



UNIVERSITY OF SARGODHA

Office of the Registrar

Ref: SU/Acad/ 884
November/05/2020

Notification

The Academic Council in its meeting held on 18.06.2020 has approved the following recommendations made by the Board of Faculty of Sciences in its meeting held on 03.06.2020. The Syndicate in its meeting held on 27.07.2020 has also endorsed the decision of Academic Council.

1. Revised Scheme of Studies and Curriculum of BS Zoology under Semester / Term System from session 2020 (Annex-'A')
2. Course contents 'Introduction to Biology' for other departments (Annex-'B')
3. Revised Scheme of Studies of MSc Zoology under Annual System from session 2020 (Annex-'C')
4. Revised Scheme of Studies and Curriculum of MSc Semester / Term System from session 2020 (Annex-'D')
5. Revised Scheme of Studies and Curriculum of MPhil Zoology from session 2020 (Annex-'E')
6. Revised Scheme of Studies and Curriculum of PhD Zoology from session 2020 (Annex-'F')

Muhammad Farooq
Deputy Registrar (Acad)

Distribution:

- Chairman, Department of Zoology
- Director, Sub-Campus Bhakkar
- Controller of Examinations
- Principals of all affiliated colleges (concerned)
- Web-Developer

C.C:

- Focal Person, Faculty of Sciences
- Deputy Registrar (Affiliation)
- Deputy Registrar (Registration)
- Secretary to the Vice-Chancellor
- P.A to Registrar

Please discuss

Muo
10.11.2020

All CR +
DEC + ACE
(for uploading on university web-site)

11/11/2020

DCE(S)

DCE(S)

No. 3833
Date 10-11-20

SCHEME OF STUDY FOR BS ZOOLOGY

(SEMESTER/TERM SYSTEM)

(Applicable from 2020)



DEPARTMENT OF ZOOLOGY

UNIVERSITY OF SARGODHA

SARGODHA - PAKISTAN



Department of Zoology

University of Sargodha

To be implemented from September 2020

SEMESTER –I

Course Category	Course Code	Course Title	Credits
COMPULSORY-I	URCE-5101	Grammar	3(3+0)
COMPULSORY-II	URCM-5101	Introduction to Mathematics	3(3+0)
GENERAL - I	BOTN-5101	Diversity of Plants	4(3+1)
GENERAL - II	CHEM-5101	Physical Chemistry	4(3+1)
FOUNDATION-I	ZOOL-5101	Animal Diversity-I (Invertebrates)	4(3+1)
		Total Credits	18

SEMESTER–II

Course Category	Course Code	Course Title	Credits
COMPULSORY-III	URCE-5102	Language Comprehension & Presentation Skills	3(3+0)
COMPULSORY-IV	URCI-5105	Islamic Studies	2(2+0)
GENERAL- III	BOTN-5102	Plant Systematics, Anatomy and Development/Embryology	4(3+1)
GENERAL- IV	CHEM-5102	Inorganic Chemistry	4(3+1)
FOUNDATION-II	ZOOL-5102	Animal Diversity-II (Chordates)	4(3+1)
		Total Credits	17

SEMESTER–III

Course Category	Course Code	Course Title	Credits
COMPULSORY-VI	URCE-5103	Academic Writing	3(3+0)
COMPULSORY-VII	URCI -5109	Introduction to Information & Communication Technologies	3(2+1)
GENERAL- V	BOTN-5103	Cell Biology, Genetics and Evolution	4(3+1)
GENERAL- VI	CHEM-5103	Organic Chemistry	4(3+1)
FOUNDATION-III	ZOOL-5103	Animal Form & Function-1	4(3-1)
		Total Credits	18

SEMESTER–IV

Course Category	Course Code	Course Title	Credits
COMPULSORY-VIII	URCE-5104	Introduction to English Literature	3(3+0)
MAJOR-I	ZOOL-5104	Animal Form & Function-II	4(3+1)
GENERAL- VII	SOCI-5101	General Sociology –I	3(3+0)
MAJOR-II	ZOOL-5105	Biological Techniques	3(1+2)
GENERAL- VIII	PSYC-5101	Psychology/Geography/Etc. (Introduction to Psychology Minor)	3(3+0)
COMPULSORY-V	URCP-5106	Pakistan Studies	2(2+0)
		Total Credits	18

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SEMESTER-V

Course Category	Course Code	Course Title	Credits
FOUNDATION-IV	ZOOL-6106	Research Methodology	2(2+0)
FOUNDATION-V	ZOOL-6107	Economic Zoology	3(2+1)
FOUNDATION-VI	ZOOL-6108	Biochemistry	4(3+1)
MAJOR-III	ZOOL-6109	Cell and Molecular Biology	4(3+1)
FOUNDATION-VII	ZOOL-6110	Evolution & Principles of Systematics	4(3+1)
		Total Credits	17

SEMESTER-VI

Course Category	Course Code	Course Title	Credits
MAJOR-IV	ZOOL-6111	Physiology	4(3+1)
MAJOR-V	ZOOL-6112	Ecology	3(2+1)
MAJOR-VI	ZOOL-6113	Developmental Biology	4(3+1)
MAJOR-VII	ZOOL-6114	Genetics	4(3+1)
MAJOR-VIII	ZOOL-6115	Wildlife	3(2+1)
		Total Credits	18

SEMESTER-VII

Course Category	Course Code	Course Title	Credits
MAJOR-IX	ZOOL-6XXX	Special Paper A1/ Thesis (Univ. Option)	3(2+1)/(0+3)
COMPULSORY-IX	ZOOL-6116	Biostatistics/Univ. Option	3(2+1)
ELECTIVE-I	ZOOL-6XXX ZOOL-6130	Special Paper A2/ Univ. Option= Ichthyology	3(2+1)
ELECTIVE-II	ZOOL-6XXX /ZOOL-6140	Univ. Option/ Principles & Kinetics Of Toxicology	3(2+1)
MAJOR-X	ZOOL-6117	Bioinformatics	3(1+2)
		Total Credits	15

SEMESTER-VIII

Course Category	Course Code	Course Title	Credits
MAJOR-XI	ZOOL-6118	Animal Behavior	3(3+0)
MAJOR-XII	ZOOL-6XXX	Special Paper B1/ Thesis (Univ. Option)	3(2+1)/(0+3)
ELECTIVE-III	ZOOL-6XXX /ZOOL-6122	Special Paper B2/ Univ. Option=Biotechnology	3(2+1)
ELECTIVE-IV	ZOOL-6XXX	Univ. Option	3(2+1)
MAJOR-XIII	ZOOL-6119	Zoogeography & Paleontology	3(2+1)
		Total Credits	15

TOTAL CREDITS 136

3

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ANNEXURE I (LIST OF OPTIONAL COURSES)

Course Codes	Course Title	Credits
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)

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* (8th 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.

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.

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
18. Permutation and combinations
19. Introduction to mathematical induction and binomial theorem
20. Basic Concepts of Trigonometry
21. Fundamental Identities of Trigonometry

Recommended Texts

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

Suggested Readings

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

This course offers an evolutionary survey of the origin and diversification of land plants through geological time. 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 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. Curriculum will emphasize on life histories, anatomical and morphological adaptations, ecology and climate change, extinction, phylogenetics, economic importance, and conservation strategies of representative taxa. The laboratory will provide ample hands-on opportunities for analysis of plant anatomy and morphology, reproductive mechanisms, evolutionary adaptations, and identification of a variety of living and preserved specimens. Plants are multi-cellular and mostly photosynthetic organisms which found essentially everywhere, both in water and on land.

Contents

1. Comparative study of life form, structure, reproduction and economic significance of: 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*)
6. Bryophytes (*Riccia*, *Anthoceros*, *Funaria*)
7. Pteridophytes: Psilopsida (*Psilotum*), Pteropsida (*Marsilea*), Sphenopsida (*Equisetum*) Lycopsida (*Selaginella*)
8. Gymnosperms (*Cycas*, *Pinus*, *Ephedra*)
9. Angiosperms: Monocot (Poaceae) , Dicot (Solanaceae)

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. Cronk, J. K., & Fennessy, M. S. (2016). *Wetland plants: biology and ecology*. Florida: CRC Press.
4. Pullaiah, T., Bahadur, B., & Murthy, K. (2015). *Plant biodiversity*: Berlin: Springer-Verlag.

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 offers complementary approach 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 & integration, significance of differentiation & integration.
2. Physical States of Matter: Gases (van der Waal's equation, critical Phenomena, Critical values of T, P & V., liquification of gases, molecular collisions, collision diameter, mean free path) Liquids (viscosity, Parachor value, Refractive index, molar refraction and its applications. Dipole moment, Solids (Unit cells. Bragg crystal analysis, crystal structure of NaCl, powder method of crystal structure analysis).
3. Atomic Structure: De Broglie equation. Schrodinger wave equation, solution for particle in 1D box, quantization concept, Heisenberg Uncertainty Principle, Pauli Exclusion Principle, Hund's Rule.
4. Chemical Thermodynamics: First law of thermodynamics, state functions, isothermal and adiabatic processes in ideal gases, heat capacity, reversible and irreversible processes. Spontaneous and non-spontaneous processes, second law of thermodynamics, change of entropy with change in T, P & V.
5. Chemical Equilibrium: Law of Mass Action, equilibrium constant, relationship between K_c , K_p , K_x and K_a and LeChaterlier's Principle.
6. Solutions: composition, ideal and non-ideal solutions. Raoult's law. Colligative properties, ebullioscopy, cryoscopy, osmotic pressure, distillation and concept of azeotropes.
7. Chemical Kinetics: Zero, first and second order reaction, Arrhenius equation, activation energy, Lindemann's mechanism, collision theory and transition state theory.
8. Electrochemistry: Conductance, dependence of conductance on the nature of solvent and temperature, Kohlrausch's law and its applications, measurement of conductance strong and weak electrolytes, degree of dissociation.

Practical

1. Determination of surface tension and Parachor value by stalagmometer.
2. Determination of percent composition of liquid solutions from surface tension measurement.
3. Determination of viscosity and Rhechor value of liquids from viscosity measurement.
4. Determination of percent composition of liquid solutions viscometrically.
5. Determination of refractive index and molar refractivity by refractometer.
6. Determination of percent composition of liquid solutions by refractive index measurements.
7. Determination of heat of solution by solubility method.
8. Determination of heat of neutralization of an acid with a base.

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9. A kinetic study of acid hydrolysis of ethyl acetate.
10. Kinetic study of saponification of ethyl acetate.
11. Determination of molecular weight of a compound by elevation in boiling point. (Ebullioscopic method).
12. Determination of molecular weight of a compound by lowering of freezing point (The Cryoscopic methods).
13. Determination of equilibrium constant of KI – I₂ K_{I3}.
14. Conductometric titration of strong acid and strong base.

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). *Textbook of physical chemistry*. Lahore: Ilmi Kitab Khawna.
2. Das, R. C., & Behera, B. (2003). *Experimental physical chemistry*. Delhi: Tata McGraw Hill.

