Republic of the Philippines
OFFICE OF THE PRESIDENT
COMMISSION ON HIGHER EDUCATION

CHED MEMORANDUM ORDER (CMO)
No. 49
Series of 2017

SUBJECT: POLICIES, STANDARDS AND GUIDELINES FOR THE BACHELOR OF SCIENCE IN BIOLOGY (BS BIO) PROGRAM

In accordance with the pertinent provisions of Republic Act (RA) No. 7722, otherwise known as the "Higher Education Act of 1994," in pursuance of an outcomes-based quality assurance system as advocated under CMO No. 46, s. 2012, and for the purpose of rationalizing the Biology education in the country by virtue of Commission en banc Resolution No. 231-2017 dated March 28, 2017, the following policies, standards and guidelines (PSGs) are hereby adopted and promulgated by the Commission.

ARTICLE I
INTRODUCTION

Section 1. Rationale

Based on the Guidelines for the Implementation of CMO No. 46, series of 2012, this PSG implements the "shift to learning competency-based standards/ outcomes-based education." It specifies the 'core competencies' expected of BS Biology graduates "regardless of the type of HEI they graduate from." However, in "recognition of the spirit of outcomes-based education and ... of the typology of HEIs," this PSG also provides "ample space for HEIs to innovate in the curriculum in line with the assessment of how best to achieve learning outcomes in their particular contexts and their respective missions ...."

ARTICLE II
AUTHORITY TO OPERATE

Section 2. Government Authority

All private higher education institutions (PHEIs) intending to offer Bachelor of Science in Biology (BS Bio) must first secure proper authority from the Commission in accordance with this PSG. All PHEIs with existing BS Biology program are required to shift to an outcomes-based approach. State universities and colleges (SUCs), and local colleges and universities (LUCs) should likewise strictly adhere to the provisions in these policies and standards.

ARTICLE III
GENERAL PROVISIONS

Per Section 13 of RA No. 7722, the higher education institutions shall exercise academic freedom in its curricular offerings but must comply with the minimum requirements for specific academic programs, the general education distribution requirements and the specific professional courses.

Section 3. The Articles that follow give minimum standards and other requirements and prescriptions. The minimum standards are expressed as a minimum set of desired program outcomes which are given in Article IV, Section 6. The CHED designed a curriculum to attain such outcomes. This curriculum is shown in Article V, Section 9 as a sample curriculum. The number of units of this curriculum is herein prescribed as the "minimum unit requirement" under Section 13 of RA 7722. In designing the curriculum the Commission employed a curriculum map which is shown in Article V, Section 10 as a sample curriculum map.

Using a learner-centered/outcomes-based approach the CHED also determined appropriate curriculum delivery methods shown in Article V, Section 11. The sample course syllabi given in Article V, Section 12 show some of these methods.

Based on the curriculum and the means of its delivery, the CHED determined the physical resource requirements for the library, laboratories and other facilities and the human resource requirements in terms of administration and faculty. See Article VI.

Section 4. The HEIs are allowed to design curricula suited to their own contexts and missions provided that they can demonstrate that the same leads to the attainment of the required minimum set of outcomes, albeit by a different route. In the same vein, they have latitude in terms of curriculum delivery and in terms of specification and deployment of human and physical resources as long as they can show that the attainment of the program outcomes and satisfaction of program educational objectives can be assured by the alternative means they propose.

The HEIs can use the CHED Implementation Handbook for Outcomes-Based Education (OBE) and the Institutional Sustainability Assessment (ISA) as a guide in making their submissions from sections in Article VII, Section 19.

ARTICLE IV
PROGRAM SPECIFICATIONS

Section 5. Program Description

5.1 Degree Name

The degree program described herein shall be called Bachelor of Science in Biology (BS Bio).

5.2 Nature of the Field of Study

Biology, as an academic discipline has broadened and diversified with the development of advanced laboratory equipment and sophisticated techniques in collaboration with chemists, physicists and engineers. This has led to a dynamic development of research in all levels of biological complexity from the molecules to ecosystems, where their properties and interactions are analyzed.

The original fear that education and training of biologists in such diversified specialized micro-areas of biology will create graduates unable to bridge the gap between low and high complexity levels seems to be unfounded, as long as a core program in the curriculum ensures the basic concepts of biology: structure/function; regulation; growth; development and evolution.

Biology programs offered in Philippine higher education institutions (HEIs) should be updated to integrate the latest trends in the teaching and the conduct of research in the field, and promote social responsibility. Thus it is imperative to set the minimum course requirements that all institutions nationwide offering the program must adopt to achieve this objective.

5.3 Program Goals

The BS Biology program is structured as a generalized framework of study with the end view of grounding students with the fundamental concepts, principles, and theories of the biological, natural and physical sciences and the conduct of research. This includes the acquisition of appropriate skills, and training in the efficient processing and presentation of information in both written and oral form.

The BS Biology program is structured to meet the needs of professional biologists who:

1. can be employed in government/ private institutions and other agencies where scientists with biological expertise are needed.
2. can engage in entrepreneurial activities.
3. conduct research in the various areas of biology.
4. undertake post graduate education in Biology and allied fields.
5. pursue a career in teaching.

5.4 Specific professions/careers/occupations or trades that BS Bio graduates may go into

The biological sciences present exciting and worthwhile career opportunities. With the wide range of areas of interest offered in the discipline, the workplaces are likewise varied from universities, zoos, hospitals, government, and laboratories in tropical rainforests to ocean depths.

A graduate of BS Biology may be engaged in basic and applied research where they can be employed as research assistants or biological laboratory technicians in government agencies, museums, zoos and aquaria, and private organizations. They can also go into industrial research work involving product development, management, or inspection particularly in agriculture, biotechnology, food and nutrition, pharmaceutical and other health care related industries.

The bachelor's degree is adequate for some non-research jobs such as testing and inspection, and technical sales or service representatives. Some private and non-government organizations also hire BS Biology graduates for advocacy and communication work involving science, technology and the environment. Graduates may also be engaged in biology-based industries such as production, food science and technology, management, marketing, and bioprospecting, public lectures and workshops, writing science articles in newspaper, magazines and books, production of educational software or multimedia applications, development of educational films and television programs, and collection, preservation and sale of biological specimens.

