

**CURRICULUM
OF
MARINE SCIENCE
FOR
MS
(2016)**



**HIGHER EDUCATION COMMISSION
ISLAMABAD - PAKISTAN**

CURRICULUM DIVISION, HEC

Prof. Dr. Mukhtar Ahmed	Chairman, HEC
Mr. Fida Hussain	Director General (Acad.)
Ms. Ghayyur Fatima	Director (Curri.)
Mr. Rizwan Shoukat	Deputy Director (Curri.)
Mr. Abid Wahab	Assistant Director (Curri.)
Mr. Riaz-ul-Haque	Assistant Director (Curri.)

TABLE OF CONTENTS

1. Preface	4
2. Minutes of the Final Meeting	6
3. Rationale	9
4. Scheme of Study for Two-Years MS in Marine Science	12
5. Detail of Courses for Two-Year MS in Marine Science	13
6. Recommendations	23
7. Annexure A	26

Composed by: Mr. Zulfiqar Ali, HEC, Islamabad

PREFACE

The curriculum, with varying definitions, is said to be a plan of the teaching-learning process that students of an academic programme are required to undergo. It includes objectives & learning outcomes, course contents, scheme of studies, teaching methodologies and methods of assessment of learning. Since knowledge in all disciplines and fields is expanding at a fast pace and new disciplines are also emerging; it is imperative that curricula be developed and revised accordingly.

University Grants Commission (UGC) was designated as the competent authority to develop, review and revise curricula beyond Class-XII, *vide* Section 3, Sub-Section 2 (ii), Act of Parliament No. X of 1976 titled “Supervision of Curricula and Textbooks and Maintenance of Standard of Education”. With the repeal of UGC Act, the same function was assigned to the Higher Education Commission (HEC) under its Ordinance of 2002, Section 10, Sub-Section 1 (v).

In compliance with the above provisions, the Curriculum Division of HEC undertakes the revision of curricula after every three years through respective National Curriculum Revision Committees (NCRCs), which consist of eminent professors and researchers of relevant fields from public and private sector universities, R&D organizations, councils, industry and civil society by seeking nominations from their organizations.

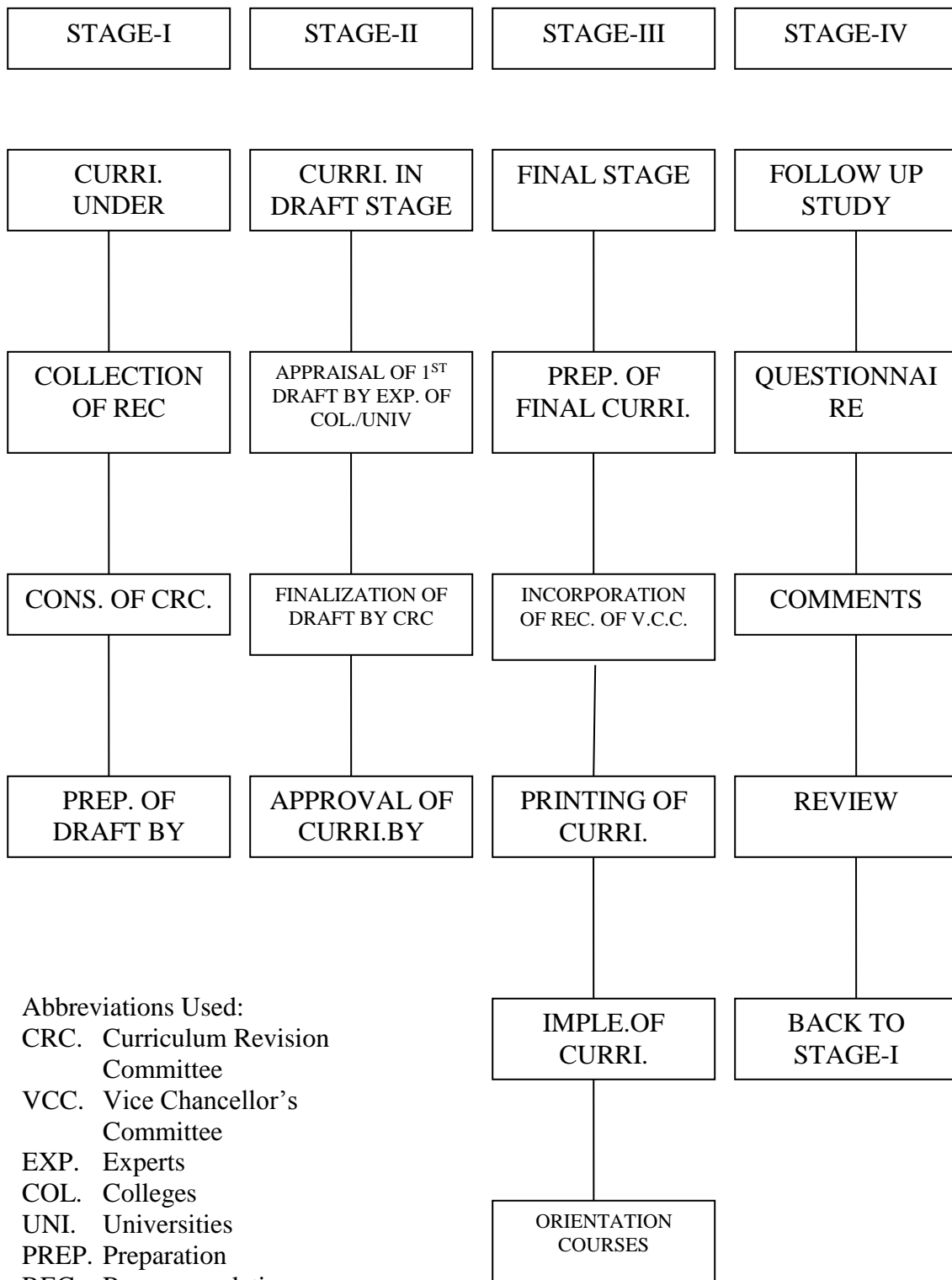
In order to impart quality education, which is at par with international standards, HEC NCRCs have developed unified templates as guidelines for the development and revision of curricula in the disciplines of Basic Sciences, Applied Sciences, Social Sciences, Agriculture and Engineering in 2007 & 2009.