This course will provide the knowledge of evolutionary/phylogenetic relationship. It imparts the basic taxonomic characteristics and classification of all the invertebrate 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 and tree diagrams: patterns of organization.
2. Animal-like protists: the protozoa: evolutionary perspective; life within a single plasma membrane, symbiotic life-styles, Protozoon taxonomy, pseudopodia and amoeboid locomotion; cilia and other pellicular structure, nutrition; genetic control and reproduction; symbiotic ciliates, further phylogenetic consideration.
3. Multicellular and tissue levels of organization: Evolutionary Perspective, Origins of Multicellularity; Animal Origins, Phylum Porifera, Cnidaria, Ctenophora, Characters and Classification, Maintenance functions.
4. The triploblastic and with acoelomate body plan: Phylum Platyhelminthes, Phylum Nematode, Gastrotricha, evolutionary perspective; classification up to class, body plan and functions.
5. Pseudocoelomate body plan: Phylum Aschelminths, evolutionary perspective: general characteristics; classification up to order with external features, feeding and digestive system; other organ system; reproduction and development including Phylum Rotifera, Phylum Nematoda and Phylum Kinorhyncha. some important nematode parasites of human.
6. Phylum Mollusca: evolutionary perspective; relationship to other animals; origin of the coelom; characteristics, classification up to class. the characteristics of shell and associated structures, feeding, digestion, gas exchange, locomotion, reproduction and development, other maintenance functions and diversity in gastropods, bivalves and cephalopods.
7. Phylum Annelida: the metameric body form; evolutionary perspective; relationship to other animals, metamerism and tagmatization, classification up to class. external structure and locomotion, feeding and the digestive system, gas exchange and circulation, nervous and sensory functions, excretion, regeneration, reproduction and development, Polychaeta, Oligochaeta and Hirudinea, Further phylogenetic consideration.
8. Phylum Arthropoda: evolutionary perspective: classification and relationship to other animals; metamerism and tagmatization; the exoskeleton; metamorphosis; classification up to class.
9. The Hexapods and Myriapods: evolutionary perspective: classification upto class. external structure and locomotion, nutrition and the digestive system, gas exchange, circulation and temperature regulation, nervous and sensory functions, excretion, chemical regulation, reproduction and development in hexapoda, insects behavior, insect and human.

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Date

10. Phylum Echinoderms: evolutionary perspective: relationship to other animals; echinoderm characteristics; classification up to class, maintenance functions, regeneration, reproduction, and development in Asterozoa, Ophiurozoa, Echinozoa, Holothurozoa and Crinozoa.
11. Some lesser known Invertebrates: Lophozoa, Entoprocta, Cycliophora, and Cheatognaths.

Practical

Note: Classification of each members of each phylum upto order with adaptations in relation to habitat of the specimen. Preserved specimen and colored projection slide and CD ROM projection of computer must be used.

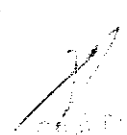
1. Study of Euglena, Amoeba, Endameba, Plasmodium, Trypanosome, Paramecium as representative of animal like Protists.
2. Study of representatives of Phylum Porifera and prepared slides of spicules of sponges
3. Study of principal representatives of classes of Phylum Coelenterate.
4. Study of principal representatives of classes of Phylum Platyhelminthes.
5. Study of representatives of phylum Rotifer, Phylum Nematode.
6. Study of principal representatives of classes of Phylum Mollusca.
7. Study of principal representatives of classes of Phylum Annelida.
8. Study of principal representatives of classes of groups of Phylum Arthropoda
9. Study of representatives of classes of Phylum Echinodermta.
10. Preparation of permanent mount of Leucosolenia, Obelia, Hydra, Proglottid of Tapeworm, Parapodia of Nereis and Daphnia. Drawing and labeling.
11. Preparation of permanent slide of mouthpart of insects (after dissection).
12. How to make grade-wise series for preparation of temporary and permanent slides.

Recommended Texts

1. Miller, A. S., & Harley, J. B. (1999, 2002, 2007, 2009, 2012 & 2016). *Zoology* (4th, 5th, 6th, 7th, 8th, 9th & 10th ed.). Singapore: McGraw Hill.
2. Hickman, C. P., Roberts, L. C., & Larson, A. (2007). *Integrated principles of zoology* (11th & 12th ed.). Singapore: McGraw-Hill.

Suggested Readings

1. Hickman, C. P., Roberts, L. C., & Larson, A. (2018). *Integrated principles of zoology* (15th ed.). Singapore: McGraw-Hill.
2. Pechenik, J. A. (2015). *Biology of invertebrates* (7th ed.). Singapore: McGraw-Hill
3. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.


 Date: _____
 Page: 11
 Chapter: _____
 Section: _____
 Teacher: _____
 Student: _____
 Class: _____

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 student's 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.

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 Muhammad ﷺ. 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
15. Historical Development of Islamic Culture & Civilization
16. Comparative Religions and Contemporary Issues
17. Impact of Islamic civilization

Recommended Texts

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

Suggested Readings

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

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. These studies also give description of the new species. It organizes the animals into groups and grouping is based on degree of evolutionary relatedness. The modern classification system has been given by Carolus Linnaeus. Plant anatomy is the study of the shape, structure, and size of plants and a typical plant body consists of three major vegetative organs: the root, the stem, and the leaf, as well as a set of reproductive parts that include flowers, fruits, and seeds. As a living thing, all of a plant's parts are made up of cells and this course will also lead towards the developmental processes that how they took place.

Contents

Plant Systematic:

1. Introduction to Plant Systematic: aims, objectives and importance.
2. Classification: Brief history of various systems of classification with emphasis on Takhtajan.
3. Brief introduction to nomenclature, importance of Latin names and binomial system with an introduction to ICBN/ ICN for plants.
4. Morphology: A detailed account of various morphological characters root, stem, leaf, inflorescence, flower, placentation and fruit types.
5. Diagnostic characters, economic importance and distribution pattern of the following families: Ranunculaceae, Brassicaceae (Cruciferae), Fabaceae (Leguminosae), Rosaceae (Euphorbiaceae), Cucurbitaceae, Lamiaceae (Labiatae), Apiaceae (Umbelliferae), Asteraceae (Compositae), Liliaceae (Sen. Lato).

Anatomy:

1. Cell wall: structure and chemical composition
2. Concept, structure and function of various tissues like: Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem, Epidermis (including stomata and trichomes)
3. Meristem: types, stem and root apices
4. Vascular cambium
5. Structure and development of root, stem and leaf.
6. Primary and secondary growth of dicot stem, periderm
7. Characteristics of wood: diffuse porous and ring porous, sap and heart wood, soft and hard wood, annual rings.
8. Development/Embryology
9. Early development of plant body: *Capsella bursa-pastoris*
10. Structure and development of Anther (microsporogenesis, microgametophyte)
11. Structure and development of Ovule (megasporogenesis, megagametophyte)
12. Endosperm formation

13. Parthenocarpy
14. Polyembryony

Practical

Anatomy and Embryology:

1. Study of stomata and epidermis.
2. Tissues of primary body of plant.
3. Study of xylem 3-dimensional plane of wood.
4. T. S of angiosperm stem and leaf.
5. Anatomy of germinating seeds
6. Study of pollens

Taxonomy:

7. Identification of families given in syllabus with the help of keys.
8. Technical description of common flowering plants belonging to families mentioned in theory.
9. Field trips shall be undertaken to study and collect local plants.
10. 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 phylogenetic approach of the angiosperms of the temperate and tropical regions*. Florida: CRC Press.
3. Hickey, M., & King, C. (2015). *The Cambridge illustrated glossary of botanical terms*. Cambridge: Cambridge University Press.
4. Lyons-Sobaski, R. C., Sheila, W., & Robert, W. (2018). *Plant anatomy*. Berlin: Springer-Verlag.

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 advanced 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 develops 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, Group trends and periodic properties, Atomic & ionic radii, ionization potentials, electron affinities and electronegativities; Redox potential, electrochemical series and its applications. Corrosion and electroplating.
2. Acid Base Equilibria: Acids and bases, relative strengths of acids, pH, pKa, pKb. Hard and soft acid & Bases. SHAB Principle & its application. Buffers, types buffer, Preparation, Buffer capacity and applications of buffers. Indicators: (Acid-base, Redox, Adsorption), Solubility product, Common ion effect and its applications.
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. Special types of bonds such as Metallic bonds, Hydrogen Bonding, Bent bond, Ion-dipole-dipole bond, ion induced-dipole bond.
4. Chemistry of p-Block Elements: Introduction to p-block elements (Group trends in p-block elements with reference to, atomic sizes & chemical reactivities). Boranes & Boride; aluminium halides, hydrides & Alums; Silicates (Structural aspects, classifications and applications); silicones (Structural aspects, classifications and applications), Germanes; phosphazenes, Phosphides, Oxoacids of Phosphorous; Oxoacids & salts of sulphur; Noble gases (compounds of Xe, Kr, Ra; bonding and applications). Production of pure silicon chips for solar energy cells.
5. Chemistry of d-Block Elements: Electronic configuration. Characteristics. Nomenclature. Nature of bonding in coordination compounds: Werner's theory, VBT, MOT and CFT for coordination compounds. Isomerism in coordination compounds. Chelates: Classification and applications. Applications of coordination compounds (Medicinal, Industrial, Agricultural).
6. Separation Techniques: General introduction and Applications (Solvent extraction and Chromatographic techniques such as paper, Ion exchange and Column).
7. Introduction to Analytical Techniques in Inorganic Chemistry: Introduction to spectroscopic Techniques: Principle, brief instrumentation, sample handling and applications (Flame emission, Atomic Absorption, IR & UV/Vis).
8. Chemical Industries: Metallurgy of Al, Cr and U, fertilizers (Urea & Phosphate fertilizers) Cement and Sugar.

Practical

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.
4. Estimation of manganese (II) using EDTA.
5. Estimation of copper (Iodometrically).
6. Determination of thiosulphate ion (Iodometrically).



7. Determination of ferricyanide using KI solution.
8. Determination of chloride by Volhard's and Mohr's methods.
9. Estimation of chloride ions using adsorption (Fluorescein) indicator.
10. Estimation of bromide ions using adsorption (Eosin) indicator.
11. Estimation of percentage of ferrous ions in the Mohr's salt using KMnO_4 .
12. Percentage determination of ferric ions in ferric alum using KMnO_4 solution.
13. Determination of purity of commercial potassium oxalate using KMnO_4 solution.
14. Estimation of ferrous ions using $\text{K}_2\text{Cr}_2\text{O}_7$ solution.

Recommended Texts

1. Iqbal, M. Z. (2015). *Textbook of inorganic chemistry* (Revised edition). Lahore: Ilmi Kitab Khana.
2. Lee, J. D. (1996). *Concise inorganic chemistry* (5th ed.). London: Chapman & Hall.
3. Vogel, A. I. (1995). *A textbook of macro and semi micro qualitative inorganic analysis*. New York: Longman Green & Co.
4. Skoog, D. A., West, D. M., & Holler, F. J. (1994). *Analytical chemistry* (6th ed.). Philadelphia: Saunders College Publications.

Suggested Readings

1. Graham, H., & Man, H. (2000). *Chemistry in context* (5th ed.). Nashville: Thomas Nelson Ltd.
2. Philp, M. (1996). *Advance chemistry*. Cambridge: Cambridge University Press.
3. David, H. (2000). *Modern analytical chemistry*. New York: McGraw Hill.