The program qualifies one to work as a teaching assistant in a college or university. With additional courses in education and passing of the Licensure Exam for Teachers, a BS Biology graduate can also be employed as a high school biology teacher.

5.5 Allied Fields

Biology is closely related to the fields of agriculture, fisheries, forestry, nutrition, medicine, veterinary medicine, animal and plant sciences, and environmental science.

Section 6. PROGRAM OUTCOMES

The minimum standards for the Bachelor of Science in Biology program are expressed in the following minimum set of learning outcomes:

6.1 Common to all baccalaureate programs in all types of institutions

a) Articulate the latest developments in their specific field of practice. (PQF level 6 descriptor)

b) Effectively communicate orally and in writing using both English and Filipino languages.
c) Work effectively and independently in multi-disciplinary and multi-cultural teams. (PQF level 6 descriptor)
d) Demonstrate professional, social, and ethical responsibility, especially in practicing intellectual property rights and sustainable development.
e) Preserve and promote "*Filipino historical and cultural heritage*" (based on RA No. 7722).

6. 2 Common to the Science and Mathematics Disciplines

f) Demonstrate broad and coherent knowledge and understanding in the core areas of physical and natural sciences.
g) Apply critical and problem solving skills using the scientific method.
h) Interpret relevant scientific data and make judgments that include reflection on relevant scientific and ethical issues.
i) Carry out basic mathematical and statistical computations and use appropriate technologies in (a) the analysis of data; and (b) in pattern recognition, generalization, abstraction, critical analysis and problem solving.
j) Communicate information, ideas problems and solutions, both, orally and in writing, to other scientists, decision makers and the public.
k) Relate science and mathematics to the other disciplines.
l) Design and perform safe and responsible techniques and procedures in laboratory or field practices.
m) Critically evaluate input from others.
n) Appreciate the limitations and implications of science in everyday life.
o) Commit to the integrity of data.

6.3 Specific to Bachelor of Science in Biology

p) Develop an in-depth understanding of the basic principles governing the science of life;
q) Utilize techniques/procedures relevant to biological research work in laboratory or field settings;
r) Apply basic mathematical and statistical computations and use of appropriate technologies in the analysis of biological data;
s) Extend knowledge and critically assess current views and theories in various areas of the biological sciences

6.4 Common to a horizontal type as defined in CMO No. 46, s. 2012

- For professional institutions: To promote service in one's profession
- For colleges: To participate in various types of employment, development activities, and public discourses particularly in response to the needs of the community one serves

- For universities: To participate in the generation of new knowledge or in research and development projects

Graduates of State Universities and Colleges must, in addition, have the competencies to support "national, regional and local development plans." (RA 7722)

The HEIs, at its option, may adopt mission-related program outcomes that are not included in the minimum set.

Section 7. Sample Performance Indicators

Performance indicators (PIs) assist in the evaluation of student learning or the achievement of the program outcomes. These are demonstrable traits developed not only through the core or discipline-specific courses but more importantly through their collective experiences.

To achieve the program outcomes, graduates of the BS Biology program are expected to possess a wide range of knowledge, skills and values as follows:

Table 1. Program Outcomes for a BS Biology graduate with corresponding sample performance indicator/s.

Program Outcomes	Performance Indicators
a) Articulate the latest developments in their specific field of practice	• Participate in continuing education and professional development in the specific field of practice
b) Effectively communicate orally and in writing using both the English/Filipino language.	• Demonstrate effective oral and written communication using both English and Filipino languages. • Exhibit adequate technical writing and oral communication abilities.
c) Work effectively in multi-disciplinary and multi-cultural teams.	• Work effectively as a member of multi-disciplinary & multi-cultural teams. • Display good judgment of people, actions and ideas and communicate them efficiently. • Demonstrate effective leadership, coordination and decision-making skills • Demonstrate productive project management skills
d) Demonstrate professional, social, and ethical responsibility, especially in practicing intellectual property rights.	• Articulate the contribution of one's profession to society and nation building. • Articulate the responsibilities of a Filipino citizen in relation to the rest of the world • Demonstrate respect for intellectual property rights • Explain professional knowledge and ethical responsibilities in the biological sciences
e) Preserve and promote Filipino historical and cultural heritage based on RA7722.	• Articulate one's possible contributions to society and nation building

Program Outcomes	Performance Indicators
f) Demonstrate broad and coherent knowledge and understanding in the core areas of the statistical theory and statistical modeling.	• Discuss extensive and articulate information in the core areas of Science and Mathematics.
g) Apply analytical, critical and problem solving skills using the Scientific Method.	• Employ problem solving skills using the Scientific Method; • Demonstrate critical thinking skills in solving problems; • Apply scientific reasoning analyzing biology-related issues
h) Interpret scientific data and reflect on relevant scientific and ethical issues.	• Recognize the importance of relevant scientific data. • Summarize information using reflection on important scientific and ethical issues.
i) Carry out basic mathematical and statistical computations and use appropriate technologies in (a) the analysis of data; and (b) In pattern recognition, generalization, abstraction, critical analysis and problem solving	• Perform appropriate suitable mathematical and statistical computations in data analysis • Utilize applicable technologies in all scientific processes
j) Communicate information, ideas problems and solutions both, orally and in writing, to other scientists, decision makers and the public.	• Demonstrate technical writing and public speaking abilities • Disseminate information, ideas, problems & solutions to fellow scientists, decision makers and the public. • Participate actively in scientific forum and public discussions.
k) Connect science and math to the other disciplines.	• Apply scientific advancements in ways that are deeply meaningful to other disciplines. • Propose solutions to biological problems based on interdisciplinary knowledge
l) Design and perform techniques and procedures following safe and responsible laboratory or field practices.	• Design suitable and appropriate experimental methods and protocols • Practice responsible laboratory & field practices that follow proper techniques & procedures. • Demonstrate precision in making observations and in distinguishing differences between samples and events • Employ appropriate and correct experimental design • Demonstrate proper animal handling practices etc. • Follow industry standards and national laws
m) Accepts and critically evaluates input from others.	• Discern significant inputs from other disciplines. • Critically evaluate data and information.
n) Appreciate the limitations and implications of science in everyday life	• Acknowledge scientific facts as part of everyday life.
o) Commit to the integrity of data.	• Adhere to data integrity. • Report results and data as honestly as possible.
p) Develop an in-depth understanding of the basic principles governing the	• Explain key concepts and theories in biology specifically in morpho-anatomy, physiology,