It is hoped that this curriculum document, prepared by the respective NCRC's, would serve the purpose of meeting our national, social and economic needs, and it would also provide the level of competency specified in Pakistan Qualification Framework to make it compatible with international educational standards. The curriculum is also placed on the website of HEC

<http://hec.gov.pk/english/services/universities/RevisedCurricula/Pages/default.aspx>

(Fida Hussain)
Director General (Academics)

CURRICULUM DEVELOPMENT PROCESS



MINUTES OF THE FINAL MEETING:

In continuation to the preliminary meeting of National Curriculum Revision Committee in the discipline of Marine Science, which was held at Pakistan Marine Academy, Karachi from February 29 to March 2, 2016, final meeting of the NCRC was held during May 30 - June 01, 2016 at HEC Regional Centre, Karachi. The objective of the meeting was to finalize the preliminary draft of BS Marine Science curriculum for circulation by the HEC. The following attended the meeting:-

1. **Prof. Dr. Rashida Qari** **Convener**
Director,
Institute of Marine Science,
University of Karachi,
University Road, Karachi-75270
2. **Prof. Dr. Naureen Aziz Qureshi** **Member**
Vice Chancellor,
Government College Women University,
Faisalabad.
3. **Dr. Javed Aftab** **Member**
Senior Research Officer,
(in lieu of Director General, NIO),
National Institute of Oceanography,
Karachi.
4. **Dr. Tariq Masood Ali Khan** **Member**
Director,
Institute of Environmental Studies,
University of Karachi,
University Road, Karachi-75270.
5. **Prof. Dr. Alia Bano Munshi** **Member**
(in lieu of Director, CEMB)
Centre of Excellence in Marine Biology (CEMB),
University of Karachi,
University Road, Karachi-75270.
6. **Capt. (PN) Mr. Fiaz Hussain TI (M)** **Member**
Deputy Chief (Maritime),
Ministry of Defence,
Maritime Affairs Wing, Islamabad.
7. **Chief Engr. Rashid Yahya Usmani** **Member**
Engineering Instructor,
Pakistan Marine Academy,
Hawks Bay Road, Maripur, Karachi.

- | | | |
|-----|--|------------------------|
| 8. | Dr. Ehsan Elahi Valeem
Assistant Professor,
Institute of Marine Science,
University of Karachi,
University Road, Karachi-75270. | Deputy Convener |
| 9. | Dr. Muhammad Aslam Buzdar
Dean,
Faculty of Marine Sciences,
Lasbela University of Agriculture, Water & Marine Sciences,
Uthal, Balochistan. | Member |
| 10. | Dr. Azra Bano
Assistant Professor,
Faculty of Marine Sciences,
Lasbela University of Agriculture, Water & Marine Sciences,
Uthal, Balochistan. | Member |
| 11. | Mr. Muhammad Tahir Khan
Lecturer,
Faculty of Marine Sciences,
Lasbela University of Agriculture, Water & Marine Sciences,
Uthal, Balochistan. | Secretary |
| 12. | Mr. Syed Ghulam Qadir Shah
National Coordinator,
International Union for Conservation of Nature,
IUCN-Pakistan, 1 Bath Island Road,
Karachi. | HEC Invitee |
| 13. | Mr. Nadeem Mirbahar,
National Resources Management Coordinator,
International Union for Conservation of Nature,
IUCN-Pakistan, 1 Bath Island Road,
Karachi. | HEC Invitee |

The following members of the NCRC either attended or could not attend the meeting due to their official/ personal engagement, however, they sent their representatives in the said or present meeting as mentioned above:-

1. **Prof. Dr. Ghazala Siddiqui**
Director,
Centre of Excellence in Marine Biology (CEMB),
University of Karachi,
University Road, Karachi-75270.
2. **Dr. Asif Inam**
Director General,
National Institute of Oceanography (NIO),
Karachi.

3. **Capt. Nasim Ahmad Tariq**
Nautical Instructor,
Pakistan Marine Academy,
Hawks Bay Road, Maripur, Karachi.
4. **Mr. A. Najeeb Bhatti**
Chief Education Officer,
Pakistan Marine Academy,
Hawks Bay Road, Maripur, Karachi.
5. **Mr. Tahir Jameel**
Chief Engineer,
Pakistan Marine Academy,
Hawks Bay Road, Maripur, Karachi.

The meeting started with recitation of Holy Verses from the Holy Quran by Dr. Ehsan Elahi Valeem, Deputy Convener (NCRC). Mr. Riaz-ul-Haque, Assistant Director (Curriculum), HEC on behalf of the Chairman, the Executive Director, HEC and Director General (Acad.), welcomed the participants and thanked all the members of the Committee for sparing precious time to participate in the meeting. He briefed the participants on the aim and objectives of the meeting with a particular focus on revising the curriculum of BS Marine Science - 2011. Mr. Sulaiman Ahmed, Director, HEC Regional Centre, Karachi while inaugurating the proceedings, appreciated the participants for their commitment to this task of national importance and assured full support from his team of HEC Regional Centre, Karachi.

The members of the Committee showed confidence on previously selected Convener, **Prof. Dr. Rashida Qari**, Director, Institute of Marine Science, University of Karachi, Deputy Convener, **Dr. Ehsan Elahi Valeem**, Assistant Professor, Institute of Marine Science and Secretary, **Mr. Muhammad Tahir Khan**, Lecturer, Faculty of Marine Sciences Lasbela University of Agriculture, Water & Marine Sciences, Uthal. The Convener thanked the participants for their confidence and started proceedings of the meeting in accordance with the agenda. The Committee started the revision process from the finalization of various modules for specialization in Marine Science programme. New modules like Integrated Coastal Zone Management (ICZM), Mangrovology, and Port Operations and Ship Management were added to provide more job opportunities to the students studying Marine Science.

The Committee reviewed and discussed the preliminary curriculum in detail and taking into account various aspects/ demand of the discipline and various issues highlighted by the faculty member and other stakeholders. After detailed discussion the inputs/ suggestions given by the members of the Committee were incorporated, where necessary, in the draft curriculum. New books were added and the contents were updated. After detailed and exhaustive discussion, the Committee finalized the layout of courses in the light of recommendations of all the participants and the guidelines provided by the HEC.