This course will enable students to understand the taxonomic characteristics of protochordates and chordates. It provides knowledge about the phylogenetic relationships of protochordates 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 ecological role of different groups of chordates and understand the diversity of chordates. Identification of the morphological and anatomical structure for the major groups of vertebrates from an evolutionary point of view will be discussed.

Contents

1. Protochordates: classification of protochordates. Structure, anatomy and organ systems of acorn worms, urochordates and cephalochordates, reproduction; life histories and metamorphosis of protochordates. phylogenetic relationships.
2. Fishes: vertebrate success in water. Phylogenetic relationships of Pisces. Classification of Chondrichthyes, Osteichthyes, Dipnoi and Holocephalli. Locomotor adaptations, nutrition and the digestive system, circulation, gas exchange, nervous and sensory functions, excretion and osmoregulation, reproduction and development of Chondrichthyes (*Scoliodon*) and Osteichthyes (*Cyprinus carpio* and *Wallago attu*).
3. Amphibians: The first terrestrial vertebrates. Characteristics of amphibians Phylogenetic relationships. Classification of amphibians and characteristics of order Caudata, Gymnophiona, and Anura. Structure and locomotor adaptations, nutrition and the digestive system, circulation, gas exchange, temperature regulation, nervous and sensory functions, excretion and Osmoregulation, reproduction, development, and metamorphosis of caudate, anura and Gymnophiona.
4. Reptiles: The First Amniotes and cladistic interpretation of the amniotic lineage. General characteristics of reptiles. Characteristics of Order Testudines or Chelonia, Rhynchocephalia, Squamata, and Crocodylia. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, reproduction and development of chelonia, squamata, Rhynchocephalia and crocodylian. Further phylogenetic considerations.
5. Birds: Classification, feathers, flight and endothermy. Phylogenetic relationships; ancient birds and the evolution of flight. Diversity of modern birds. Adaptation in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and regulation, nervous and sensory systems, excretion and osmoregulation, reproduction and development. Migration and navigation.
6. Mammals: Classification, Specialized teeth, endothermy, hair and viviparity. Diversity of mammals. Adaptations in external structure and locomotion, nutrition and the digestive system, circulation, gas exchange, and temperature regulation, nervous and sensory functions, excretion and osmoregulation, behavior, reproduction and development.

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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
Hickman, C. P., Roberts, L. C., & Larson, A. (2009). *Integrated principles of zoology* (14th ed.). Singapore: McGraw-Hill
2. Pechenik, J. A. (2000). *Biology of invertebrates* (4th ed.). Singapore: McGraw-Hill.

Department of
Biology
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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.

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 include 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.

Cell biology, genetics and evolution are fundamental to an understanding of the processes of life. In this unit, students will be able to 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. There are thousands of opportunities within the medical, pharmaceutical, agricultural, and industrial fields for a person with a concentrated knowledge of molecular and cellular processes. This course will give you a general introduction of cell organelles, cell division and enzymes which are involved in the process of metabolism. 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 (prokaryotes, eukaryotes), basic properties of cell.
3. Brief description of structure and function of the following cell organelles (Cell wall, Cell membrane, Nucleus, Endoplasmic reticulum, Plastids, Mitochondria, Ribosomes, Dictyosomes, Vacuoles)
4. Reproduction in somatic and embryonic cell, mitosis, meiosis and cell cycle

Genetics:

5. Introduction, scope and brief history of genetics. Mendelian inheritance; Laws of segregation and independent assortment, back cross, test cross, dominance and incomplete dominance
6. Molecular genetics; DNA replication, nature of gene, genetic code, transcription, translation, protein synthesis, regulation of gene expression (e.g. lac operon).
7. Chromosomal aberrations; Changes in the number of chromosomes. Aneuploidy and Euploidy. Changes in the structure of chromosomes, deficiency, duplication, inversion and translocation.
8. Evolution: Introduction and theories.

Practical

Cell Biology:

1. Study of cell structure using compound microscope and elucidation of ultra structure from electron microphotographs
2. Measurement of cell size.
3. Study of mitosis and meiosis by smear/squash method and from prepared slides.
4. Study of chromosome morphology and variation in chromosome number.

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5. Extraction and estimation of carbohydrate, protein, RNA and DNA from plant sources.

Genetics:

6. Genetical problems related to transmission and distribution of genetic material.
7. Identification of chromosomes in plant material. Carmine/orcein staining.
8. Determination of blood groups

Recommended Texts

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

Suggested Readings

1. Verma P. S., & Agarwal, V. K. (2016). *Cell biology (cytology, biomolecules and molecular biology)*. Dehli: S. Chand Publishing.
2. Milo, R., & Phillips, R. (2015). *Cell biology by the number* (1st ed.). London: Taylor and Francis publications.
3. Bradshaw, R., & Stahl, P. (2015). *Encyclopedia of cell biology*. Amsterdam: Elsevier Publications.

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 develops 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, properties of bonds, inductive effect, dipole moment. The concept of resonance, rules of resonance, resonance energy, steric inhibition of resonance, hyperconjugation, resonance effect, hydrogen bonding, tautomerism.
2. Introduction to spectroscopy with special reference to the infrared, ultraviolet/visible spectroscopy.
3. Hydrocarbons: classification of hydrocarbons. Nomenclature. Methods of preparation, physical characteristics and chemical reactions of alkanes, alkenes and alkynes. Source of aromatic hydrocarbons. Structure of benzene and the concept of aromatic hydrocarbon. Aromatic electrophilic substitution.
4. Stereoisomerism: conformational analysis of ethane and butane. Optical isomerism, optical activity, chiral carbon atom and optical isomerism, relative and absolute configuration, creation of chiral carbon and racemization. Optical isomerism in compounds containing two chiral carbons atom, diastereoisomer, elements of symmetry, resolution of racemic mixture, geometric isomerism, cis/trans isomerism, designation of isomerism, determination of configuration.
5. Alkyl halide: nomenclature, method of preparation and chemical reaction with special reference to the nucleophilic substitution and elimination reaction of alkyl halide. Preparation, structure and synthetic application of grignard reagent.
6. The hydroxyl group and ether: nature of hydroxyl group in phenol and alcohol.
7. Alcohol: classification and nomenclature, preparation method and chemical reaction, distinction between primary, secondary and tertiary alcohol, polyhydric alcohols. Phenol: preparation method, acidity of phenol, chemical reaction.
8. Ether: preparation and reactions.
9. The carbonyl group: nature and its reactivity, nomenclature of aldehyde and ketone, aldehyde and ketone preparation and reactions along with distinction between them. Carboxylic acid and their derivatives: nomenclature, preparation and chemical reactions, strength of acid and factors affecting it, formation and hydrolysis of acid anhydrides, acid halides, acid amides, esters including glycerides. Introduction to amino acid.
10. Nitrogen compounds: amines; classification, nomenclature, preparation and chemical reactions, distinction between primary, secondary and tertiary amines. Preparation and reaction of aniline. Basicity of aromatic and aliphatic amines and factors affecting it. Diazonium salts and their synthetic applications.

Practical

1. Qualitative organic analysis; systematic identification of organic compounds containing group like COOH, OH, NH₂, C=O.
2. Purification techniques viz solvent extraction distillation and recrystallization, etc.
3. Preparation of simple organic compounds viz, Ethyl benzoate, benzoic acid, tribromophenol, aspirin, nitrobenzene.

Recommended Texts

1. Younas, M. (2006). *Organic spectroscopy*. Lahore: A. H. Publisher.
2. Solomons, T. W. G. (2016). *Fundamentals of organic chemistry* (12th 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.
3. Streitwieser, A., Heathcock, C., & Kosower, E. M. (2017). *Introduction to organic chemistry* (4th ed.). New York: Macmillan.

This course teaches about animals 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 animals 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: protection: the integumentary system of invertebrates and vertebrates; movement and support: the skeletal system of invertebrates and vertebrates; movement: non-muscular movement; an introduction to animal muscles; the muscular system of invertebrates and vertebrates
2. Communication I: nerves: neurons: structure and function.
3. Communication II: senses: sensory reception: baroreceptors, chemoreceptors, georeceptors, hygroreceptors, phonoreceptors, photoreceptors, proprioceptors, tactile receptors, and thermoreceptors of invertebrates lateral line system and electrical sensing, lateral-line system and mechanoreception, hearing and equilibrium in air and water, skin sensors of mechanical stimuli, sonar, smell, taste and vision in vertebrates.
4. Communication III: The Endocrine System and Chemical Messengers: Chemical messengers: hormones chemistry; and their feedback systems; mechanisms of hormone action, Hormones with principal function each of porifera, cnidarians, platyhelminthes, nemertean, nematodes, molluscs, annelids, arthropods, and echinoderms invertebrates; an overview of the vertebrate endocrine system; endocrine systems of vertebrates, endocrine systems of birds and mammals
5. 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; the hearts and circulatory systems of bony fishes, amphibians, reptiles, birds and mammals; 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 Labeo (*Labeo rohita*), Frog (*Hoplobatrachus tigerinus*), Varanus (*Varanus bengalensis*), fowl (*Gallus domesticus*) and rabbit (*Oryctolagus cuniculus*).

Note: Exercises of notes on the adaptations of skeletons to their function must be done.

3. Earthworm or leech; cockroach, freshwater mussel, Channa or Catla catla or Labeo or any other local fish, frog, pigeon and rat or mouse and rabbits dissections as per availability.

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4. Study of heart, principal arteries and veins in a representative vertebrate (dissection of representative fish/mammals).

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.

SEMESTER IV

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.

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 like temperature regulation adequately and 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 adapted by 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 of nutrition; the metabolic fates of nutrients in heterotrophs; digestion, Animal strategies for getting and using food, diversity in digestive structures of invertebrates., The mammalian digestive system: gastro intestinal motility and its control, Oral cavity, pharynx and esophagus, stomach, small intestine: main site of digestion; large intestine; role of the pancreas in digestion; and role of the liver and gallbladder in digestion.
2. Temperature and body fluid regulation : homeostasis and temperature regulation; the impact of temperature on animal life; heat gains and losses; some solutions to temperature fluctuations;
3. Temperature regulation in invertebrates, fishes, amphibians, reptiles, birds and mammals; heat production in birds and mammals , control of water and solutes (osmoregulation and excretion); invertebrate and vertebrate
4. Excretory systems; how vertebrates achieve osmoregulation; vertebrate kidney variations; mechanism in metanephric kidney functions.
5. Reproduction and development: asexual reproduction in invertebrates; advantages and disadvantages of asexual reproduction, sexual reproduction in invertebrates; advantages and disadvantages of sexual reproduction; sexual reproduction in vertebrates; reproductive strategies; examples of reproduction among various vertebrate classes; the human male reproductive system: spermatogenesis, transport and hormonal control, reproductive function; the human female reproductive system: folliculogenesis, transport and hormonal control, reproductive function; hormonal regulation in gestation; prenatal development and birth: the placenta; milk production and lactation.

Practical

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

Note: Prepared slides and preserved specimen and/or projection slides and/or CD ROM computer projections may be used to develop better understanding among students.