Program Outcomes	Performance Indicators
science of life.	systematic biology, developmental biology, genetics, ecology, microbiology and cell and molecular biology
q) Utilize techniques/procedures relevant to laboratory or field work research settings.	• Make an accurate and precise observations • Design proper/correct experiments for particular tasks. • Perform proper animal handling practices etc. • Knowledgeable and compliant of national laws and industry standards regarding laboratory work.
r) Carry out basic mathematical and statistical computations and use of appropriate technologies in the analysis of biological data	• Perform statistical techniques commonly used for analyzing biological data (e.g. T-test, ANOVA, std deviation, uncertainty of measurement) • Choose appropriate statistical tests for a given dataset.
s) Extend knowledge and critically assess current views and theories in selected areas of the biological science.	• Develop an objective viewpoint for discerning information. • Participate in scientific conferences and/or meetings of professional organizations

Table 2. Abilities and Skills of BS Biology Graduates with Corresponding Assessment Mechanisms

Abilities and Skills	Sample Assessment
Biology-related Cognitive Abilities and Skills	
• Conceptual understanding of the fundamentals of biology and chemistry, earth science, mathematics and physics	• Diagnostic Exam, Post-Test • Written reports and essays • Problem Solving Exercises • Examinations
• Critical Thinking and complex problem solving skills	• Journal review • Problem Solving Exercises • Examinations on Experimental Design
• Mathematical Skills and Reasoning	• Problem Solving Exercises • Examinations on Experimental Design
Biology-related Practical Skills	• Capstone/special project • Presentations • Thesis • Portfolio of student work • publication or short communications
• Biological Laboratory Skills	• Practical laboratory exams • Field work • Research Projects • Practicum/OJT
• Preparation of basic biological specimens, including handling and processing	• Practical laboratory exams • Field work • Research Projects

Abilities and Skills	Sample Assessment
• Proper use of biological and chemical instrumentation	• Practical laboratory exams • Field work • Research Projects
• Basic laboratory and field research procedures and safety practices	• Practical laboratory exams • Field work • Research Projects • Practicum/OJT
• Sampling design, procedures and processing techniques	• Practical exams • Field work • Research Projects • Practicum/OJT
• Experimental Design and testing	• Research Proposal Writing • Research Projects • Practicum/OJT
• Data and Information gathering, processing and assessment	• Field work • Practicum/OJT • Research Projects • Thesis • Manuscript writing
• Basic monitoring by observation and measurement of biological characteristics	• Field work • Practicum/OJT • Research Projects • Thesis
General Skills	
• Communication and comprehension skills both oral and written	• Public Performance or presentation • videotaped or audio taped performance • written reports • manuscript publication
• Interpersonal and organizational skills	• Active participation in group projects • Membership in academic organizations
• Administrative and Management Skills (Leadership and Decision-Making)	• Active participation in group projects
• Quality Assurance and Assessment	
• ICT Utilization	
• Continuing Professional Development/Lifelong Learning	• Participation in scientific conferences
• Ethical principles	• Involvement in socially relevant projects • Appropriate citations in written manuscript

ARTICLE V
CURRICULUM

Section 8. Curriculum Description

The curriculum below presents a balanced treatment of all branches of biology with the inclusion of recent advances in biology such molecular biology. It does not emphasize a particular specialty such as those in ecology, microbiology, zoology or botany. Institutions may opt to implement a specialty when resources are available.

Section 9. Sample Curriculum

9.1 Curriculum Components

The components of the BS Biology curriculum are listed in Table 3 together with the minimum number of units in each component.

Table 3. Components of the BS Bio curriculum and their corresponding units

COMPONENTS	UNITS
a. General Education Curriculum	***36***
b. Biology Tool Courses	***18***
c. Fundamental Courses	***50***
d. Specialization Courses	***25***
e. Free Electives	***6***
f. Undergraduate Thesis	***6***
g. Practicum or On-The-Job Training or equivalence or apprenticeship	***3***
h. Physical Education (PE)	**8**
i. National Service Training Program (NSTP)	**6**
Total	***158***

9.1.1 General Education (GE) Courses

The GE is based on CHED Memorandum Order No. 20 series of 2013, entitled "General Education Curriculum: Holistic Understandings, Intellectual and Civic Competencies" and has a minimum of thirty six (36) units. Listed in Table 4 are the general education courses and their corresponding units.

Table 4. General Education courses per CMO No. 20, series of 2013

Core courses (24 units)	
1. Understanding the Self (Nature of identity)	3 units
2. Readings in Philippine History	3 units
3. Mathematics in the Modern World (application of mathematics in daily life)	3 units
4. Purposive Communication (Writing, speaking and presenting to different audiences)	3 units
5. Art Appreciation	3 units
6. Science, Technology and Society	3 units
7. Ethics	3 units
8. The Contemporary World (Globalization and its impact on individuals, communities and nations)	3 units
Elective courses (9 units)	
9. Mathematics, Science and Technology (e.g. Environmental Science)	3 units
10. Arts and Humanities (e.g. Great Books)	3 units
11. Social Sciences and Philosophy (e.g. Entrepreneurship)	3 units
Rizal course (3 units)	**3 units**
TOTAL	**36 units**

9.1.2 Biology Tool Courses (18 units)

The biology tool courses component has a total of 18 units. These are courses in other basic science fields needed to enhance the understanding of biology concepts.

Table 5. Biology Tool Courses

AREA	COURSES	Lec	Lab	Units
Chemical Biology	Chemical Biology I (Organic Molecules)	2	1	3
	Chemical Biology II (Analytical Methods for Biology)	2	1	3
	Chemical Biology III (Biomolecules)	3	2	5
BioPhysics	Biophysics	2	2	4
Biostatistics	Statistical Biology	2	1	3
	TOTAL			**18**

9.1.3 Fundamental Courses (50 units)

The fundamental courses are the basic, foundation courses in biology covering essential topics. Laboratory is required in all courses.