The Convener and the Secretary of the NCRC thanked the NCRC members for their inputs and worth mentioned Deputy Convener Dr. Ehsan Elahi Valeem for his contribution in finalizing the draft curriculum keeping in view the requirement of the country and to make it more practical, competitive and effective. The Committee highly appreciated the efforts vested by Mr. Sulaiman Ahmed, Director, HEC Regional Centre, Karachi and his staff for providing local hospitality and comfortable stay during three days meeting and Mr. Riaz-ul-Haque for his coordination.

Mr. Riaz-ul-Haque, Assistant Director (Curriculum) thanked the Convener, the Deputy Convener, the Secretary and all the members of the committee for sparing precious time and for their quality contribution towards accomplishment of revision process of the curriculum in Marine Science through NCRC.

The meeting ended with the vote of thanks to and from the chair as well as the participants of the meeting.

Rationale of BS in Marine Science:

Placed in the north-western part of Indian Subcontinent, Pakistan borders the Arabian Sea with a sizeable coastline running for approximately 990 km in the east-west direction. Nearly 320 km of this seashore falls in the province of Sindh whereas the rest of 670 km constitute the Makran coast. The Exclusive Economic Zone, that stretches 350 nautical miles seaward from the coast, provides 290,000 km² area of the Arabian Sea for exploitation of the renewable and non-renewable resources, on which coastal population of the Sindh and Balochistan provinces largely depends for their livelihood. Besides, a huge volume of raw materials, finished products and oil imported through the maritime trade as well as the exports of Pakistani products provides employment opportunities to thousands of families in both the provinces.

Marine scientists work on the sustainable use, development and conservation of marine and coastal environment. Growing world population emphasizes the ability of our society to produce food, energy and water from oceans to help sustain our basic needs. Advances in technology, will improve our ability to derive food, drinking water and energy sources from the oceans and use the same for waste disposal, and transportation. It will be up to us and our future generations to build upon our existing knowledge of oceans and their potential to help meet needs of the world and its inhabitants. Because of the growing concerns for the protection and prudent use of our natural resources, there is an increasing need for skilled personnel who can advise on, organize and control the development of marine resources and activities.

In view of the importance of Arabian Sea with respect to fishing, use of mangrove forest, its potential for offshore hydrocarbon exploration and import/export of goods through the ports of Karachi and Gawadar, makes it highly desirable that a fully devoted degree programme is launched in Marine Science in order to cater the need of appropriately trained and skilled manpower in this

field. BS Marine Science is a branch of Earth Science that studies almost everything related with oceans, seas, their coasts and seabed. It covers a wide range of topics including ocean currents, waves and tides; marine organisms and ecosystem dynamics; geophysical fluid dynamics; plate tectonics and geology of the sea floor including their minerals and hydrocarbon potential; and fluxes of various chemical substances and physical properties within the ocean and across its boundaries. These diverse topics relate to a multitude of disciplines like chemistry, physics, biology, geology, meteorology and geography that oceanographers blend together to comprehend knowledge of the world oceans and processes within it. Marine science is a contemporary field of education having emerged as a hybrid of traditional fields such as biology, chemistry and geology forming biogeochemistry.

The BS Marine Science programme will enrol such students who have completed 12 years of studies with traditional science courses as biology, chemistry, physics, and mathematics. It integrates science curricula so as to provide a thorough understanding of the related earth and life science education in the realm of oceans. The curriculum is designed to provide standard marine science education in Pakistan that can be divided into following branches and electives in each module:

- **Biological Oceanography and Conservation:** Biological Oceanography or Marine Biology is the study of plants, animals and microbes of the ocean and their ecological interaction with the habitat and Conservation Biology is the scientific study of nature and of Earth's biodiversity with the aim of protecting species, their habitats, and ecosystems from excessive rates of extinction and the erosion of biotic interactions.
- **Chemical and Environmental Oceanography:** Chemical Oceanography or Marine Chemistry is the study of ocean chemistry, the behaviour of the chemical elements within the Earth's oceans. The ocean is unique in that it contains - in greater or lesser quantities - nearly every element in the periodic table, which interacts with the atmosphere. Environmental Oceanography or Environmental Science is the study of the interactions among the physical, chemical and biological components of the environment; with a focus on pollution and degradation of the environment related to human activities; and the impact on biodiversity and sustainability from local and global development.
- **Fisheries and Aquaculture:** Fisheries may involve the capture of wild fish or raising fish through fish farming or aquaculture. It provides science-based conservation and management for sustainable fisheries and aquaculture, marine mammals, endangered species, and their habitats. Aquaculture, also known as aqua-farming, is the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic marine organisms. Aquaculture involves cultivating freshwater and saltwater populations under controlled conditions, and can be contrasted with commercial fishing, which is the harvesting of wild fish.

- **Geological Oceanography:** Geological Oceanography or Marine Geology studies the structure and morphology of the ocean floor, tectonic activity and volcanism associated with plate margins, continental margins, beaches and coastal areas, sediment transport and deposition regimes, and offshore mineral and hydrocarbon deposits *etc.*
- **Integrated Coastal Zone Management (ICZM):** Integrated Coastal Zone Management (ICZM) or Integrated Coastal Management (ICM) is a process for the management of the coast using an integrated approach, regarding all aspects of the coastal zone, including geographical and political boundaries, in an attempt to achieve sustainability.
- **Mangrovology:** Mangrovology is the study of mangroves including flora and fauna inhabiting the Mangrove roots (Pneumatophores) as epiphytes, endophytes, epifauna and endofauna respectively. Mangrove habitats provide nursery grounds for a variety of juvenile organisms. Several economic activities are also associated with Mangroves environment, which are not only untapped but also unexplored. There is a need to plant Mangrove saplings on the wetlands to help them grow and foster other marine creatures. Mangrove Forests can also be developed into a precious ecotourism sights.
- **Physical Oceanography:** Physical Oceanography or Marine Physics studies the physical attributes of the oceans including temperature-salinity structure, mixing, waves, tides and currents, light and sound transmission *etc.*
- **Port Operations and Ship Management:** Maritime transport is the shipment of goods (cargo) and people by sea and other waterways. Port operations are a necessary tool to enable maritime trade between trading partners. To ensure smooth port operations and to avoid congestion in the harbour it is inevitable to permanently upgrade the port's physical infrastructure, invest in human capital, fostering connectivity of the port and upgrade the port operations to prevailing standards. Hence, port operations can be defined as all policies, reforms and regulations that influence the infrastructure and operations of port facilities including shipping services.