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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.
3. Kent, G. C., & Miller, S. (2001). *Comparative anatomy of vertebrates*. New York: McGraw-Hill.
4. Hickman, C. P., & Kats, H. L. (2000). *Laboratory studies in integrated principles of zoology*. Singapore: McGraw-Hill.

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.

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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 of light microscopy. Magnification, resolution, types of microscopy (bright field, dark field, phase contrast), confocal microscopy, electron microscope: scanning electron microscope and transmission electron microscope (SEM and TEM).
2. Standard unit system for weight, length, volume and Different measurement systems (length; surface; weight, volume, temperature), calculations and related conversions , concentrations-percent volume; ppt; ppm - molarity, normality, molality , preparation of stock solutions of various strength
3. Micrometry: Use of stage and ocular micrometers, calibration of ocular micrometer and measurement of size animal and plant cell and nuclei.
4. Specimen preparation for optical microscopy: introduction to microtome and its types, tissue fixation, dehydration, clearing, embedding, section cutting (transverse, longitudinal section), tissue mounting (dry mount, wet mount), staining: hematoxylin and eosin staining.
5. Separation and purification techniques, cell fractionation, centrifugation and its types, filtration
6. Chromatography: principle, applications, types, paper chromatography and thin layer chromatography, column chromatography, high pressure liquid chromatography,
7. Electrophoresis: principle, applications and types (agarose and PAGE).
8. Spectrophotometry: principle, applications, types, visible/UV spectrophotometry
9. Basic principles of sampling and preservation: sampling from soil, water, air, plants and animals, preservation of dry and wet specimens, preservation techniques, lyophilization, preservation in ethanol, formalin etc.
10. DNA sequencing: Polymerase chain reaction (PCR), principle and application, DNA sequencing.

Practical

1. Preparation of slides (dry mount and wet mount)
2. Observation of wet mounts of human cheek cells employing bright and dark field microscopy
3. Measurement of cell size: bacterial and eukaryotic Cell
4. Recording of microscopic observations with the help of camera lucida
5. Liquid handling: proper use of pipettes and micropipettes
6. Hematoxylin and eosin staining
7. Gram's staining,
8. Handling of centrifuge machines

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9. Paper Chromatography, Thin layer chromatography of amino acids
10. Spectrophotometric estimation of glucose
11. Collection and Preservation of representative animals of various phyla

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.

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 essential 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
8. Personality development: concept & theories; tips to improve personality
9. Health and stress and coping, stress, health, and coping in the workplace, effective measure to deal with stress and ways to cope.
10. Application of psychology in our social lives

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.

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.
3. Talbot, I. (1998). *Pakistan: A modern history*. London: Hurst and Company.

The course 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, scales of measurement, error of measurement and its sources
10. Data analysis: processing, statistics in research, hypothesis testing, t-tests and ANOVA
11. Scientific writing: difference between thesis/report/synopsis/research proposal, parts of synopsis/project proposal, parts of thesis/report.
12. 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.
4. Laurel, B. (2003). *Design research, methods and perspectives*. Cambridge: The MIT Press.

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 familiarize 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. Basic concepts in Economic Zoology.
2. Parasitic protozoans and human disease.
3. Economic importance of protozoa.
4. Vectors of human and domestic animals.
5. Ecto- and endo-parasites of fish, poultry, cattle and Man (Crustacea, Helminthes and Arachnida).
6. Pests of pulse crops. Pests of oil seed crops, stored grain pests, pests of cotton, vegetables, fruits and tea.
7. Apiculture, and sericulture, lac insect culture and pearl culture
8. Aquaculture and fisheries (edible fresh water, pond and marine fish, prawns, pearl oysters). economic importance of fishes
9. 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. Pests of important crops and stored grains in Pakistan.
4. To visit Honey Bee farm. Write 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. Report writing.
8. Identification of important species of Fish and their natural animal.
9. Visit to any bird farm and write a report on their observations.

Recommended Texts

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

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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.

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 help 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: Standard amino acids, their structure and classification; acid/base properties of amino acids and their titration curves; peptides, their ionic behavior and amino acid composition, Cytochrome C; Proteins: level of structural organization, example of structural and functional proteins.
2. Enzymes: Introduction; important characteristics of enzymes; immobilized enzymes; How enzymes work; example of enzymatic reaction; enzyme kinetics, enzyme rate of reaction and substrate concentration, how pH and temperature effect on enzyme activity.
3. Classification, types, important characteristics and structure of carbohydrates; cyclic structure of monosaccharides; cyanohydrin formation; disaccharides their types structure and function;
4. Polysaccharides, storage and structural types; structure and major functions of polysaccharides.
5. Lipids: Fatty acids, their types and major characteristics; storage lipids, acylglycerols; waxes;
6. Structural lipids in membranes; Major functions of lipids; lipoproteins, their types and major functions.
7. Vitamins and cofactors: Occurrence, structure and biochemical function of vitamins B complex group.
8. Metabolism: Detailed description of glycolysis and catabolism of other hexoses; regulation and bioenergetics of glycolysis. Anabolic role of glycolysis; fate of pyruvate under aerobic and anaerobic conditions, lactate, acetyl CoA and ethanol formation; alcoholic fermentation; gluconeogenesis, its regulation and significance in the tissues; feeder pathways in glycolysis; utilization of other carbohydrates in glycolysis phosphorolysis and starch; regulation of glycogen metabolism.
9. Citric acid (TCA) cycle: conversion of pyruvate to acetyl CoA, pyruvate dehydrogenase, a multi-enzyme complex; detailed description of citric acid cycle; bioenergetics and conservation of energy produced in the cycle. Anabolic or biosynthetic role of citric acid cycle intermediates; replenishing or anaplerotic reactions and their role; regulation of citric acid cycle; Electron transport and its components, oxidative phosphorylation, chemiosmotic theory, ATP synthesis, uncouple electron transport and heat generation.
10. Lipid metabolism: oxidation of fatty acids; digestion, mobilization and transport of fats: biosynthesis of triacylglycerol; utilization of triacylglycerol; activation of fatty acids and their transportation to mitochondria; beta-oxidation; bioenergetics of beta-oxidation; oxidation of unsaturated and odd chain fatty acids; omega oxidation pathway; biosynthesis of saturated fatty

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- acid, supply of raw material for palmitic acid synthesis; fatty acid synthetase (FAS) multienzyme complex
11. Ketone bodies their biosynthesis, utilization and role in the tissues;
 12. Cholesterol metabolism: steroid hormones.
 13. Nitrogen metabolism: metabolic fate of amino acids; catabolism of amino acids; deamination and transamination; nitrogen excretion and urea cycle; regulation of urea cycle.

Practical

1. Preparation of standard curve for glucose by *ortho*-Toluidine method.
2. Tests for detection of carbohydrates in alkaline and acidic medium.
3. Tests for detection of Disaccharides.
4. Detection of Non-Reducing sugars in the presence of reducing sugars.
5. Demonstration of Acid Hydrolysis of Polysaccharide.
6. Separation and identification of various types of sugars, fatty acid and amino acid Thin Layer Chromatography (TLC).
7. Determination of pKa values of an amino acid by preparation of titration curves.
8. Biochemical tests for detection of different amino acids.
9. Separation of various protein fractions by precipitation method.
10. Demonstration of differential solubility of lipids in various solvents.
11. Quantitative analysis of phospholipids by estimation of inorganic phosphorous.
12. Quantitative analysis of Amylase activity from blood serum or liver.
13. Study on the effect of temperature on the enzymatic rate of reaction

Recommended Texts

1. Nelson, D. L., & Cox, M. M. (2012). *Lehninge 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.

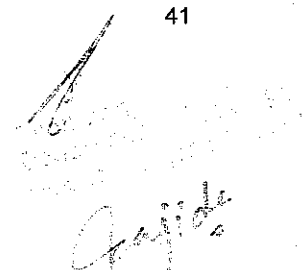
The course aims to impart knowledge about the animal cell and its complex organization and architecture. It enables students to understand various ultra-structural, molecular and functional aspects of the cells. Students will be able to describe and discuss the properties and biological significance 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 become 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, its chemical composition structure and functions of plasma membranes, cell permeability, active transport, endocytosis, phagocytosis.
2. Cytoskeleton: microfilaments, microtubules, intermediate filaments.
3. Cytoplasmic Organelles: Membrane system, structural and functional commonalities.
4. Ultrastructure, chemical composition and functions of endoplasmic reticulum and their role in protein synthesis and drug metabolism, Golgi apparatus its role in synthesis of glycoprotein,
5. Mitochondrial respiration and its significance as semi- autonomous organelle;
6. Lysosome, its diverse roles due to hydrolytic activity of enzymes, Peroxisome, its role in metabolism of hydrogen peroxide, glyoxysome with reference to glyoxylic acid cycle.
7. Nucleus: chromatin, heterochromatin, euchromatin, chromosome structure, coiling and nucleosome during different phases of cell cycle.
8. Replication: mechanism, DNA replication in prokaryotes specially with reference to variety of DNA polymerases and other proteins involved, DNA replication in eukaryotes with emphasis on DNA polymerases, concept of replicons etc.,
9. Transcription: variety of RNA and their characteristics, synthesis of mRNA, rRNA and tRNA with special reference to enzymes involved, RNA splicing, split genes, concept of ribozymes and Post transcriptional processing, RNA transduction, Genetic code, point mutations.
10. Translation: specific role of ribosomes, various factors, and posttranslational processing, control of gene expression in Prokaryotes.

Practical

1. Identification of cell organelles
2. Preparation of temporary whole mount.
3. Preparation of permanent whole mount (demonstration)
4. Preparation of human blood smear and identification of Leucocytes.
5. Tissues (permanent slides of epithelial tissues, striated muscle, smooth muscle, cartilage, bone).
6. Squash preparation of onion root tip for mitotic stages.
7. Mounting of polytene chromosome (*Drosophila/Chironomous*.) Demonstration.
8. Detection and quantitative determination of chromosomal DNA and RNA.

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9. Cultural and staining of bacteria and yeast.
10. Separation of different sized DNA fragments on agarose gel.
11. Isolation and characterization of proteins on polyacrylamide gel electrophoresis (native and sub-unit molecular weights).

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.

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

Evolution:

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) by changing gene frequencies, mutation pressure, selection pressure, immigration and crossbreeding, genetic drift.
4. Role of isolation in evolution: Factors of large evolutionary changes (macro/mega evolution) - allometry, orthogenesis, adaptive radiation.
5. Modern concept of Natural Selection: Levels of selection, selection patterns, laboratory and field example regarding action of Natural Selection. Action of Natural Selection leading to convergence, radiation, regression and extinction,
6. Batesian mimicry, Mullerian mimicry, Sexual selection: Darwin's concept, Fisher's view, Zahavi's handicap theory, Recapitulation theory, trend and rates in evolution.

Systematics:

7. Importance and applications of systematics: Systematics as a profession and its future perspectives. Taxonomy in Animal science,
8. History of taxonomy: systematics, basic terminology of systematics. Theories of biological classifications.
9. Taxonomic characters: Kinds and weightage, microtaxonomy, taxonomic categories: Specific category, infraspecific category, higher categories; Species concept.
10. Typological species concept: nominalistic species concept, biological species concept, Evolutionary species concept. Kinds of different species, Speciation, Taxonomic procedures, taxonomic collection; their preservation and duration, Taxonomic keys, different kinds of keys and their merits and demerits.
11. Systematics publications: International code of zoological nomenclature; its objective, principles, interpretation, application of important rules, with reference to: Zoological nomenclature, law of priority and validity of names.