Table 6. Fundamental Courses

COURSES	Units
General Botany	5
General Zoology	5
General Ecology	5
General Physiology	5
Systematics	5
Developmental Biology (Plants and Animals)	5
Genetics	5
Evolutionary Biology	5
Microbiology	5
Cell and Molecular Biology	
Total Units	**50**

9.1.4 Specialization Courses (25 units)

Specialization courses are the courses that provide in-depth knowledge in various branches of biology and may concentrate on specific themes that the HEI may choose. Below is a list of suggested areas of study where HEIs may choose to offer as their specialization. Other areas of biology may be included.

Table 7. List of suggested specialization courses.

(Number of lecture and laboratory units totaling 25 units shall be left to the discretion of the institution.)

Field of specialization	Suggested courses
Cellular and Molecular Biology	Immunology Recombination DNA Techniques Radiation Biology Molecular Genetics Molecular Systematics Bioinformatics Genomics and Proteomics
Medical Biology	Medical Entomology Medical Parasitology Human Anatomy and Physiology Epidemiology Immunology

Field of specialization	Suggested courses
	Medical Histology Medical Microbiology Radiation Biology Human Genetics BioSocial Genetics
Microbiology	Virology Microbial Taxonomy Microbial Physiology Microbial Ecology Microbial Genetics Industrial Microbiology Food Microbiology Pathology Epidemiology
Plant Biology	Mosses, Hepatics, Ferns Ethnobotany Economic Botany Plant Physiology Plant Morphoanatomy Plant Growth and Development Taxonomy of Higher Vascular Plants
Systematic Biology	Molecular Systematics Phylogenetics Population Genetics Bioinformatics Evolutionary Systematics
Developmental Biology	Animal Development Plant Development Cellular Physiology Developmental Genetics Reproductive Biology
Ecology	Population Ecology Behavioral Ecology Community Ecology Freshwater Ecology Marine Ecology Terrestrial Ecology Biological Resource Management

Field of specialization	Suggested courses
Biotechnology	Health Biotechnology Agricultural Biotechnology Industrial Biotechnology Food Biotechnology Molecular Genetics Bioprocessing Tissue Culture Bioinformatics Genomics and Proteomics
Animal Biology	Comparative Vertebrate Anatomy Developmental Zoology Animal Physiology Invertebrate Zoology Protozoology Herminthology Nematology Entomology Malacology Acarology Parasitology
Genetics	Cytogenetics Molecular Genetics Human Genetics Microbial Genetics Population and Quantitative Genetics Developmental Genetics Biosocial Genetics

HEIs may offer majors and courses depending on their areas of strength and available resources

9.1.5 Free Electives (6 units)

The number of units assigned to the electives is left to the discretion of the institution. May include but not limited to Education, BioEntrepreneurship, and Management courses.

9.1.6 Undergraduate Thesis (6 units)

Thesis includes a seminar course which shall be offered in any term during the last two years of the program. Undergraduate seminar may either be a presentation of the students' Thesis proposal or a progress report of their Thesis work.

9.1.7 Practicum or On-The-Job Training or Equivalent or Apprenticeship (3 units)

Minimum of 150 hours and may be offered during Summer before Senior Level.

9.2 Sample Program of Study

The program of study herein is only an example. HEIs may use this sample and modify it according to its needs. They may also add other preferred courses.

Table 8. Sample program of study and recommended sequence of courses

Year	Course (First Semester)	Units	Year	Course (Second Semester)	Units
1	General Botany	5	1	Systematics	5
	General Zoology	5		Chemical Biology I (Organic Molecules)	3
	GE 1 (Understanding the Self)	3		Statistical Biology	3
	GE 2 (Readings in Philippine History)	3		GE 4 (Purposive Communication)	3
				GE 5 (Art Appreciation)	3
	GE 3 (Mathematics in the Modern World)	3		Physical Education II	2
				NSTP II	3
	Physical Education I	2		Total	**22**
	NSTP I	3			
	Total	**24**			
2	Microbiology	5	2	Chemical Biology III (Biomolecules)	5
	General Ecology	5			
	Chemical Biology II (Analytical Methods for Biology)	3		Evolutionary Biology	5
				Genetics	5
				GE 8 (The Contemporary World)	3
	GE 6 (STS)	3		Physical Education IV	2
	GE 7 (Ethics)	3		Total	**20**
	Physical Education III	2			
	Total	**21**			
3	Cell and Molecular Biology	5	3	Biophysics	4
	General Physiology	5		Developmental Biology	5
	GE 9 (MST)	3		Specialization Course I	5
	GE 10 (Arts and Humanities)	3		GE 11 (Social Sciences and Philosophy)	3
	Rizal Course	3		Thesis I	2
	Total	**19**		Total	**19**
SUMMER Practicum 3 units					
4	Specialization Course II	5	4	Specialization Course IV	5
	Specialization Course III	5		Specialization Course V	5
	Thesis II	2		Thesis III	2
	Free Elective I	3		Free Elective II	3
	Total	**15**		Total	**15**

Section 10. Curriculum Map and Course Map

Based on the required minimum set of program outcomes, the CHED has determined a program of study that leads to the attainment of the outcomes. This program of study specifies a set of courses sequenced based on flow of content, with each course having a specified title, description, course outcome and credit unit. For this purpose, a sample curriculum map (Annex A) is included as part of the PSGs. It is a matrix of all courses and the minimum set of program outcomes showing which outcome each course addresses and in what way. The map also determines whether the outcomes are aligned with the curriculum.

Higher education institutions shall formulate its curriculum map based on its own set of program outcomes and courses. A sample curriculum map can be found in **Annex A.**

Section 11. Sample Means of Curriculum Delivery

The department can employ a range of instructional methods that are particularly suited to the biological sciences. Use of variety of appropriate teaching/learning methods and strategies based on learning objectives, learner characteristics, involvement of community, time requirements, community dynamics and policies, available resources and instructional setting should be considered.