The programme of BS in Marine Science is aimed at preparing graduates for a range of interesting careers and opportunities. A marine scientist can be employed in federal, state and local government agencies to manage and monitor the use of resources, solve problems and conduct research better than anybody else. They can be employed by private industries such as seafood, fisheries, aquaculture, exploratory marine geology, satellite imagery, and ecological modelling, including environmental agencies and numerous non-government organizations.

SCHEME OF STUDY FOR TWO-YEARS MS IN MARINE SCIENCE

Semester/ Year	Name of Subject	Crh
First Semester/ First Year		
MS-701	Advanced Marine Ecology	2+1 = 3
MS-703	Chemical Oceanography	2+1 = 3
MS-705	Fisheries Biology	2+1 = 3
MS-707	Marine Pollution	2+1 = 3
MS-709	Principles of Mariculture	2+1 = 3
		15
Second Semester/ First Year		
MS-702	Advances in Marine Biology	2+1 = 3
MS-704	Coastal Zone Management	2+1 = 3
MS-706	Marine Geology	2+1 = 3
MS-708	Physical Oceanography	2+1 = 3
MS-710	Research Methodology*	3
		15

*Research Methodology is a compulsory course and will be offered by DFS in accordance with the University Policy.

Students may opt for 30 Cr.h. course work comprising of ten courses as given above to be completed in two semesters/ an year without any research work enabling them to earn M.S./ M.Phil. degree or 24 Cr.h. course work comprising of eight courses to be completed in two semesters/ an year with a research/ thesis work of six Cr.h. They have to leave two courses *i.e.* one from each semester if they want to do research work for M.S./ M.Phil.

DETAIL OF COURSES FOR TWO-YEAR MS IN MARINE SCIENCE

MS - 701 ADVANCED MARINE ECOLOGY 2+1 = 3 Crh

Objectives:

To provide a pursuit of basic knowledge of science for better understanding the working of marine ecosystems that is increasingly an applied science devoted to understanding how ecosystems respond to stressors and environmental changes.

Course Outline:

Introduction: The nature and global distribution of Marine Organisms, Habitats and Productivity. Patterns of Marine Ecosystem: Climate changes: Sea surface temperature, *El-Nino*; Productivity and Biogeography. Endemism, Abundance, Size and Biodiversity. Primary productivity, Light and photosynthesis. Nutrients and growth. Microbial decomposition of Organic Material. Pelagic ecosystem: The planktonic system of surface waters. Environmental features, Temporal and spatial variability in pelagic ecosystem. Pelagic Inhabitants, Pelagic fisheries. The Deep Sea: Organisms and environment of the deep sea; Food supply to the deep sea, Hydrothermal vents. Continental shelf and Seabed: Habitat, biota, food web on the seabed, continental shelf and littoral sediments Patterns of Distribution; Zonation pattern on shores, Causes of zonation, community dynamics. Coping with physical and biological environment. Ecosystem of Mangrove forests and Seaweeds: Population dynamics of inhabiting organisms; economic/ commercial importance of mangroves and seaweeds. Human impact on the shores: Collecting marine organisms for food bait and trade. Chronic pollution, Introduction of new species; Coastal zone change.

Lab. Work:

Survey and collection of marine animals and plants from intertidal, subtidal, supratidal zones of rocky and sandy shores and Mangrove area. Study of zonation pattern at rocky, sandy and muddy shores. Estimation of species richness, density and diversity of intertidal zone organisms.

Recommended Books:

1. Barnes, R.S.K. and Hughes, R.N., 1999. *An Introduction to Marine Ecology*. Blackwell. Sci.
2. Boaden, P.J.S. and Seed, R. 1992. *An Introduction to Coastal Ecology*. Blackie A & P. Press, U.K.
3. Kaiser, M.J., Attrill M. and Jennings, S., 2005. *Marine Ecology, Processes, Systems and Impacts*. Oxford Univ. Press.
4. Nybakken, J.W., 1993. *Marine Biology: An Ecological Approach*. 3rd edition. Harper & Row, Publ. New York.

5. Raffaelli, D. and Hawkins, S., 1996. *Intertidal Ecology*. Chapman & Hall, UK.

MS - 702

ADVANCES IN
MARINE BIOLOGY

2+1 = 3 Crh

Objectives:

To provide advanced comprehensive information on marine animal and plant groups and their ecology. To educate qualified multipliers for the idea of protection of marine life to increase the access to the complex interaction and the "tiny life" in the sea. To encourage the diver to raise awareness and participate in environmental activities.

Course Outline:

Organisms of the Open Sea: Plankton. Crustacean and gelatinous plankton. Bioluminescence. Nekton, Cephalopods, Fishes, turtles and whales. Phytoplankton: Biodiversity, Distribution, Life cycles, Ecology of Diatoms, Dinoflagellates, Coccolithophores, Silicoflagellates and other small groups. Red tide Phenomenon. Seaweeds: Biodiversity, Biomass, Distribution, and Ecology of Chlorophyta, Phacophyta, Rhodophyta and other small groups: Utilization of seaweed in developed and developing countries including Pakistan. Mangroves: Biodiversity, Distribution, Associations. Mangrove forest in Pakistan, Economic importance of mangroves. Benthic Marine Invertebrates: Taxonomic level, Distribution and diagnostic characters of Phyla: Protista Porifera, Cnidaria, Platyhelminthes, Annelida, Mollusca, Crustacea, Echinodermata and Urochordata. Benthic Life Habits: Life habit classification, Feeding classification, Life in mud and Life in Sand, Life on hard surfaces and Moving waters, Benthic herbivores, Benthic carnivores. Intertidal Zone: Factors affecting intertidal organisms. Zonation. Larval dispersion. Predation and interspecific competition. Conserving Marine Biodiversity: Estimation of Diversity, Value and Reduction in biodiversity, Marine Invasions.

Lab. Work:

Collection, Preservation and Identification of Phytoplankton. Preservation and Identification of Seaweeds and Mangroves with associated fauna. Sampling and preservation techniques of marine invertebrates, identification of major groups: Molluscs, Crustaceans, Echinoderms Annelids and Fishes. Identification of macro zooplankton collected from northern Arabian Sea.