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Practical

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

Recommended Texts

Evolution:

1. Strickberger, M. W. (2012). *Evolution*. Burlington: Jones & Bartlett Publisher.
2. Ridley, M. (1993). *Evolution*. New Jersey: Blackwell Scientific Publications.

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.

Systematics:

Recommended Texts

1. Wiley, E. O., & Lieberman, B. S. (2011). *Phylogenetics: Theory and practice of phylogenetic systematic*. New Jersey: Wiley-Blackwell.
2. Mayer, E. (1994). *Principles of systematic zoology*. New York: McGraw-Hill.

Suggested Readings

1. Heywood, V. H. (1975). *Taxonomy and ecology*. London: Academic Press.
2. Whili, M. J. D. (1978). *Modes of speciation*. San Francisco: W.H. Freeman and Co.

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, and collecting, analyzing, interpreting, and reporting experimental data.

Content

1. Concept of Physiology: Principles of homeostasis and conformity, principles of regulation and adaptation
2. Membrane Physiology: Ionic distribution across membrane, resting membrane potentials: electrogenic ion pump, Donnan equilibrium, Ion channels
3. Muscle Physiology: Action potentials in neurons, electrical and chemical synaptic transmission , Neurotransmitters in communications, receptors of neurotransmitters in diverse physiological responses, excitatory and inhibitory postsynaptic potentials, neuronal networks and their role in nervous integration,
4. Muscles: Structure, types, components, muscle proteins, molecular basis of muscle contraction, Sarcoplasmic reticulum and role of calcium, neuromuscular interaction at cell and molecular level muscle, types of muscle contractions and muscle fatigue.
5. Endocrine Physiology: Hormones of invertebrates and specifically of arthropods for the functions in their modes of life, hormones of various vertebrates' endocrine organs and comparison of their roles in adaptability of mode of life, mechanisms of hormone actions, hormone receptors, signal transduction and hormonal coordination.
6. Cardiovascular Physiology: Electrical activity of heart; self-excitability and auto-rhythmicity of myogenic heart, neurogenic heart and their expression, electrocardiography and Kymograph, hemodynamics, relationship between blood flow, pressure and resistance. Their role in performance of the function in variety of vertebrates, control of cardiac activity, cardiac output and peripheral circulation
7. Respiratory Physiology: mechanism of respiratory gases exchange in aquatic and terrestrial respiratory structures, Control of respiration and stimulus factors in various animals, respiration adaptations in hypoxia and percapniaetc, air breathing and respiratory adaptations diver animals.
8. Excretory Physiology: Strategy of mammalian large glomerular filtration and reabsorption in nitrogenous excretion, patterns of nitrogenous excretion in various animals and their phylogenetic significance.
9. Physiology of Nutrition: Adaptation of nutritive canal for digestion and absorption of nutrients in different animals specifically the vertebrates, regulation of digestive secretions, mechanisms of

water, ions and nutrients absorptions and their significances in diverse groups, potential and movements in gastrointestinal tract and control of motility.

Practical

1. Respiration and Circulation: Study of respiratory pigments in various animals and hemoglobin in various vertebrates, normal cardiac activity in amphibian model, effect of temperature, effect of drug, heart block, tantalization of heart, measurement and effects of various factors on blood pressure.
2. Blood pressure alteration in exercise, oxygen consumption in fish and effect of temperature (by dissolved oxygen meter) and terrestrial animal (mouse). Oxygen consumption (by respirometer),
3. Nerve and Muscle: Study of salient features of electromyography, study of excitable and contractile properties of a nerve-muscle preparation.
4. Nervous System: Study of brains in different animals in relation to complexity of functions, Study of human brain model and different areas eliciting behaviors, videos study on 1 and 2 studies.
5. Hormones System: Video studies on the effects of hormones in breeding season behaviors of various behaviors, Study through clinics data on the insulin and glycaemia in type1 and type 2 diabetic subjects.

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: 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.
2. Hill, R. W., Wyse, G. A., & Anderson, M. (2016). *Animal physiology* (4th ed.). Massachusetts: Sinauer Associates.

This course will enable students to understand about habitat, ecology, ecosystems and environmental threats. Students will learn about the 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 of and types of ecology, laws of thermodynamics, primary and secondary productions , trophic levels and energy variation with increasing trophic levels, 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, an overview of ecosystem with special reference to ecological niche, basic concepts and types, major ecosystem of world, forest, grassland, desert, tundra and agricultural ecosystems. marine, estuarine, freshwater and wetlands
5. Population ecology: basic population characters, growth and growth curves, population dynamics and regulations.
6. Community ecology: basic concepts, community analysis, ecotones, inter-population interactions
7. Applied Ecology: Resources and their ecological management; mineral, agricultural desalination, weather modification, forest and range management, landscape and land use
8. Pollution: definition, types, water, air, land and noise, sources and management.
9. Radiation ecology: global environmental changes (ozone depletion, acid rain, greenhouse effect and global warming, koyota protocol, radioactivity leakage, environmental laws).
10. Exotic and Invasive Species: desertification, deforestation, exotic and invasive species

Practical

1. Population Sampling Techniques (quadrante, line transact, point count, focal scan and capture and recapture method).
2. Study of different Ecosystems (fresh water, terrestrial, marine/mountain/ desert).
3. Ecological notes.
4. Measurements of physical factors of different ecosystems.
5. Adaptive features of animals in relation to food and environment.
6. Food chain studies through analysis of gut contents.
7. Analysis of polluted and fresh water for biotic and abiotic variations.
8. Field visits for study of selected terrestrial habitat and writing notes.
9. Experimental design and approaches in ecological research; writing a research project

10. Development of an ecological management plan of some selected area

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 Univ. 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.

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 is having a 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 understand and 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 and Basic Concepts of developmental biology, Principal features of developmental biology and embryology with special emphasis on vertebrate models, origin of sexual reproduction, developmental patterns
2. Spermatogenesis: Mammalian spermatogenesis as model for all vertebrates, Spermiogenesis or (spermateliosis), The role of Sertoli and Leydig cells in spermatogenesis, Hormonal control of spermatogenesis
3. Primates menstrual cycle
4. Oogenesis: mechanism of oogenesis among various classes of vertebrates, vitellogenesis hormonal control of vitellogenesis and oogenesis
5. Fertilization: external & internal fertilization, species-specific recognition of sperm and egg, fusion of male and female gametes
6. Polyspermy: slow and fast blocks to polyspermy, activation of egg metabolism
7. *IN VITRO* Fertilization (IVF): history, steps and advantages of IVF, disadvantages and risk factors
8. Cleavage & blastulation, patterns of embryonic cleavage and blastulation among different vertebrate classes, mechanism of cleavage
9. Gastrulation: fate maps, gastrulation in amphibians, birds and mammals
10. Early vertebrate development
11. Neurulation, ectoderm, mesoderm and endoderm formation
12. Placenta and extraembryonic membranes
13. Cellular basis of morphogenesis: differential cell affinity, cell adhesion molecules,
14. Organogenesis, Mechanism of teratogenesis
15. Aging and regeneration in vertebrates

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. Microscopic analysis of hen's egg yolk, albumin and shell membranes.

4. Study of cleavage and subsequent development from prepared slides and/or models in various animals i.e., frog, mammals and chick etc.
5. Study of fertilization, early development of frog/fish through induced spawning under laboratory conditions.
6. Study of developmental stages of nematodes through microscopic analysis of animal dung.
7. Semen analysis.
8. Dactylography and its uses in developmental biology.

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*. 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. Davies, J. A. (2014). *Life unfolding: How the human body creates itself*. Oxford: Oxford University Press.
4. Balinsky, B. I. (2012). *An introduction to embryology* (5th ed.). Dehli: Cengage.

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 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. Introduction: Forward and reverse genetics. The basic principles of inheritance (Mendelism): monohybrid and dihybrid crosses (definition - characteristics criss-cross inheritance),
2. Multiple alleles: blood groups and coat color in rabbits, genetics of Rh factor and erythroblastosis foetalis.
3. Chromosomal basis of inheritance: chromosomal theory of inheritance, interaction of genes, epistasis, lethality and pleiotropism.
4. Chromosomal aberrations: changes in chromosomal number, euploidy, aneuploidy (Klinefelters syndrome, and turners syndrome, down syndrome and Edwards syndrome), structural changes, insertion, deletion (Cri du chat syndrome), duplication, inversion and translocation
5. Pedigree Analysis: Normal human chromosome complement; karyotyping, sex-determination and sex-linkage, sex determination in animals and humans, sex linked (hemophilia, muscular dystrophy, color blindness), sex influenced and sex limited traits,
6. Prenatal diagnosis: amniocentesis and choriovillus sampling - ultrasound scanning and fetoscopy. genetic counselling, Eugenics and Euthenics
7. Chromosome mapping: linkage, recombination (crossing over), chromosome mapping in eukaryotes.
8. Molecular genetics: gene concept (classical and modern), genetics of viruses and bacteria, transposons, mutation and DNA repair molecular genetic analysis,
9. Regulation of gene expression in prokaryotes: gene regulation in eukaryotes, genetic basis of diseases, like cancer,
10. Genetic control of animal development, the genetic control of the vertebrate immune system
11. Recombinant technology: the techniques of molecular genetics (elements of genetic engineering), PCR
12. Human genetics: single and multifactorial disorders, autosomal anomalies, pseudoautosomal genes, single gene disorders: gene mutation and disorders;
13. Autosomal single gene disorders (sickle cell anemia, brachydactyly; inborn errors of metabolism such as phenylketonuria, alkaptonuria), complex inheritance patterns, polygenic traits- cleft lip and cleft palate, population genetics,
14. Hardy-Wienberg equilibrium, systematic and dispersive pressures, inbreeding and heterosis



Practical

1. Drosophila culture techniques: preparation and maintenance of culture
2. Identification of male and female fruit fly and isolation of virgin females
3. Study of polytene chromosomes from the salivary glands of *Drosophila melanogaster*
4. Mutation induction in *Drosophila*
5. Human karyotyping from photographs prepared slides: paper cut out method
6. Preparation of human metaphase chromosomes from blood lymphocytes
7. Study of mitosis in plants by using onion root tip cells
8. Study of meiosis in the testes of male grasshopper
9. Extraction of genomic DNA from whole blood (lymphocytes)
10. Separation of heterogeneous population of bio-molecules through electrophoresis
11. Study of blood group polymorphisms in local population
12. Study of qualitative traits in humans: a survey of common physical heritable (monogenic) polymorphisms
13. Human Pedigree analysis problems (Determination of inheritance pattern of different human characters (Widows Peak, ear loop, etc), risk estimation and genetic counseling
14. Study of quantitative traits in humans: finger prints as model of polygenic traits
15. Study of Barr bodies in human cell nucleus
16. Dermatoglyphics in normal and mentally retarded subjects
17. Probability problems. Tossing of coins. X^2 test
18. Study of transformed bacteria on the basis of antibiotic resistance
19. PCR

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 and Sons Ltd.
2. Tamarin, R. H. (2001). *Principles of genetics* (7th ed.). New York: McGraw-Hill.