Some sample delivery schemes/learning methods which can also become means of assessing outcomes include:

- Selection of relevant biological topics and issues
- Fieldwork: hands-on observation and discovery in the environment
- community-based action research and problem solving
- simulations and models
- case studies
- classroom discussion of current environmental issues
- Capstone/Special projects
- Journal Review
- Written Report/Essays
- Thesis
- Practicum or on-the job training,
- Public performance or presentation: written report, videotaped or audio taped performances
- Participation in scientific conferences
- Field work

Section 12. Sample Syllabi for Core Biology Courses

The course specifications provided in this CMO in Annex B apply only to the core courses and indicate the minimum topics to be covered in each area. The HEIs shall formulate the syllabus for all the courses in their respective BS Biology program.

HEIs may follow their own course specifications in the implementation of the program but must not be less than those specified for the major courses.

It is suggested that the introductory and/or concluding part of each course present an informative survey of advances and prospects in this area in order to elicit more interest from the student. The course must continue to impart skills to the student through field work or hands on experience.

ARTICLE VI
REQUIRED RESOURCES

Section 13. Administration

The minimum qualifications of the head of the unit that implements the degree program are the following:

13.1 Dean of the unit/college

The dean of a unit/college must be at least a Ph.D. holder in the sciences and mathematics disciplines for which the unit/college offers a program; and a holder of a valid certificate of registration and professional license, where applicable.

13.2 Head of the biology unit/department

The head of the unit/department must have, at least, a Master of Science degree in Biology or a post graduate degree in an allied program identified in the policies and standards; and a holder of a valid certificate of registration and professional license, where applicable.

Section 14. Faculty

14.1 General Requirements

a. As a rule, a master's degree in the discipline or its equivalent is required for teaching in the tertiary level.
b. At least 50% of the full-time faculty must have a Master's degree in the discipline or its equivalent.

14.2 Qualification of faculty

Faculty teaching in a BS Biology program must have an appropriate master's degree in Biology or in any of the allied fields in Article IV Section 5.5.

14.3 Full time faculty members

The institution shall maintain 50% of the faculty members teaching in the BS Biology program as full time.

14.4 Teaching Load

A faculty for the BS Biology program should not be assigned more than four (4) different courses/subjects within a semester.

14.5 Faculty Development

The institution must have a system of faculty development. It should encourage the faculty to:

a. pursue graduate studies
b. undertake research activities and publish their research output
c. give lectures and present papers in national/international conferences, symposia and seminars
d. attend seminars, symposia and conferences for continuing education

The institution must provide opportunities and incentives such as:

a. tuition subsidy for graduate studies
b. study leave with pay
c. deloading to finish a thesis or to carry out research activities/extension services
d. travel grants for academic development activities such as special skills training and attendance in national/ international conferences, symposia and seminars.
e. awards & recognition

Section 15 Library

Library personnel, facilities and holdings should conform to existing requirements for libraries which are embodied in a separate CHED issuance.

The HEI is likewise encouraged to maintain periodicals and other non-print materials relevant to environmental science to aid the faculty and students in their academic work. CD-ROMs could complement a library's book collection but should otherwise not be considered as replacement for the same.

Internet access is encouraged but should not be made a substitute for book holdings (hard or soft copies) and/or on-line subscription of books and journals.

Libraries shall participate in inter-institutional activities and cooperative programs whereby resource sharing is encouraged.

Section 16. Laboratory and Physical Facilities

HEIs should provide the appropriate facilities and equipment to ensure the effective delivery of the courses and achievement of program outcomes. There should be a system of updating and enhancing the needed facilities, computing software and equipment to be provided to the students.

ARTICLE VII
QUALITY ASSURANCE

Section 17. Assessment and Evaluation

The institution/department shall have in place a program assessment and evaluation system. The HEI must show this in their syllabi and catalogue. Institutions may refer to the CHED Implementation Handbook for Outcome-Based Education (OBE) and the Institutional Sustainability assessment (ISA) for guidance.

Section 18. Continuous Quality Improvement (CQI) Systems

The HEI shall maintain at all times a high standard of instruction and delivery through the establishment of a program level Continuous Quality Improvement system. Institution/department must show organizational and process plans, and implementation strategies. Institutions may refer to the CHED Implementation Handbook for Outcome- Based Education (OBE) and the Institutional Sustainability assessment (ISA) for guidance.

Section 19. CHED Monitoring and Evaluation

The CHED, in harmony with existing guidelines on monitoring and evaluation, shall conduct regular monitoring on the compliance of respective HEIs to this PSG. An outcomes-based assessment instrument shall be used during the conduct of monitoring and evaluation.

Using the CHED Implementation Handbook for OBE and ISA as reference, an HEI shall develop the following items which will be submitted to CHED when they apply for a permit for a new program:

1. The complete set of **program outcomes**, including its proposed additional program outcomes.
2. Its proposed **curriculum** and its justification including a **curriculum map.**

3. Proposed **performance indicators** for each outcome. Proposed **measurement system** for the level of attainment of each indicator.
4. Proposed **outcomes-based syllabus** for each course.
5. Proposed **system of program assessment and evaluation**
6. Proposed **system of program Continuous Quality Improvement** (CQI).

ARTICLE VIII
TRANSITORY, REPEALING AND EFFECTIVITY PROVISIONS

Section 20. Transitory Provision

All private HEIs, state universities and colleges (SUCs) and local universities and colleges (LUCs) with existing authorization to operate the Bachelor of Science in Biology program are hereby given a period of three (3) years from the effectivity thereof to fully comply with the requirements in this CMO. However, the prescribed minimum curricular requirements in this CMO shall be implemented starting Academic Year 2018-2019.

Section 21. Repealing Clause

All CHED issuances, rules and regulations or parts thereof, which are inconsistent with the provisions of this CMO, are hereby repealed.

Section 22. Effectivity Clause

This CMO shall take effect fifteen (15) days after its publication in the Official Gazette, or in a newspapers of general circulation. This CMO shall be implemented beginning Academic Year 2018-2019.

Section 23. References

These policies, standards and guidelines for the BS Biology program were in reference to CHED Memorandum Order Number 24 Series 2005.

Quezon City, Philippines, May 18 2017.