Recommended Books:

1. Hoqarth, P.J., 2000. *The Biology of Mangroves (Biology of Habitats)*. England, 162 pp.
2. Levinton, J.S., 2001. *Marine Biology: Function, Biodiversity, Ecology*. 2nd Ed., Oxford University Press.

3. Luning, K., 1990. *Seaweeds: Their Environment, Biogeography & Ecophysiology*. Wiley. Inter. Sci. Publ.
4. Nybakken, J.W. and Bertness, M.D., 2005. *Marine Biology: An ecological Approach*. 5th Ed., Pearson Benjamin Cummings. Publ.
5. Pechenick, 2005. *Biology of the Invertebrates*. 5th Ed., McGraw-Hill.

MS - 703

CHEMICAL OCEANOGRAPHY

2+1 = 3 Crh

Objectives:

This course is designed to develop concept of Marine Chemistry and important chemical processes in the oceans.

Course Outline:

Chemical Composition of Seawater: Major constituents and minor constituents. Hydrographic Conditions: Temperature, pH, Salinity, Dissolved oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Dissolved Gases: The earth atmosphere Nitrogen. Oxygen, Noble gases. Carbon Dioxide and Carbonate System: Exchange in ocean & atmosphere. Acid-Base Equilibria in seawater, Equilibria of carbonate species, Parameters of the CO₂ system in seawater, Distribution of carbonate species, CaCO₃ dissolution in seawater. Nutrient Chemistry: Phosphorus cycle. Nitrogen cycle, Silicon cycle, Use of nutrients as water mass tracers. Chemical Equilibria in the Ocean: The types species in seawater, Principles of chemical equilibria, Chemical kinetics. Chemical species and equilibria in the seawater. Radio Chemistry of the Ocean: Classification of radio isotopes in the marine environment, Natural radioactive elements, Radioactive contamination of the sea. Residence time and mixing in the sea. Suspended Particulate Matter in Seawater: Variability and concentration of suspended material, State of division, Inorganic suspended material, Organic suspended material, Silicon, Biochemistry of the Ocean: Body fluid, Biomaterial, Photosynthesis, Animal metabolism, Decomposition of the dissolved organic content, Phosphate, Nitrate and Nitrogen Substance, Anoxic condition, the concentration of chemical elements by organisms.

Lab. Work:

Study of Hydrographic Condition: pH, Salinity, Dissolved Oxygen, Biological Oxygen, Demand, Chemical Oxygen Demand. Nutrient Chemistry: Nitrite, Nitrate, Phosphate and Silica estimation. Determination of heavy metals by atomic absorption spectroscopy.

Recommended Books:

1. Eisler, R.L., 1981. Trace Metal Concentration in Marine Organisms. Pergamon Press.

2. Kennish, M.J., 2001. Marine Science: Practical hand book CRC Press.
3. Mare, I.L. and Cresser, M.S., 1983. Environmental Chemical Analysis. International text book Company. Chapman and Hall New York.
4. Millero, F.J., 2006. Chemical Oceanography. CRC Press NY, London.
5. Satyanarayana, D., 2007. Marine Chemistry, Daya Publ. House Delhi.

MS - 704 COASTAL ZONE MANAGEMENT 2+1 = 3 Crh

Objectives:

To understand coastal zones, the dynamic environments shaped by natural forces as well as human intervention enabling students to develop management strategies and identify threats to these environments.

Course Outline:

General Concepts Principles. Definition of ICZM, Evaluation of an ICZM Program. Coastal Ecosystem and Resources: Basic concepts, Factors affecting carrying capacity, shoreland systems, Estuarine systems, Nearshore and ocean systems, Conserving and Restoring Coastal Habitats, Wetlands along Pakistan coast, Renewable and non-renewable resources, use of resources. Environmental Impact Assessment for Coastal Developmental Projects and EIA in Pakistan. Coastal Zone Management Techniques: Concept of integration in coastal zone management, Discussion of various techniques. Water Quality Management in the International legislation, Pollution Prevention in the Coastal Zone, legislation and its implementation. Management of Beaches & Coastal Hazards: Recreational value of beaches, Beach erosion and water quality control, Copping with Beach Erosion, Guarding People and Property against Natural Hazards, Managing Sediments and Shorelines, Mitigating Shore Erosion along Coasts. Marine and Coastal Protected Area Management: Design and implementation of marine and coastal protected areas, Principles for management, Marine and coastal protected areas in Pakistan. Future Problems of Coastal Zone: Eutrophication, Habitat modification, exploitation of resources, toxic effects, introduction of non indigenous species. Pathogen and toxins and their affects on human health, global climate change and vulnerability of coastline. Institutional and Legal Arrangements: Coastal zone management stakeholders, Pakistan legislation pertinent to coastal zone management, Institutional structure, Coastal Zoen Management Acts, managing coasts and their watersheds, Coastal Programme Guides of Sindh and Balochistan Provinces.

Lab. Work:

Specific exercises of lgical framework may be given.

Recommended Books:

1. Clark, J.R., 1996. Coastal Zone Management Handbook, CRC Press.

2. Harvey, N., 2006. Global Change and Integrated Coastal Management. The Asia-Pacific Region, Springer.
3. Kay, R.C. and Alder, J., 2005. Coastal Planning and Management. Taylor & Francis.
4. Timothy, B., Brower, D.J. and Schwab, A.K., 2002. An Introduction of coastal zone management. 2nd edition, Island Press.
5. Vernberg, W.B., 2001. The coastal zone: Past, present and future. Univ. South Carolina Press.

MS - 705

FISHERIES BIOLOGY

2+1 = 3 Crh

Objectives:

To develop understanding of fisheries resources and recognize all major taxonomic groups of fish and systematics of common fish. To understand basic anatomy and physiology, evolution and zoogeography of major groups of fish and current issues concerning conservation and fisheries management.

