Pearson.
2. Widmaier, E., Raff, H., & Strang, K. (2018). *Vander's human physiology* (25th ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Fox, S. (2015). *Human physiology* (14th ed.). New York: McGraw-Hill Education.
2. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *Eckert animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman and Company.
3. Bullock, J., Boyle, J., & Wang, M.B. (2001). *Physiology* (4th ed.). Philadelphia: Lippincott, Williams and Wilkins.

ZOOL-8126 Physiology of Nervous Co-ordination 3(3+0)

Coordination is the property of connectivity among the body organs of an animal/ human being. It is generally needed to bring harmony among the body organs to make the body capable to respond appropriately to the internal and external changes and thus to survive as a single unit. The study of nervous coordination includes the in depth understanding of the anatomy of central nervous system that includes the brain and the spinal cord, the protective bony and membranes protective coats of the CNS, the peripheral nervous system that include the cranial and spinal nerves as well as autonomic nervous system. The anatomical details of the structural parts of brain - the prosencephalon (the telencephalon and the diencephalon), mesencephalon and the rhombencephalon (metencephalon and the mylincephalon) and the sensory and motor activities attributable to the parts are to be studies in details. The structure of neurons, neuronal types, structure and biological roles of glial cells, the nerve impulse- graded potential and the action potential, synaptic transmissions, neurotransmitters etc. are also needed to be explained in detail. Apart from these the basis of higher center activities like memory, learning, behavior etc. and the sensory perceptions will also be discussed.

Contents

1. Physiological mechanisms at cellular level
2. Cellular membrane and transmembrane transport
3. Resting membrane potentials
4. Generation and conduction of action potentials
5. Synaptic transmissions
6. Membrane receptors, second messenger and signal-transduction pathways
7. Nervous System: organization of nervous system
8. General sensory system; visual, auditory, vestibular and chemical sensory system
9. Motor system with brainstem, cortical, cerebellar and basal ganglia
10. Control of posture and movements
11. Anatomy of mammalian brain
12. Components of forebrain
13. The limbic system, thalamus, hypothalamus
14. Neuroendocrine integration
15. Cranial nerves

Recommended Texts

1. Stanfield, C. L. (2016). *Principles of human physiology* (6th ed.). San Francisco: Pearson.
2. Widmaier, E., Raff, H., & Strang, K. (2018). *Vander's human physiology* (25th ed.). New York: McGraw-Hill Education.

Suggested Readings

1. Fox, S. (2015). *Human physiology* (14th ed.). New York: McGraw-Hill Education.
2. Randall, D., Burggren, W., French, K., & Fernald, R. (2002). *Eckert animal physiology: mechanisms and adaptations* (5th ed.). New York: W.H. Freeman and Company.

ZOOL-8127 Regenerative Medicine 3(3+0)

Regenerative medicine is characterized as the process of replenishing or restoring human cells, tissues, or organs to rehabilitate the normal organ functional integrity and capability. This field holds the promise of transforming human medicine, by actually curing or treating diseases once poorly managed with conventional drugs and medical procedures. It involves the study of genetic control over the organ activity. The general activity based and pathological wear and tear in the body organs and the basis of the normal regenerative activity and capacity of the organs are to be discussed. The general mechanisms of regulation of gene expression at both the transcriptional and translational levels and the post transcriptional and post translational processing are to be explained. The regulatory control of endogenous and exogenous bioactive compound and medicines on the regenerative activities in specific body organs are to be introduced to the students. Similarly, the possible roles of stem cells in regenerative abilities and the stem cells therapies will also be discussed in detail.

Contents

1. History of animal cell culture, cell culture media and reagents
2. Culture of mammalian cells, primary culture and secondary cell lines, continuous cell lines,
3. Suspension cultures, somatic cell cloning and hybridization
4. Cloning vectors- plasmids, expression vectors viral, baculo and yeast vectors
5. Construction of genomic and cDNA library, transcript analysis
6. Study and Regulation of gene expression.
7. Transfection and transformation of cells
8. Application of animal cell culture for *in vitro* testing of drugs and toxicity assay
9. Cell proliferation
10. Ageing of cell
11. Induced pluripotent stem cells
12. Cellular reprogramming
13. Disease modelling and drug screening in pathogenic bacteria, epigenetics of reprogramming
14. Immuno-cytochemical analysis, gene promoter methylation of pluripotent stem cells
15. Gene knock out and gene silencing using siRNA and ShRNA for genetic disorders
16. iPS cells to elucidation of pathogenesis
17. Drug discovery, toxicology study, and cell transplantation therapy in the future

Recommended Texts

1. Portner, R. (2014). *Animal cell biotechnology: methods and protocols.* Berlin: Springer Publisher.
2. Dutta, A. K., & Dutta, R. C. (2018). *3D cell culture: fundamentals and applications in tissue engineering and regenerative medicine.* Stanford: Pan Stanford.

Suggested Readings

1. Warburton, D. (2015). *Stem cells, tissue engineering and regenerative medicine* (1st ed.). Singapore: World Scientific Publishing Company.
2. Lewin, B. (2011). *Genes XI.* Massachusetts: Jones and Bartlett Publishers.
3. Mather, J.P., & Barnes, D. (2008). *Methods in cell biology, animal cell culture methods,* volume 57. New York: Academic Press.