For the Commission:

PATRICIA B. LICUANAN, Ph.D.
Chairperson

Attachments:

Annex A – Curriculum Mapping
Annex B – Course Specifications

ANNEX A

CURRICULUM MAPPING - BS BIOLOGY

PROGRAM OUTCOMES

At the end of this program, the students are expected to be able to:

1. Common to all baccalaureate programs in all types of institutions

The graduates have the ability to

a) articulate the latest developments in their specific field of practice. (PQF level 6 descriptor)
b) effectively communicate orally and in writing using both English and Filipino languages.
c) work effectively and independently in multi-disciplinary and multi-cultural teams. (PQF level 6 descriptor)
d) demonstrate professional, social, and ethical responsibility, especially in practicing intellectual property rights and sustainable development.
e) preserve and promote "*Filipino historical and cultural heritage*". (based on RA 7722)

2. Common to the Science and Mathematics Discipline

f) Demonstrate broad and coherent knowledge and understanding in the core areas of physical and natural sciences.
g) Apply critical and problem solving skills using the scientific method.
h) Interpret relevant scientific data and make judgments that include reflection on relevant scientific and ethical issues.
i) Carry out basic mathematical and statistical computations and use appropriate technologies in (a) the analysis of data; and (b) in pattern recognition, generalization, abstraction, critical analysis and problem solving.
j) Communicate information, ideas problems and solutions, both, orally and in writing, to other scientists, decision makers and the public.
k) Relate science and mathematics to the other disciplines.
l) Design and perform safe and responsible techniques and procedures in laboratory or field practices.
m) Critically evaluate input from others.
n) Appreciate the limitations and implications of science in everyday life.
o) Commit to the integrity of data.

3. **Specific to Bachelor of Science in Biology**

The graduates of the BS Biology program should be able to:

p) develop an in-depth understanding of the basic principles governing the science of life;
q) develop and utilize techniques/procedures relevant to biological research work in laboratory or field settings;
r) carry out basic mathematical and statistical computations and use of appropriate technologies in the analysis of biological data;
s) extend knowledge and critically assess current views and theories in various areas of the biological sciences.

ANNEX A. CURRICULUM MAPPING - BS BIOLOGY

COURSES	RELATIONSHIP OF COURSES TO PROGRAM OUTCOME																		
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
A. General Education Courses																			
General Education Core Courses																			
1. Understanding the Self (Nature of identity)																			
2. Readings in Philippine History																			
3. Mathematics in the Modern World (application of mathematics in daily life)																			
4. Purposive Communication (Writing, speaking and presenting to different audiences)																			
5. Art Appreciation																			
6. Science, Technology and Society																			
7. Ethics																			
8. The Contemporary World (Globalization and its																			

COURSES	RELATIONSHIP OF COURSES TO PROGRAM OUTCOME																		
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
impact on individuals, communities and nations)																			
General Education Elective Courses																			
9. Mathematics, Science and Technology (e.g. Environmental Science)																			
10. Arts and Humanities (e.g. Great Books) Social Sciences and Philosophy (e.g. Entrepreneurship)																			
11. Social Sciences and Philosophy (e.g. Entrepreneurship)																			
Rizal Course																			
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
B. Biology Tool Courses																			
Chemical Biology																			
Chemical Biology I (Organic Molecules)			*L*	*O*			*L*	*L*	*P*	*L*	*P*	*L*	*L*	*O*	*L*	*L*			
Chemical Biology II (Analytical Methods for Biology)			*L*	*O*			*L*	*L*	*P*	*L*	*P*	*L*	*L*	*O*	*L*	*L*			
Chemical Biology III (Biomolecules)			*L*	*O*			*L*	*L*	*P*	*L*	*P*	*L*	*L*	*O*	*L*	*L*			
Biophysics																			
Biophysics			*L*	*O*			*L*	*L*	*P*	*L*	*P*	*L*	*L*	*O*	*L*	*L*			
Biostatistics																			
Statistical Biology							*L*		*L*		*O*								
C. Fundamental Courses																			
General Botany	*L*	*P*	*P*	*P*		*L*	*L*	*P*	*L*	*L*	*L*			*L*	*L*	*P*	*P*	*L*	*P*

COURSES	RELATIONSHIP OF COURSES TO PROGRAM OUTCOME																		
	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
General Zoology	L	P	P	P		L	L	P	L	L	L			L	L	P	P	L	P
General Ecology	L	P	P	P		L	L	P	L	P				L		P	P	L	P
General Physiology	L	P	P	P		L	L	P	L	P		L		L	L	P	P	L	P
Systematics	L	P	P	P		L	L	L		P		L	L	L	L	P	P	L	P
Developmental Biology	L	P	P	P		L	L	P	L	P			L	L	L	P	P	L	P
Genetics	L	P	P	P		L	L	P	L	P				L		P	P	P	P
Evolutionary Biology	L	P	P	P		L	L	L		P		L	L	L	L	P	P	L	P
Microbiology	L	P	P	P		L	L	P	L	P				L		P	P	P	P
Cell and Molecular Biology	L	P	P	P		L	L			P						P	P	P	P
D. Specialization Courses*																			
E. Free Electives*																			
F. Undergraduate Thesis	L	P	P	P		P	P	P	P	P	P	P	P	L	P	P	P	P	P
G. Practicum or On-The-Job Training or equivalent or apprenticeship	L	P	P	P		P	P	P	P	P	P	P	P	L	P	P	P	P	P

L: *facilitates learning of competency*
P: *allows student to practice competency (no input, but competency is evaluated)*
O: *opportunity for development (no input or evaluation, but competency is practiced)*