Course Outline:

Fisheries Resources: Identification, nomenclature, classification, major groups of Fishes and Shellfish. Fish Capture Devices in Industrial and Artisanal Fisheries and their influence on Management, Trawling and Gillnetting. Artisanal fisheries. Marketing Fish: International markets for fish. Determination of values. Handling and storage. Resource management and marketing. Marine Protected Areas and Fisheries: Abundance, body size, fecundity and recruitment of target species in MPAs. Population Dynamics: Distribution and abundance. Size relationship. Selection of fishing gear. Food and feeding; Age and Growth, Survival and Mortality. Life history patterns. Reproduction and Spawning: Link between spawner abundance and recruitment. Influence of survival and growth rate on age, size and reproductive effort at maturity; Effect of fishing on life history. Parental care. Mating patterns. Reproductive behaviour and life histories and exploitation. Assessment and Monitoring: Collection of Basic Data; Stock size Data analysis and stock assessment. Yield analysis. Ecosystem Effects of Fishing: Effect on benthic communities and habitats. Effects of removing predators. Population Structure: Age determination, back calculation techniques. Estimating food consumption. Recruitment variability, pelagic eggs, larval and juvenile stages. Fish as Predators and Prey: Foraging behaviour and diet choice. Feeding ecology of piscivorous fishes. Biodiversity of Fish communities. Habitat associations. Interaction between Fish, parasites and disease.

Lab. Work:

Identification of commercially important species of edible fishes. Taxonomic study of most common edible crabs, shrimps oysters, mussels, clams and squids obtained from Pakistan coast. Visit to hatcheries and fish harbours.

Recommended Books:

1. **Blaber, S.J.M., 1997. *Fish and Fisheries of Tropical Estuaries*. Chapman and Hall London.**
2. **Hart, P.J.B. and Reynolds, J.D. 2002. *Handbook of Fish Biology and Fisheries*. Vol. 2. Blackwell Publ.**
3. **King, M., 2007. *Fisheries Biology; Assessment and Management*. Fishing News Book.**
4. **Royce, W.F., 1996. *Introduction to the Practice of Fishery Science*. Acad. Press.**
5. **Yadav, B.N., 2006. *Fish & Fisheries*. Daya Publ. House, India.**

MS-706

MARINE GEOLOGY

2+1 = 3 Crh

Objectives:

To give detail of structure, evolution and geological processes of the ocean basin and continental margin. This course will enable the students to fully understand the marine environment, what dynamic processes shape the surface of the earth under the ocean surface, sedimentation processes, and Sediment distribution on seafloor.

Course Outline:

Introduction: Landmark events in development of Marine geology. Scientific Deep Sea Drilling, Contribution of Deep Sea Drilling Project (DWSDP) 1974-80, Ocean Drilling Program (ODP; 1980-1990). Morphology of the Oceans: Hypsometry, the principal topographic features of the Ocean, classifications and geological processes of continental margins. Origin of Ocean Basin: Major ocean basins, Gulfs and Seas, Estuaries, Deltas, Barrier Islands and Coral Reefs, Plate tectonics and sea floor spreading, Rock magnetism, spreading processes at ocean ridges, Age and structure of ocean crust, distribution of deep ocean basins, Wilson cycle: opening and closing of ocean basins. Marine Sedimentation: Sediment types and distributions, Biogenic calcite production and deposition (CCD, Lysocline), Shelf sedimentation, Sediment types and distributions, Biogenic calcite production and deposition (CCD, Lysocline), shelf-to-basin transport phenomena, Deep sea sedimentation, Global distribution of deep sea sediments. Sediment thickness and type variations. Non-Living Marine Resources: Hydrocarbons, Minerals, Building material, Marine energy resources (Renewable and Non renewable), Chemicals, Drugs. Methods and instrumentation in Marine Geology: Navigation and Exploration Techniques, Seafloor imaging: shipborne seafloor imaging (Echosounding, multibeam bathymetry, sidescan sonars, airborne seafloor imaging multi and hyper spectral sensors, radar methods, spaceborne seafloor imaging (GEOSAT, ESR-1, SEASAT, LANDSAT), seismic and sub bottom profiling, Deep submergence vehicles (ROVS). Sediment sampling Methods: Grabs, Dredgers, core drilling (vibrocore, Piston core, Gravity core, Box core, Deep sea drilling).

Lab. Work:

Exercises of Marine Charts, Navigation and bathymetry, Acoustic Seismic profiling, Marine environments, Sea floor spreading and Plate Tectonics,

Marine sediments, Coastal Processes.

Recommended Books:

1. Erickson, J., 2002. **Marine Geology: Exploring the new Frontiers of Oceans.** Facts on File, USA.
2. Garrison, T., 2005. **Oceanography: An Invitation to Marine Science.** Wadsworth Publ. Company.
3. Kennish, M.J., 2001. **Practical Handbook of Marine Science.** CRC Press Washington D.C. 875 pp.
4. Segar, D.A., 1998. **Introduction to Ocean Science.** Wadsworth Publ. Co.
5. Seibold, E., 1996. **The Sea Floor: An Introduction to Marine Geology.** Springer, UK.

MS - 707

MARINE POLLUTION

2+1 = 3 Crh

Objectives:

To understand pollution, its sources and implication with the biotic and abiotic environment.

Course Outline:

Introduction to Pollution: Definition, Types of pollutants; Nature of input, sources of input, Priorities. Oil Pollution: What is oil, oil discharges to marine environment, Genesis of oil, Toxicology, Fate of spilled oil, Treatment of oil at sea, Beach cleaning, Ecological impact of oil pollution, Impact of refinery waste water, Impact of offshore operations, Commercial damage from oil pollution, Public health risk from oil pollution. Metal Pollution: Input routes, Atmospheric inputs, Uptake of metals, Biological magnification, Mercury, Lead, Cadmium, Iron, Tin, Copper. Sewage Treatment: Primary, secondary & tertiary treatment, d application of sewage, Unconventional sewage treatment, Detergent phosphates. Pesticides: Classification, Use, Effect on marine organisms, Magnification, Effects on marine birds, pest resistance. Radioactivity: Nature of radioactivity, Toxicology, Input of radioactivity to the sea, Ecological impact of radioactivity, Hazard to human health. Thermal Pollution and Power Plants: Power plant design, Discharges of waster from thermal power plants, Toxic effects of effluent waters on biota. Plastics Pollution: Nature of the problem, Effect on marine environment *i.e.*, aesthetics, ingestion, entanglement, Solutions & Education. Institutional Arrangements: Introduction, The water pollution control, Sub-sector, Institutions and organizations, Criteria and determinants, Example of institutional arrangements, Capacity building.