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 be 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.). Dehli: 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.

SEMESTER VII

ZOOL-6XXX

Special Paper A1 (University Option/Thesis)

3(2+1)/ (0+3)

Note: University Option: To be selected from the list provided (Annexure-I) as special paper.

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 scope of 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, effectively, and in context. 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: Definition, branches of statistics, scope and importance of statistics
2. Data: Population and sample, variable, categorical and non-categorical data, Scales of measurements, Errors of measurements
3. Presentation of data: descriptive statistics, tabulation of data, parts of table and construction of table, diagrams and graphs, pictogram, histogram, line chart, histogram, applications and uses of histogram, construction of histogram, comparison of data using histogram, bar chart, multiple bar chart, pie chart, gantt chart, timeline, infogram, pedigree chart
4. Frequency distribution: empirical FD, relative FD, cumulative FD, class frequency, class limits, class boundaries, class mark, class interval, midpoints
5. Measures of central tendency : types of averages, arithmetic mean for grouped and ungrouped data, harmonic mean for grouped and ungrouped data, geometric mean for grouped and ungrouped data, median, quartiles, deciles, percentiles and mode, advantages and disadvantages of arithmetic mean, harmonic mean, geometric mean, median and mode.
6. Measures of dispersion: range, grouped and ungrouped data, coefficient of range, mean deviation of grouped and ungrouped data, coefficient of mean deviation, standard deviation and variance of grouped and ungrouped data, variance and standard deviation of population and sample data
7. Probability: definition and properties, experiment and random experiment, event, outcome, trial and multiplication rule, sample space and sample point, mutually exclusive event, combinations and permutations, probability distribution, binomial experiment
8. Tests of significance: hypothesis testing, steps of hypothesis testing, Z-test, t-test; its types, Chi-square, ANOVA, its uses and LSD, Correlation, Regression

Practical

1. Data collection, arrangement and frequency table
2. Data presentation in table, graphs (simple bar chart, multiple bar chart, component bar chart)
3. Construction of timeline, pedigree chart, organogram, Gantt chart, infogram
4. Calculating arithmetic mean, harmonic mean and geometric mean, median and mode from ungrouped and grouped data
5. Calculating mean deviation, standard deviation and variance from ungrouped and grouped data
6. Probability distribution
7. Z-test



8. T-test
9. ANOVA
10. Correlation
11. Regression

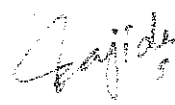
Recommended Texts

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.

Note: University Option: To be selected from the list provided (Annexure-I) as special paper.



Note: University Option: To be selected from the list provided (Annexure-I).

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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 three 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, including the ability to develop new algorithms and analysis methods.

Contents

1. Introduction: Introduction to computers, software, hardware, operating systems
2. Bioinformatics: scope of bioinformatics, useful websites, aims of bioinformatics, disciplines related to bioinformatics, major tasks involved in bioinformatics analysis, bioinformatics tools
3. Biological databases: data and information, databases, data acquisition, NCBI, major DNA databases around the world, major protein databases in the world, primary protein sequence databases, secondary protein databases, tertiary protein databases, protein structure databases, specialized databases, genome and organism databases, miscellaneous databases
4. Genome mapping: genetic and linkage mapping, physical mapping
5. Gene family: introduction and types, protein family, globin family as an example, globin genes and chains, evolution of globin proteins in human, combination and types of globin proteins in human
6. Data retrieval: Searching sequence databases, FASTA format, retrieval of nucleotide sequence data, retrieval of protein sequence and structure data, retrieval of literature and map data
7. Primer designing: primer and probe, qualities of primer, general rules for primer designing
8. Websites used for primer designing
9. Sequence alignment: importance and significance of alignment, methods for sequence alignment, Local and global alignment, pair-wise local alignment, uses of local alignment
10. BLAST: introduction and types, uses, algorithm , BLAST Score
11. Amino acid matrices: amino acids and their symbols, amino acid scoring matrices, PAM and BLOSUM, comparison of PAM and BLOSUM
12. Multiple sequence alignment: introduction, tools for MSA, uses and importance
13. Phylogenetic analysis: Introduction, interpretation, rooted and unrooted tree, phylogenetic methods, tree terminology, comparison of methods, software
14. Protein structure prediction: homology modelling, threading, *ab initio* modelling, motivation to acquire structure, protein 3D structure, software/databases
15. Molecular docking: introduction, steps, importance and uses
16. Microarrays: Gene expression, differential expression, DNA chips, principle of microarray, types, steps of a microarray experiment, qualitative interpretation of results, applications of microarray, advantages and disadvantages of microarray.

Practical

1. Introduction to NCBI
2. Retrieving Literature from NCBI
3. Classification of an organism using NCBI
4. Retrieving FASTA sequence for nucleotide and protein
5. Retrieving disease gene information
6. Searching gene families
7. Primer Designing
8. BLASTing a nucleotide / amino acid sequence
9. Multiple sequence alignment using different amino acids / nucleotide sequences
10. Phylogenetic analysis of different nucleotide / amino acid sequences
11. Microarrays data retrieval from the web

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.
2. Primrose, S. B., & Twyman, R. M. (2004). *Genomics: applications in human biology*. New York: Willey-Blackwell.
3. Krane, D. E., & Raymer, M. L. (2002). *Fundamental concepts of bioinformatics*. New Jersey: Benjamin Cummings.

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. Innate behavior of three spines stickle back fish. Learned behavior and its mechanisms: quick learners' vs. slow learners.
4. Concept of animal cognition: key to understand and develop multiple behavioral choices, Ecological and genetics to maintain animal behavior, concept of territoriality and defense in animals.
5. Circadian rhythms and concept of bio-rhythmicity in animals.
6. Maintenance of internal biological clock to perform various diurnal and nocturnal periodicities.
7. Costs and benefit ratios in behavior; successful foragers and winners of predator-prey relationships. Altruism and parental sacrifice to nurture the young.
8. Competition for resources; survival of the most suitable individuals; evolutionary arms races in behavior.
9. Social organization in animals and concept of group living; benefits and losses, Aggression, appeasement and selfish individuals. Social organization in insects and mammals.
10. Communication in animals: visual, bio acoustic, electrical, chemical and tactile.
11. Various types of chemical signals in animal's behavior and their importance in ecosystems.

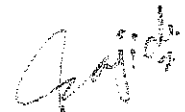
Recommended Texts

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., & Wallace, R. A. (2009). *Perspective on animal behavior*. New York: John Wiley & Sons.

Note: University Option: To be selected from the list provided (Annexure-I) as special paper.

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Note: University Option: To be selected from the list provided (Annexure-I)

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Note: University Option: To be selected from the list provided (Annexure-I).

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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 Palaeartic, 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: cosmopolitan distribution, discontinuous distribution, isolation distribution, bipolar distribution, endemic distribution, barriers and dispersal
3. Zoogeographical regions: zoogeographic division and boundaries, geographic ranges, physical features, climates, faunas and affinities of Palaeartic, Nearctic, Oriental, Ethiopian, Australian, and Neotropical regions,
4. Zoogeography of Pakistan: The planet earth, history, age, shells of earth, atmosphere, hydrosphere, biosphere and lithosphere.
5. Rocks: igneous rocks, sedimentary rocks, metamorphic rocks.
6. Fossil and fossilization: fossil types and uses of fossils, nature of fossils, fossilization, invertebrates and vertebrates fossil, biostratigraphy, fossils of Pakistan, Paleontological important areas of Pakistan.
7. Fossilization: geological time scale, Pre-Cambrian life, Post Cambrian life, Paleozoic life, Mesozoic life, Cenozoic life.
8. Paleontological techniques: excavation techniques, excavation tools and techniques, transportation and processing of fossils, presentation of fossils, pre requisites for paleontological excavation.
9. Geochronometry: Uranium/Lead dating, radiocarbon dating, methods, index fossils, evolutionary history of man, elephant, horse and camel, Paleoecology, Paleomagnetism.

Practical

1. Study of fauna of various zoogeographical regions.
2. Study of mould, cast, pseudomorph, coprolite, petrified fossils of plants and animals.
3. Study of invertebrate 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.

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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.

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As there is an increased demand of natural and organic food globally, there are various scientific strategies being adapted at commercial level to fulfill 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.
8. Culture of freshwater prawns and shrimps:
9. Artificial feeds for aquaculture: Feed constituents, Diet formulation and Processing.
10. 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.). New Dehli: Campus Books International.
2. Sharma, O. P. (2009). *Handbook of fisheries and aquaculture*. New 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*. New Dehli: APH Publishing Corporation.
3. Parker, R. O. (2004). *Aquaculture science* (4th ed.). London: Delmar Learning.

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.
8. Wildlife census techniques
9. Modern census techniques for mammals and birds, diversity indices.

Practical

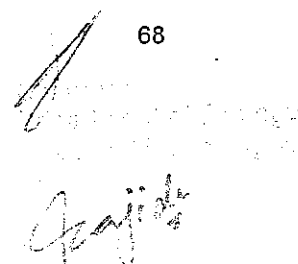
1. Procedures for studying species richness, Simpson Index, Shannon and Weiner Function.
2. Population of some local subterranean animals.
3. Bird's population census techniques.
4. Mammal's population census techniques.
5. Study of wildlife habitats.

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.). India: 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.



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, classes, types of modern biotechnology and historical perspective,
2. Genetics and biotechnology: genome, human genome, diversity of human genome, short tandem repeats, nomenclature,
3. Polymerase Chain Reaction, principle, requirements, procedures and applications, gel electrophoresis, definition, principle, steps/methods involved, DNA ladder, allelic ladder
4. Genetic engineering introduction, steps, vectors and its types, characteristics of vectors, plasmids and restriction enzymes, screening, blue white screen, negative and positive control, competent cells, insulin as an example, genetically modified organisms,
5. Cloning, its types of cloning, cell cloning, molecular cloning, organism cloning, applications and uses
6. Animal and insect biotechnology: introduction, reasons for producing GM animals.
7. Bioprocess technology: introduction, requirements of bioreactors, types of bioreactors, bacterial and mammalian cell culturing, production of industrially important chemicals
8. Biotechnology and medicine: applications, monoclonal antibodies, importance, steps for production of monoclonal antibodies
9. Public perception of biotechnology: current issues in bioethics (autopsy, GMOs, stem cells, euthanasia, organ transplant, human cloning, IVF, surrogacy and sperm donor)
10. Bioethics and Islam: introduction and principles of bioethics, concept of bioethics in different religions, principles of Islamic bioethics.

Practical

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

Recommended Texts

1. Clark, D. B., & Pazdernik, N. J. (2015). *Biotechnology* (2nd ed.). Amsterdam: Academic Cell.

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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. Butler, J. M. (2009). *Fundamentals of forensic DNA typing*. Amsterdam, Boston: Academic Press.
3. Furr, A. K. (2008). *CRC handbook of laboratory safety* (5th ed.). Florida: CRC Press.
4. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge: Cambridge University Press.