**The competencies for free electives and specialization courses will be defined by the institution.*

ANNEX B. COURSE SPECIFICATIONS

BS BIOLOGY

Sample Core Course Syllabi

SYSTEMATICS

A. Course Details

COURSE NAME	**Systematics**
COURSE DESCRIPTION	Scientific study of the kinds and diversity of organisms (populations, species and higher taxa) and the relationships among them, determination by means of comparison of what the unique properties of each species and higher taxa are, properties certain taxon have in common and biological causes of the difference or shared characteristics, study of variation within taxa.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Zoology (5 units lecture and laboratory) General Botany (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	**PROGRAM OUTCOME**																		
At the end of this course, the students should be able to:	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**
describe the history, roles and significance of Taxonomy and Systematics to other fields of Science.	✓	✓				✓	✓	✓		✓						✓			✓
describe the taxonomic characters of the different organisms and provide mastery	✓	✓				✓	✓	✓		✓			✓		✓	✓	✓	✓	✓

on the use and determination of taxonomic (diagnostic) characters as major tools for classification and identification.																		
effectively describe the distinctive features, classify and name the major groups of organisms; and understand and appreciate the diversity of the different organisms.	✓	✓				✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓
classify organisms into groups that reflect evolutionary relationships.	✓	✓				✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓
effectively apply the rules and procedure of classification and nomenclature.	✓	✓				✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓
construct cladograms, phenograms and phylograms in describing relationships among organisms.	✓	✓				✓	✓	✓	✓	✓			✓		✓	✓	✓	✓	✓
appreciate and employ Taxonomy as a tool in Systematics	✓	✓				✓	✓	✓		✓					✓	✓	✓	✓	✓
distinguish among the schools of Systematics (Cladistics, Phenetics and Evolutionary Taxonomy)	✓	✓				✓	✓	✓	✓	✓					✓	✓	✓	✓	✓
At the end of the laboratory course, the students should be able to:																			
describe the taxonomic characters of the	✓	✓					✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓

different organisms and provide mastery on the use and determination of taxonomic (diagnostic) characters as major tools for classification and identification																		
effectively describe, classify and name organisms, understand and appreciate the diversity of different organisms (monerans, protists, fungi, plants, and animals).	✓	✓					✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
effectively apply the rules and procedures of classification and nomenclature.	✓	✓					✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
classify organisms into groups that reflect evolutionary relationship. a. Construct cladograms, phenograms and phylograms in describing relationships among organisms. b. To appreciate and employ taxonomy as a tool of Systematics	✓	✓					✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
provide students' exposure to representative groups of organism (plants and animals) their identification, classification and nomenclature.	✓	✓					✓	✓	✓	✓		✓	✓			✓	✓	✓	✓
learn some basic statistical tools in describing	✓	✓					✓	✓	✓	✓					✓	✓			

morphological diversities among organisms.																		
construct cladograms, phenograms, and phylograms in describing relationships among organisms.	✓	✓				✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

C. Lecture Course Outline (2013 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1-2	Introduction A. History of Life on Earth 1. Geological Time Scale 2. Origin of Life 3. Features of the Earliest Organisms 4. Extinction	Lecture Classes	Written Examination
3-4	Systematics and Taxonomy 1. Definition of Terms 2. Scope and aims of Systematics A. Seven component fields that systematic encompassed 3. Contributions to other fields in Biology 4. Roles and products of Systematics in Modern Biology 5. History of Taxonomy	Lecture Classes	Written Examination
5-6	Microtaxonomy A. Species concepts and speciation B. Variation of species	Lecture Classes Exercises Group Reporting and Discussion	Written Examination Exercises Reports
7-10	Macrotaxonomy A. Some basic principles of classification B. Taxonomic characters C. Rules and procedures of classification and nomenclature a. Hierarchial classification (Linnaean) D. Diversity of Life 1. Kingdom systems: 2-, 3-, 4-, 5-, etc.	Lecture Classes Exercises Group Reporting and Discussion	Written Examination

	2. Survey to the 5- Kingdom system a. Monera b. Protista c. Fungi d. Plantae e. Animalia		
11-16	Three Schools of Systematics A. Phenetics B. Cladistics C. Evolutionary Classification	Lecture Classes Exercises Group Reporting and Discussion	Written Examination
17-18	Modern Approaches and Tools in Studying Systematics	Lecture Classes Group Exercises	Written Examination Exercises Reports

D. Laboratory Course Outline (2005 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1	The Plant and Stem	Laboratory Exercise	Laboratory Report Practical Examinations
1	The Leaf	Laboratory Exercise	Laboratory Report Practical Examinations
2	The Flower and the Inflorescence	Laboratory Exercise	Laboratory Report Practical Examinations
2	The Stamen and Carpel and the Cross Floral Diagram	Laboratory Exercise	Laboratory Report Practical Examinations
3	The Fruit and Seed	Laboratory Exercise	Laboratory Report Practical Examinations
4	Family 1 (Dicot)	Laboratory Exercise	Laboratory Report Practical Examinations
4	Family 2 (Monocot)	Laboratory Exercise	Laboratory Report Practical Examinations
5	Family 3 (Gymnosperm)	Laboratory Exercise	Laboratory Report Practical Examinations
5	Family 4 (Fern)	Laboratory Exercise	Laboratory Report Practical Examinations
6	Family 5 (Coral)	Laboratory Exercise	Laboratory Report Practical Examinations
6	Family 6 (Mollusc)	Laboratory Exercise	Laboratory Report Practical Examinations
7	Family 7 (Arthropod)	Laboratory Exercise	Laboratory Report Practical Examinations

7	Family 8 (Echinoderm)	Laboratory Exercise	Laboratory Report Practical Examinations
8	Family 9 (Fish)	Laboratory Exercise	Laboratory Report Practical Examinations
8	Family 10 (Amphibian)	Laboratory Exercise	Laboratory Report Practical Examinations
9	Family 11 (Reptile)	Laboratory Exercise	Laboratory Report Practical Examinations
9	Family 12 (Bird)	Laboratory Exercise	Laboratory Report Practical Examinations
10	Family 13 (Mammal)	Laboratory Exercise	Laboratory Report Practical Examinations
	Constructing and Using Dichotomous Keys	Laboratory Exercise	Laboratory Report
	Phenetics	Laboratory Exercise	Laboratory Report Special Problem
	Cladistics	Laboratory Exercise	Laboratory Report Special Problem
	Application of Geometric Morphometric in Biology	Laboratory Exercise	Laboratory Report Special Problem
	Statistical Tools and its Application to Systematics	Laboratory Exercise	Laboratory Report Special Problem

E. Learning Resources (2005 version)

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GENETICS

A. Course Details

COURSE NAME	**Genetics**
COURSE DESCRIPTION	Mechanism of heredity and variation, cytogenetics, mutation, nature of genes, population genetics, quantitative genetics, human genetics and evolutionary genetics; biometrical procedures.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Botany (5 units lecture and laboratory) General Zoology (5 units lecture and laboratory)
Co-Requisite	Biomolecules (5 units lecture and laboratory)