ZOOL-8128 Research Methods in Entomology 3(3+0)

Research is the systematic investigation into and study of materials and sources in order to establish facts, reach new conclusions, and use of different methods which help in study of insects and how they interact with their environment, other species and humans. Entomology is now a well-established degree and with the scope of the environmental sciences continuing to expand, the evidence that we can acquire from it is expected to continue to have the broadest possible appeal. Research in insect molecular biology, physiology and genetics are the major areas employing differential sampling techniques. This course describes effective methods and equipment for collecting, identifying, rearing, examining, and preserving insects, and explains how to store and care for specimens in collections. It also provides instructions for the construction of many kinds of collecting equipment, traps, rearing cages, and storage units, as well as updated and illustrated keys for identification of the orders of insects. The primary motive of research on insects is to convey integral details about insect groups to design new strategies regarding pest control and employing insects in biological control. Insect-plant interaction, tracing evolutionary pathways among different entomological orders, biochemical aspects of host-parasite-pathogen interactions, chemical communication, quantitative genetics are few core areas of research focusing on insect populations.

Contents

1. Introduction; techniques and apparatus employed in entomological research
2. Sampling methods to collect field and laboratory data
3. Lab and field experimental techniques
4. Temporary and permanent mounts, microtomy, ocular grid use, micrometry
5. Scientific photography
6. Bio assay techniques
7. Atomic absorption and UV-visual spectrophotometery, gas chromatography, HPLC
8. amino acid analysis via analyzer
9. Gel electrophoresis
10. Polymerase chain reaction (PCR)
11. recombinant DNA techniques
12. electron microscopy
13. Computer softwares in entomological research
14. Analysis of data and report writing

Recommended Texts

1. Gibb, T. J., Oseto, C. Y., & Oseto, C. (2005). *Arthropod collection and identification: laboratory and field techniques* (1st ed.). San Diego: Academic press.
2. Binns, M. R., Nyrop, J. P., van der Werf, W., & Werf, W. (2000). *Sampling and monitoring in crop protection: the theoretical basis for developing practical decision guides* (1st ed.). Oxfordshire: CAB International.

Suggested Readings

1. Pedigo, L. P., & Buntin, G. D. (1993). *Handbook of sampling methods for arthropods in agriculture* (1st ed.). New York: CRC Press.
2. Singh, P. (1985). *Handbook of insect rearing.* Philadelphia: Elsevier.

ZOOL-8129 Transgenic Animal Technology 3(3+0)

Animals with manipulated genetic material (carrying recombinant DNA) are known as transgenic animals. These animals represent models that can address particular biological queries. Thus the ability to incorporate housekeeping and regulatory genes in animal genome provides a powerful tool for the study of intricate biological processes and mechanisms. Transgenic technology provides methods to rapidly introduce new genes into animals without cross breeding. It is a powerful technique for studying fundamental problems of mammalian development. The present course is designed to introduce to the students with latest cutting edge technologies of whole genome sequencing, cell culture, gene knockout, gene expression, cellular differentiation and the stem cells culture and management. The students will also be introduced applications of molecular genetics and epistasis, stem cell therapies, cloned gene recombinant protein products like enzymes, hormones vaccines and interferons. The student will also learn the use of viruses as vectors for gene transfer in to an animal cell.

Contents

1. Animal cell culture: cell lines, bioreactor models for animal cell culture, characterization and maintenance of cell lines; cryopreservation, cell bank; applications of cell line
2. Viral vectors – biology, adenovirus, adeno associated virus, retroviral vectors, Herpes virus, vaccinia virus.
3. Stem cells – definition, functions and origin, types, stem cell therapy, stem cell culture and applications
4. Biotechnology in aquaculture: transgenic fishes; animal bioreactor and molecular farming; selected traits and their breeding into livestock; applications of molecular genetics in improvement of livestock
5. Cloning and recombinant products: cloned genes and production of recombinant proteins and vaccines; Insulin, somatotrophin, somatostatin, β-endorphin, human interferons; hepatitis B virus vaccine, vaccine for foot and mouth disease virus – DNA vaccine; development of RNAi to target various diseases like diabetes and cancer
6. Transgenic animals: Mice, cattle, gene knockout mice; DNA fingerprinting; Ethical issues in animal biotechnology; current scenario of next generation sequencing and its application in biology; recent achievements in DNA/ protein microarray and biochip technology

Recommended Texts

1. Pinkert, C. A. (2014). *Transgenic animal technology- a laboratory handbook* (3rd ed.). Amsterdam: Elsevier.
2. Butler, M. (2003). *Animal cell technology: principles and product.* New York: Open University Press.

Suggested Readings

1. Winnacker, E.L. (2005). *From genes to clones: introduction to gene technology.* Berlin: VCH Publications.
2. Epplen, J.T., & Lubjuhn, T. (2004). *DNA profiling and DNA fingerprinting*. Basel: Birkhauser Verlag.
3. Gupta, P. K (2012). *Biotechnology and genomics.* Meerut: Rastogi Publications.