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,
7. Morphogenetic movements and gastrulation in mammals and frog.
8. Stem cells technology and its uses in developmental biology.
9. Embryonic adaptations and placentation, umbilical cord and parturition.
10. Aging

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/ *Neosascaris vitularum* eggs from cattle dung (kept for 3 weeks at 24°C in desiccator) by using Telman's centrifugation technique.
4. Study of prepared slides for the development of Amphioxus, mammals, frog and chick.
5. Semen analysis by using improved Neubauer Hemocytometer, Use of dactylography in developmental biology,
6. Peripheral blood smear (abnormal erythrocyte morphology e.g., target cells, microcyte, macrocytes, slit cell, acanthocytes & tear drop cells as screening procedures for thalassemia diagnosis.

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. Oppenheimer, S. (2004). *Introduction to embryonic development* (4th ed.). New Jersey: Pearson Education.
2. Sandler, T. W. (2011). *Langmans medical embryology* (Revised ed.). New York: Wolters Kluwer Health.

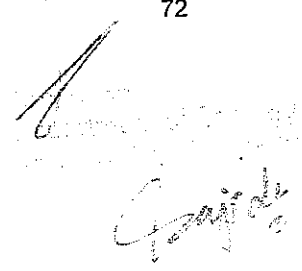
The course is aimed to impart knowledge about endocrine glands, their anatomy, the hormones released from them and the physiological role of these hormones in body. Endocrinology involves the evaluation and management of disorders of the body's glands, hormonal secretions, and resultant changes in body 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 to examine and describe glands and can 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 hormone family, corticotrophins and other pro-opiomelanocortin peptides; posterior pituitary: release, regulation and actions of vasopressin and oxytocin.
3. Thyroid gland: anatomy and histology of gland; formation and secretion of thyroid hormones; factors affecting thyroid function.
4. Calcitropic and mineral metabolism hormones: chemistry, physiological actions and metabolism of parathyroid hormone, calcitonin and calciferols.
5. Pancreatic hormones and regulatory peptides of the gut: anatomy and histology for sources of the hormones; chemistry, physiological roles and mechanism of action of insulin and glucagon
6. Adrenal medulla and catecholamines: chromaffin cell and organization; structure of adrenal medulla; biosynthesis, storage, release and metabolism; adrenergic receptors.
7. Adrenal cortex: steroid biochemistry; physiological actions of corticoid hormones; regulation and metabolism of glucocorticoids, mineralocorticoids and adrenal sex steroids.
8. Testes: androgenic tissue: structure and chemistry; transport, metabolism and mechanism of action.
9. Ovaries: ovarian hormones: steroid biochemistry and biosynthesis; transport, metabolism and mechanism of action.
10. Overview of endocrine mechanisms in invertebrates.

Practical

1. Demonstration of endocrine glands and associated structures in dissections, transparencies, computer projections etc.
2. Histological and ultra-structure features of endocrine glands;
3. Experiments to demonstrate physiological roles of hormones of different endocrine glands;
4. Experiments to demonstrate regulation of hormones releases.
5. Experiments to demonstrate functional diversity of hormones in different vertebrates.



6. Experiments on endocrine mechanism 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.

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 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.
7. Wings: origin; development and basal attachments, main veins and their branches
8. Abdomen: secondary appendages and external genitalia,
9. Flight; types of flight.
10. Soft parts: muscular system; basic structure, types of muscles
11. Sense organs: sound and light producing organs.
12. Nutritive requirements: fat body, exocrine and endocrine glands
13. Reproduction: reproductive organs and different types of reproduction in insects,
14. Development: embryology up to dorsal closure, different types of metamorphosis, apolysis and ecdysis and the role of endocrine secretions.
15. Ecology: insect population and community studies, insect communication.

Practical

1. Preparation of permanent slides.
2. All the hard parts (antennae, mouth parts, wings, legs, terminal segments and genitalia).
3. Different systems, especially digestive, reproductive of the following insects.
4. American cockroach, gryllus, grasshopper, housefly, butterfly, mosquito, any common beetle.
5. Red cotton bug.
6. Wasp and honey bee.
7. Sympathetic nervous system of cockroach and gryllus.
8. Salivary glands of cockroach, red cotton bug and honey bee.

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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*. London: Springer Science & Business Media.
2. Tembhare, D. B. (2002). *Modern entomology*. Dehli: Himalaya Publishing House.
3. Henderson, P. A., & Southood, T. R. E. (2016). *Ecological methods*. London: Wiley Blackwell.
4. Peterson, P. G. (2018). *Elements of insect ecology*. London: Ed- Tech Press.

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, Dictyoptera, 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*. New Dehli: Agri Horti Press.

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. Environmental and social impacts of growing
2. Food production and its distribution
3. Pest and pest control: need and approach to pest control.
4. Water pollution: human impact on water resources,
5. Sewage pollution: sewage hazards and sewage managements.
6. Hazardous chemical pollution: nature of chemical risks, pollution sources and control.
7. Major atmospheric changes: acid deposition, global warming / cooling, greenhouse effect, ozone depletion.
8. Solid waste: landfills, incineration, management and solutions.
9. Energy resources: energy sources and uses; issues related to fossil fuel and nuclear power, alternate energy resources.
10. Environmental issues in Pakistan
11. Issues related to conservation of habitat and biodiversity:
12. Conservation strategies. Industrial pollution: sources and remediation.

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.).
2. Study of the types of the pesticides and their characteristics.
3. Study of the relationship between relative humidity and temperature of Lahore for a particular time period.
4. Estimation of total particulate matter in air by using air sampler.
5. Determination of Sodium and Potassium in various water samples using flame photometer.
6. Determination of Chromium, Lead and Copper in industrial effluent.
7. To study the urban environment and urban environmental issues.
8. To study the eutrophic conditions in various ponds.
9. To study noise level at different places in city (main road crossings, railway station, hospital) using noise level meter.

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10. To study the level of occurrence of various diseases among families of (i) Class students (ii) Low income groups, high income groups.

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.). London: Pearson Prentice Hall

Suggested Readings

1. Bradbury, I. K. (1999). *The biosphere* (2nd ed.). New Jersey: Wiley.
2. Ahmad, R. Z. (2000). *Pakistan- a descriptive atlas: a comprehensive geo-politics course* (1st ed.). Lahore: Feroze sons Pvt. Ltd.
3. Khan, F. K. (1993). *A geography of Pakistan environment (environment, people and economy)* (1st ed.). New York: Oxford University Press.

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

Practical

1. Study of gut contents.
2. Study of feeding modification and adaptation in fish.
3. Study of respiratory adaptation in fish.
4. Study of blood cells and their counts in normal and diseased fish.
5. Study of water quality parameters (DO, NH₃, hardness, alkalinity, turbidity, transparency, temperature, salinity).
6. Study of various forms of swim bladder as hydrostatic organ.
7. Study fecundity of various fish species.
8. Study the effects of reproductive hormone (GnRH) on fish maturation.
9. Diagnosis of bacterial infection in infected fish.
10. Study of fish parasites.
11. 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, Oxford.
3. Huet, M. (1973). *Textbook of fish culture: breeding and cultivation*. London: Blackwell Publishing Company.
4. Gorbman, A. (1983). *Comparative endocrinology* (1st ed.). New York: John Wiley & Sons.

Qajida

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 megaloblastic anemia.
4. Blood collection techniques.
5. Anticoagulants. Hemolytic anemia.
6. Structure, types and genetic disorders of hemoglobin.
7. Leukopoiesis. Lymphocytes, monocytes, granulocytes and their disorders.
8. Platelets and thrombopoiesis.
9. Blood coagulation. Bleeding disorders.

Practical

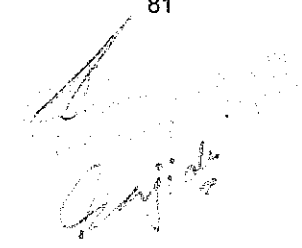
1. Blood smear of different vertebrates to compare the RBCs morphology.
2. Total erythrocyte and leucocyte counts. Study of granulocytes and agranulocytes.
3. Differential leukocytes. Estimation of Hemoglobin. Study of erythrocytes sedimentation.
4. Comparison of blood counts of diseased (Anemia) and healthy individuals.
5. Morphological alterations in erythrocytes in various disease conditions like sickle cell anemia.

Recommended Texts

1. Hoffbrand, A. V., & Moss, P.A.H. (2002). *Essential hematology*. New York: Blackwell Publishing.
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.

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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. Morphological features of fish,
2. Fish muscular system and locomotion.
3. Physiology of respiration and air breathing among fishes.
4. Cardiovascular system, blood and its circulation
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.
8. Process of aestivation in fish. Sensory system and communication in fish: Sound reception

Practical

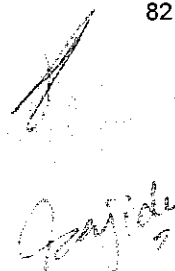
1. Study of classification of fishes and some selected fish species
2. Study of Fish anatomy, physiology and adaptations, fish dissections
3. Study of fish habitats, fish fauna of Pakistan
4. Study of fish reproduction, oocytes and aquaculture and food requirements
5. Study of environmental, ecological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

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 DC: Argent Labs.



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 and how it is triggered and regulated and they acquire for problem solving capacity about immune responsiveness.

Contents

1. Immunology: introduction.
2. Immunity: types: natural and acquired immunity.
3. Antigens and their types, antigenicity, factors important for immunogenicity of an antigen, cell mediated and humoral: nature of antigens
4. Immunoglobulins: synthesis of antibodies, types of antibodies
5. Detection and application of antigen-antibody reactions
6. Antigen antibody interactions
7. Monoclonal antibodies: importance, synthesis. Major histocompatibility complex: types and importance.
8. Cellular basis of immune response: origin of lymphocytes, primary and secondary lymphoid organs, specific response of individual lymphocytes to antigenic stimulation,
9. Hypersensitivity: Immediate hypersensitivity, delayed type or cell mediated hypersensitivity.
10. Immunological tolerance and autoimmunity: autoimmune diseases and types, factors responsible for autoimmunity. Transplantation immunology, immunity against infectious diseases, immunodeficiency diseases.
11. Immunization; immunization procedures, vaccines and their types.

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.
6. Antigen-antibody reaction by agglutination and precipitation reaction.
7. Antigen antibody reaction by using adjuvant.
8. Diagnosis of typhoid fever by Widal test.
9. Visit to pathological laboratory and report writing.



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.). Amsterdam: Elsevier.
2. Abbas, A. K., Lichtman, A. H., & Pillai, S. (1994). *Cellular and molecular immunology*. London: Elsevier Health Sciences

Arifade

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 learning's. 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.). London: CABI.
2. Pedigo, L. P., & Rice, M. E. (2015). *Entomology and pest management* (6th ed.). Amsterdam: Waveland Press.
3. Van Driesche, R. G., & Bellows, T. S. Jr. (2012). *Biological control*. London: Springer Science & Business Media.

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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

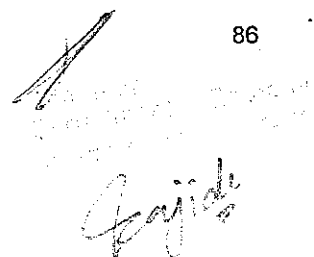
1. Study of bacteria, fungi and protozoa.
2. Staining of microorganisms: simple staining, negative staining.
3. Demonstration of special structures by stains; capsular stain, spore stain, metachromatic granule stain, acid fast stain, flagella stain.