Lab. Work:

Estimation of heavy metals in sediments and sessile organisms by atomic absorption spectrometry. Estimation of aromatic compounds in seawater samples by GLC.

Recommended Books:

1. Clark, B., 1992. **Marine Pollution**. Oxford University Press, New York.
2. Helmer and Hespanhol, I., 1997. **Water Pollution Control**. St. Edmundsbury Press, UK.
3. Kennish, M.J., 1998. **Pollution Impacts on Marine Biotic Communities**. C.R.C. Press, New York.
4. Law, A., 2000. **Aquatic Pollution**. John Wiley & Sons Inc. Canada.
5. Sindermann, J., 2006. **Coastal Pollution: Effect on Living Resources and Humans (Marine Science Series)** CRC Press.

MS - 708

PHYSICAL OCEANOGRAPHY

2+1 = 3 Crh

Objectives:

To introduce important physical processes in the oceans in such a way that they will understand both the conceptual physical principles and at the larger scale how these fit into the earth as a system.

Course Outline:

Physical properties of sea water. Physical Laws and Classification of Forces, and Motion in the Sea. Basic Forces, Pressure Gradient force, Wind stress, Coriolis force, friction, viscosity, continuity equation, Equation of motion, role of non-linear terms in the equation of motion. Waves: Characteristics, Shallow Water and Deep Water Waves, Wave Reflection and Refraction, Effects of Waves and Wave Energy. Tides: Measurements and Tides Origins and Characteristics, Tidal forcing, Large scale tides, Tides near coasts, tidal mixing, Estuaries, River outflow plumes, Fronts. Currents: Surface currents, Response of the Upper Ocean to Winds, Ekman Layer and Ekman Mass Transport. Application of Ekman Theory, Geostrophic flow, hydrostatic equilibrium, Inertial flow, vorticity, westward intensification, Gulf Stream, thermohaline effects, deep ocean circulation, and Tidal currents. Mass Transport in the Ocean: Water mass identification and formation, distribution of various properties, T-S relationship, water mass formation in the North Indian Ocean. Ocean-atmosphere System: Ocean Atmosphere Heat Exchange, air-sea heat flux components and geographic distribution, computation of heat fluxes for Arabian Sea. Monsoon circulation, equatorial waves, Impact of *El Nino* on global Weather. Coastal Hazards: Cyclones, storm Surges, High Waves, Coastal Flooding. Salt Water Intrusion, Tsunami, Tsunami Early Warning System for Indian rim countries.

Lab. Work:

Oceanographic Instruments: Instruments and Methods for measurements

of oceanographic parameters, measurements of tides, currents, waves and sampling procedures for collections of sediments biological and chemical sampling.

Recommended Books:

1. Dijkstra, H.A., 2005. Nonlinear physical oceanography: a dynamical systems approach to the large scale ocean circulation and *El Nino*. Springer.
2. Emery, W.J. and Thomson, R.E., 2001. Data Analysis Methods in Physical Oceanography. Elsevier.
3. Mann, H. & Lazier, J.R. 2006. Dynamic of Marine Ecosystems. Blackwell Publ.
4. Stewart, R.H., 2007. Introduction to Physical Oceanography. Texas A&M Univ.
5. Thurman, H.V., 2001. Introductory Oceanography. Charles E. Merrill Publ.

MS-709

PRINCIPLES OF MARICULTURE

2+1 = 3 Crh

Objectives:

To understand different culture systems, their designs and operations. Overview of different environment management systems required for aquaculture as well as nutritional requirements for aquaculture practices.

Course Outline:

Introduction: An overview of status of mariculture of fishes with special reference to Indo-Pacific region. **Different Farming Systems:** Extensive, Semi-intensive and Intensive; Cage and Pen culture; Recirculatory and running water systems. **Important Cultivable Finfishes:** Distribution, biology, seed collection, hatchery technology, culture techniques, problems and prospects (seabass, milkfish, mullets, sea breams, grouper, etc.). **Culture of Marine Crustaceans:** Important cultivable species of shrimps, crabs and lobsters; distribution, biology, broodstock collection, different systems of culture. **Culture of Marine Molluscs:** Present status and scope, Species cultured (mussels, oysters, pearl oysters, scallops, clams, sea cucumber) distribution, biology, farming methods, problems and prospects. **Seaweed Culture:** Major seaweed species of commercial importance; methods of culture; farming of agar, algin, carrageenan yielding species; emerging trends in their farming in open seas; Integration with other farming systems.

Fish and Shellfish Nutrition: Nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults; role of natural food in fish nutrition; Role of nutrients; amino acids, fatty acids, proteins, lipids, carbohydrates, vitamins and minerals. **Soil And Water Quality**

Management: Physical and chemical properties of soil and water, soil and water quality monitoring and management.

Lab. Work:

Identification of cultivable marine finfish, shellfish and seaweeds. Designing of cages and pens. Soil and water quality parameters. Visit to mariculture sites.

Recommended Books:

1. **Davenport, J., 2003. Aquaculture: The ecological issues. Springer-Verlag.**
2. **Marianne, H. Carto, K.B., Duarte, S.M. 2008. Aquaculture in Ecosystem. Springer-Verlag.**
3. **McVey, J.P., 1993. CRC Handbook of Mariculture: Crustacean Aquaculture. 2nd Edition. CRC press.**
4. **Parker, R. 2002. Aquaculture Science. 2nd Edition. Delmer Thomson Learning U.K., U.S.**
5. **Wicking, J.T. and Lee, D. 2002. Crustacean Farming. Blackwell Sci. Publ.**

RECOMMENDATIONS

The NCRC for marine science submitted following recommendations to be considered by HEC:

- I. Admission Criteria in B.S. Marine Science
 - A. Pre-requisite qualification should be Intermediate Science (or Equivalent) with minimum 2nd Division from the following groups as per preference of order given below:
 - i. Pre-Medical Group
 - ii. Pre-Engineering Group
 - iii. Other Groups (should have studied at least two subjects from Chemistry, Physics and Mathematics).
 - B. Zero Semester would be offered to overcome students' deficiency if required.
- II. Compulsory Courses
 - A. Weightage of English may be reduced from 12 to 6 credit hours.
 - B. Urdu being the national language and as per decision of Supreme Court of Pakistan must be included.
 - C. Biology should be included in the list of compulsory courses.
 - D. Citizenship Education and Community Engagement should be included in the list of compulsory subjects and one credit hour out of three credit hours should be given for community services (Project work).
- III. Nomenclature of Degrees
 - A. Associate Degree [68 credit hours would be completed in two years (four semesters)].
 - B. B.S. Degree [124-136 credit hours would be completed in four years (eight semesters)].
 - C. If a candidate obtains prevalent B.Sc. degree and wants to join B.S. programme, can join in 5th semester through bridging (after attending 15 to 18 credit hours' deficiency courses).
 - D. If a candidate obtains Associate degree and wants to join B.S. programme, can join in 5th semester.
- IV. Inclusion of new disciplines
 - A. Being maritime country the B.S. programmes should be extended to following specializations in 7th and 8th semester to be added among the elective modules:
 - i. Biological Oceanography and Conservation (BOC)
 - ii. Chemical and Environmental Oceanography (CEO)
 - iii. Fisheries and Aquaculture (FA)
 - iv. Geological Oceanography (GO)
 - v. Mangrovology (Mangl)
 - vi. Integrated Coastal Zone Management (ICZM)
 - vii. Physical Oceanography (PO)
 - viii. Port Operations and Ship Management (POSM)
 - B. Field Project/ thesis/ Internship (to be reflected in transcript)

- i. Field Project would be substituted by one course.
 - ii. Thesis would substitute two courses of two different semesters.
 - iii. Internship can be offered in summer/ winter vacations that would substitute a course to be ratified by assessment report.

- V. Suggestions regarding promotion of research in M.Sc./B.S. and M.Phil./M.S. programmes:
 - A. That the research activities should be started from M.Sc./ B.S. programme by including six Cr.h. research as part and parcel of the programme wherein community may be involved and their problems can be addressed.
 - B. That the M.Phil./M.S. programmes should be a blend of course and research work being the intermediate phase between courses and research. Awarding M.Phil./ M.S. merely on the basis of courses and certain CGPA is unjust as it would produce learned force having no creativity.
 - C. That students involved in research work at the level of B.S./ M.Sc. should be given preference in admitting M.S./ M.Phil. course. In that the student who have not done research work either at the level of B.S./ M.Sc. or M.S./ M.Phil. should not be allowed to take admission in Ph.D.
 - D. That the research activities need proper funding for field visits and laboratory investigations where means of transportation, appropriate equipments and chemicals are indispensable pre-requisites. Admission in research oriented degrees should be avoided if such facilities are lacking.
 - E. That the involvement of social sector is important but it should be confined to social science and not to pure as well as applied science. If we have to involve social sector then it should be under Corporate Social Responsibility (CSR) with the collaboration of industries so that spirit of scientific research may not be jeopardized. There should be a liaison among academia, industry and community so that research activities may focus on future needs of country and the nation pave the way towards self reliance.
 - F. That the culture of scientific research should not be curbed by involving community based interactions both in research grants and research works. Converting scientific research into social service is a clear contravention to its doctrine.
 - G. That the HEC-Pakistan may write to governmental, non governmental agencies and different stakeholders to create job opportunities for fresh graduates/ postgraduates of marine science. The HEC should also give equivalence certificates to graduates so that they may apply against various vacancies.

In the light of above facts the NCRC-HEC for marine science requests the HEC-Pakistan to make policies in accordance with the Biovision Championing Agenda 2030 of UN, wherein 17 Sustainable Development Goals (SDGs) were set in contrast to the

Millennium Development Goals (MDGs) for industrialised as well as developing and emerging countries. The MDGs were not beneficial for our country; therefore, we should follow the Biovision of SDGs.

GENERAL BIOLOGY (BIOL.-301)
LIST OF EXPERIMENTS FOR THE SESSION 2015 - 2016

S. No.	Inv. No.	Date	Experiment	Page	Signature
I	1		Microscope		
1.	1.1		To study and handle a compound microscope.		
2.	1.2		To calibrate a compound microscope for micrometry.		
II	2		Life forms		
3.	2.1		To introduce Phytography.		
4.	2.2		To study some plant specimens (Solanaceae & Mimosaceae).		
5.	2.3		To study some algal organisms (Field study, Seaweeds).		
6.	2.4		To study some animal specimens (Field study).		
III	3		Plasmolysis and Deplasmolysis		
7.	3.1		To study plasmolysis and deplasmolysis in plant cells.		
8.	3.2		To study plasmolysis and deplasmolysis in blood cells.		
IV	4		Gram Staining		
9.	4.1		To prepare a smear of bacterial culture and staining it.		
10.	4.2		To perform Gram staining to differentiate Gram positive and Gram negative bacteria.		
V	5		Study of Fungi		
11.	5.1		To prepare slide and identify the fungus from given culture.		
VI	6		Study of Cell Division		
12.	6.1		To study mitosis in onion root tip.		
13.	6.2		To study meiosis in Grasshopper testis.		
VII	7		Identification of Chemical Nature of Living Organisms		
14.	7.1		To determine R_f value of plant extract by chromatography.		
15.	7.2		To study the phenomenon of Imbibition in plant material.		
VIII	8		Biochemical Tests		
16.	8.1		To test the presence of glucose in plant material.		
17.	8.2		To test the presence of sucrose in plant material.		
19.	8.3		To test the presence of glucose in animal material.		
20.	8.4		To test the presence of sucrose in animal material.		
21.	8.5		To test the presence of cellulose in plant material.		
22.	8.6		To test the presence of carbohydrates in plant material.		
23.	8.7		To test the presence of proteins in plant material.		
24.	8.8		To test the presence of lipids in plant material.		
25.	8.9		To test the presence of carbohydrates in animal material.		
26.	8.10		To test the presence of proteins in animal material.		
27.	8.11		To test the presence of lipids in animal material.		
IX	9		Protein Digestion		
28.	9.1		To demonstrate protein digestion by enzyme pepsin.		
X	10.		Cytochemical Studies		
29.	10.1		To demonstrate DNA in Avian blood.		
30.	10.2		To demonstrate RNA in Avian blood.		
31.	10.3		To demonstrate DNA in Protozoa.		
32.	10.4		To demonstrate RNA in Protozoa.		