Recommended Texts

1. Benson, H. J. (2002). *Microbial applications: laboratory manual in general microbiology* (8th ed.). London: 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.). London: Pearson/Benjamin Cummings.
2. Stainier, R. Y., Ingraham, J. L., Wheelis, M. L., & Painter, R. R. (1986). *The microbial world*. London: Prentice Hall.



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 chemo organotrophic 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 and proteobacteria,
3. Aerobic and facultative aerobic proteobacteria,
4. Bacterial physiology
5. Delta and epsilon proteobacteria,
6. Firmicutes, mollicutes and actinobacteria,
7. Cyanobacteria and prochlorophytes,
8. Chlamydia, the planctomycetes,
9. Verrucomicrobia, Flavobacteria and Acidobacteria,
10. Cytophaga group, Green Sulfur bacteria, Spirochetes, Dienococci, the green non sulfur bacteria.

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. The turbidimetric estimation of microbial growth.
4. Study of bacterial viruses. Biochemical characterization of bacteria.

Recommended Texts

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

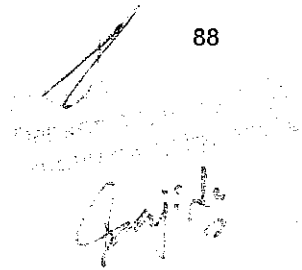
The course is designed to develop understanding of molecular mechanisms of hormone action, their molecular assessment and use of molecular techniques to treat endocrine disorders. The course of Molecular and Clinical Endocrinology aims to provide excellence in clinical care for all aspects of health and disease related to endocrine management like thyroid, adrenal, parathyroid, diabetes, pituitary, bone, and obesity and lipid disorders. It also provides an understanding of the general mechanisms in molecular endocrinology, radioimmunoassay, immune radiometric, immune chemiluminometric and radio receptor 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 Poly endocrine 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: subcellular 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 of gonadotrophin, prolactin, growth hormone, corticotrophin regulation;
6. Pituitary disorders: prolactinomas, acromegaly, Cushing's syndrome. Diabetes insipidus,
7. Thyroid diseases of excess and deficient hormones
8. Adrenal gland: disorders of cortex; disorders of adrenal medulla
9. Disorders of ovarian function and hormonal therapy;
10. Abnormalities of testicular functions and hormonal therapy.
11. Fuel homeostasis: glucose homeostasis and hypoglycemia; diabetes mellitus; disorders of lipoprotein metabolism; eating disorders: obesity, anorexia nervosa and bulimia nervosa.
12. Development and growth: disorders of growth and puberty.
13. Hormones and Cancers: Hormones Effect on Tumors, Breast and Prostate Cancer;
14. Measurements of hormones: radioimmunoassay, immune radiometric, immune chemiluminometric and radio receptor assays and their statistical procedures

Practical

1. Studies on recognition and response of receptors.
2. Studies of disorders of pituitary by observing anatomical and histological features.
3. Studies of thyroid status in deficient and excess hormone functions.
4. Studies of type 1 and type 2 diabetes mellitus: Epidemiology of the types in population, studies of management of the type 2.
5. Model studies of disorders of ovarian and testicular disorders.
6. Model studies of obesity and anorexia.



7. Studies of hormonal status in puberty and aging.

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. Griffin, J. E., & Ojeda, S. R. (2000). *Textbook of endocrine physiology* (4th ed.). Oxford: Oxford University Press.
3. Neal, J. M. (2000). *Basic endocrinology: an interactive approach*. London: Blackwell Science Inc.

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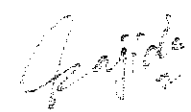
The course will provide knowledge about bird diversity, avian anatomy, physiology and adaptations, bird behavior and socioeconomic and ecological importance. This course is an advanced undergraduate survey of ornithology. This means that students will learn about both science and birds at the same time. 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, 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;
2. Biology of fossil bird's archaeopteryx, archaeornithes, neornithes;
3. Morphology and surface anatomy of bird, and development structure of feathers, plumage;
4. Structure of bones;
5. Basic embryology of birds;
6. Internal anatomy of birds;
7. Systems physiology;
8. Blood circulatory, cardiovascular physiology, heart, blood cells
9. Respiratory system, air sacs, ventilation of lungs, metabolic rates, oxygen consumption;
10. Urinary system, kidney physiology and production of solid or semisolid excreta, brain physiology and anatomy, special senses, olfaction, vision, taste;
11. Digestive system, anatomy,
12. Morphological and physiological adaptations of birds to flying,
13. Reproductive organs anatomy and physiology
14. Types of behavior in birds
15. Endangered species of birds; bird conservation and sanctuaries.
16. Anatomy and physiology of game and predatory species.
17. Birds of Pakistan: aquatic, forest and game birds and birds of prey.
18. Birds as pests.

Practical

1. Identification characteristics and taxonomy of birds to orders and families
2. Dissection of sparrow, pigeon, myna, other available birds
3. Anatomy of bones, skull, girdles, spine, vertebrae, feathers, plumage
4. Study of gut contents of birds to understand feeding habits
5. Incubation of chicken eggs to learn avian embryogenesis
6. Bird stuffing and preservation of eggs
7. Identification of bird species through feathers and egg shells
8. Beak and claw structures



9. Study of bird songs, recording bird songs, fundamental experimentation to understand bird songs in sensitive and sensorimotor phases
10. Bird watching and preparation of ethograms
11. Study of Predator-prey relationship among birds
12. Study of Brood parasitism
13. Study of flying mechanics through models

Recommended Texts

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

Suggested Readings

1. Rank, B. (2004). *Ornithology: ecology and evolution of Darwin's finches*. New Jersey: Princeton. W. H. Freeman.
2. Sibley, D. A., & Alfred, A. (2002). *Sibley's birding basics*. New York: New York Press.
3. Ali, S. S., & Ripley, D. (2001). *Handbook of the birds of India and Pakistan: together with those of Bangladesh, Nepal, Bhutan and Sri Lanka*. Reprint. New Delhi: Oxford University Press.

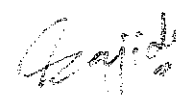
This course gives details of physiological systems maintaining the homeostasis of animals. Inter-relations of the systems and regulatory features of the each system's function will be focused. The major goal of the course is to provide a course of study in mammalian, principally human, systems physiology, 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
2. Arterial system; microcirculation and lymphatics; control of cardiac output; special circulations: cutaneous, skeletal, coronary, cerebral and fetal.
3. Respiratory System: overview of respiratory system; mechanical aspects of breathing; transport of oxygen and carbon dioxide; 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:
6. Osmoregulation: Problems of osmoregulation; obligatory exchange of ions and water; osmoregulators and osmoconformers; osmoregulation in aqueous and terrestrial environments.
7. Environmental challenges: temperature relation of ectotherms, heterotherms and endotherms; dormancy: special metabolic state;
8. Body rhythms.

Practical

1. Experiments on the study of heart in prepared frogs.
2. Study of blood pressure in various physiological states.
3. Study of electrocardiograms.
4. Blood coagulation study. Determination of oxygen consumption in fish and mouse and effects of factors.
5. Demonstration of respiratory volume and pulmonary function tests.
6. 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.
7. Urine analysis.
8. Study of osmoregulatory adaptations in animals inhabiting various environments; Demonstration of effect of temperature on several physiological responses; Study of animals in various types of dormancy.



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.). St. Louis: Mosby.
2. Guyton, A. C., & Hall, J. E. (2015). *Textbook of medical physiology* (12th ed.). Philadelphia: W.B. Saunders Company.

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 behavior 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;
3. The interactions in development in estrous and menstrual cycle
4. Reproductive behaviors: Physiological basis of male and female sexual behavior and maternal behavior;
5. Endocrine basis of communication in reproduction
6. Pheromone in mammalian reproduction;
7. Rhythms in reproduction and pregnancy;
8. Hormonal mechanism in fertilization, zygote transport and implantation.
9. Placental steroid and polypeptide hormones; maternal metabolism gestation, hormonal mechanism in parturition.
10. Lactation: Hormonal mechanism in lactation,
11. Hormonal and metabolic aspects in menopause
12. Fertility control mechanisms in male and female

Practical

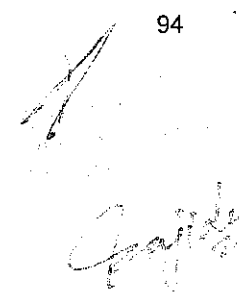
1. Study of male and female reproductive tract; physiological histology of segments of male and female reproductive tracts;
2. Recognition of spermatogonial cells, ovarian follicles and corpus luteum in gonads; study of hormonal mechanisms in super ovulation and implantation;
3. Tests for pregnancy recognition;
4. Experiments on role of gonads in maintenance of accessory sex gland in males and target structures in females;
5. 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* (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.



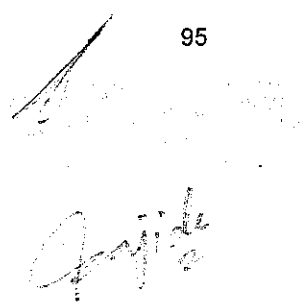
This course will provide knowledge regarding different modes of transmission of parasites of medical and veterinary importance knowledge about their pathology, host parasite relationship and control measures. Overall aim of the course is to provide students with knowledge concerning biological, epidemiological 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.
2. Relationship to other sciences.
3. Some basic definitions: basic principles and concepts.
4. Immunology and pathology.
5. Susceptibility and resistance, innate defense mechanisms.
6. Acquired immune response in vertebrates
7. Immunodiagnosis and pathogenesis of parasitic infections.
8. Host-parasite relationship.
9. Parasitic protozoa, form, function and classification: Kinetoplasta, trypanosomes and their kin, forms of trypanosomatidae.
10. The Amoebas: Order Amoebida, order Schizopyrenida.
11. Phylum Apicomplexa, Gregarines, Coccidia and related organisms.
12. Phylum ciliophora, ciliated protistan parasites,
13. Classification of Phylum Mesozoa.
14. Systematics, morphology and biology of Arthropods (causing or responsible for transmission of disease).
15. Chemical and non-chemical control of Arthropods of medical and veterinary importance.
16. Pathology of Helminths: host parasite relationships and control of parasitic Helminths with particular reference to Helminths of Medical and Veterinary importance.

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 fecal examination for helminth ova.
5. Collection, preservation and preparation of slides of local helminthes and their identification.
6. Identification of insects of medical and veterinary importance.



Recommended Texts

1. Roberts, L. S., & Janovy, J. Jr. (2005). *Foundations of parasitology* (7th ed.). Chicago, London, Tokyo, Toronto: 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: University Press Cambridge.

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 Biototoxicity 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, Taylor and Francis Group.
2. Marquardt, H., Schafer, S. G., McClellan, R. O., & Welsch, F. (2004). *Toxicology*. San Diego: Academic press.
3. Barile, F. A. (2013). *Principles of toxicology testing*. London: CRC Press, Taylor and Francis Group.