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	**PROGRAM OUTCOME**																	
At the end of this course, the students should be able to:	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**
illustrate the chromosomal behavior during mitosis and meiosis in somatic and germ cells.	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓		✓		✓
understand the basic concepts underlying heredity and variation in Mendelian and non-Mendelian inheritance.	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓	✓
connect the structure of DNA to its functions	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

and the mechanisms by which it fulfills them.																		
describe the molecular process of gene expression from DNA to protein.	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
compare and contrast prokaryotic and eukaryotic gene expression.	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓
understand the sources of variation in individuals and population basic principles in genetic manipulation of organism through genetic engineering or recombinant DNA technology.	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
understand quantitative inheritance and its applications	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
understand mechanisms of inheritance in humans, use of pedigrees, understanding genetic control of selected genetic disorders	✓	✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓
understand genetic mechanisms in understanding evolutionary process	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C. Course Outline

Weeks	Topic/s	Common Teaching Strategies	Common Assessment/ Evaluation
Lecture			
1	Genetics: The Science of Heredity and Variation A. Definition of Genetics B. The beginnings of Genetics C. The Scope of Genetics D. Application of Genetics	Lecture Oral Discussion	Quiz, Written Examination

2	The Chromosomes Basis of Heredity A. The Cell B. The Chromosome Structure C. Cell Division 1. Mitosis 2. Meiosis D. Life Cycles 1. Terminal or Gametic Meiosis 2. Intermediary or Sporic Meiosis 3. Initial or Zygotic Meiosis	Lecture Visualization Group demonstration	Quiz Written Examination
3	Gene Segregation and Integration A. Law of Segregation B. Law of Independent Assortment C. Segregation and Assortment in Haploid Organism D. Dominance Relationship 1. Complete Dominance 2. Incomplete or No Dominance 3. Overdominance 4. Co-dominance E. Multiple Alleles F. Lethal Genes 1. Recessive Lethals 2. Dominant Lethals G. Modifier Genes H. Gene Interactions 1. Novel Phenotypes 2. Recessive Epistasis 3. Dominant Epistasis 4. Complementary Genes 5. Duplicate Genes I. Pseudoalleles J. Environmental Influence on Gene Expression 1. Definition of Terms 2. External Environmental 3. Internal Environmental K. Twin Studies: Concordance and Discordance L. Probability and Statistical Testing 1. Level of Significance 2. Chi-Square Test	Board work Problem solving Drill and Practice	Written Examination Homework/Worksheet
4	Linkage and Recombination A. Definition of Linkage B. Determination of Linkage C. Chromosome Mapping: Linkage Maps D. Factors Affecting Recombination Frequencies E. E. Mechanisms of Crossing Over	Lecture Drill and Practice Board work	Written Examination Homework/Worksheet

	F. Sex Determination G. Sex Linkage		
5	The Chemical Basis of Heredity A. The Concept of the Gene B. Chemical Composition of the Chromosome C. DNA as the Genetic Material D. Chemical Composition of the DNA E. Molecular Structure of DNA F. Organization of DNA in Chromosomes 1. Prokaryotic Chromosomes 2. Eukaryotic Chromosomes G. Replication or Synthesis of DNA 1. Mode of Replication 2. Process of DNA 3. Replication 4. Confirmation of DNA 5. Replication H. Error Correction in DNA Replication I. RNA as the Genetic Material	Lecture Group activity Visualization	
6	Gene Function: Proteins and Enzymes A. Genetic Control of Proteins 1. Gene – Enzyme Relationship 2. Inborn Errors of Metabolism 3. One-Gene – One-Enzyme Hypothesis 4. Protein Structure 5. Colinearity of DNA and Proteins B. Protein Synthesis 1. Central Dogma of Molecular Biology 2. General Information Transfers 1.1 Transcription 1.2 Translation 3. Special Information Transfers 4. Interrupted Genes C. The Genetic Code 1. The Triplet Code 2. The Universality of the Genetic Code D. Regulation of Gene 1. Regulation of Gene Action in Prokaryotes 1.1 Definition of Terms 1.2 Negative Transcriptional Control	Lecture Group activity Visualization	Written Examination Oral Discussion

	Systems 1.3 Positive Transcriptional Control Systems 2. Regulation of Gene Action in Eukaryotes 1.1 The Britten-Davidson Model 1.2 Control of Specific Gene Expression by Hormones		
7	Genes in Development A. Differential Gene Action 1. The Basis of Cell Differentiation 2. Gene Amplification 3. Transcriptional Control 4. Translational Control 5. Epigenetic Control Mechanism B. Neoplasmic Interactions 1. Molecular Exchanges Between Nucleus and Cytoplasm 2. Control of Macromolecular Synthesis in the Nucleus by the Cytoplasm C. Genes and Morphogenesis 1. Gene Effects on System of Embryonic Induction 2. Gene Effect on Endocrine Systems 3. Gene Effects on Migrating Cells 4. Gene Effects on the Regulation of Growth and Metabolism	Lecture Visualization Oral Discussion	Written Examination
8	Mutation A. Variation in Genome Structure or Numerical Changes of the Chromosomes Euploidy 1. Autopolyploidy 2. Allopolyploidy 3. Physical Characteristics of Polypoids 4. Segregation and Linkage in Polyploids 5. Aneuploidy B. Changes in Chromosome Structure or Chromosomal Aberrations 1. Deficiencies or Deletions 2. Duplications or Repeats	Lecture Drill and Practice Board work	Written Examination Homework/Worksheet

	3. Inversions 4. Interchanges and Reciprocal Translocations C. Gene Mutations 1. Microlesions: Base Pair Substitution 2. Frameshift Mutations 3. Mutaor Genes 4. Trasposons or Jumping Genes D. Reverse Mutations E. Mutaagenic Agents F. Evolutionary Significance of Mutations		
9	Delayed Chromosomal and Extrachromosomal Inheritance A. Delayed Chromosomal Inheritance B. Extrachromosomal Inheritance 1. Cytoplasmic Inheritance 2. Cytoplasmic Particles 3. Chloroplasts 4. Mitochondria C. Plasmid of Extracellular Origin 1. Infective Heredity 2. Episomes D. Criteria for Extrachromosomal Inheritance	Lecture Visualization Oral Discussion	Written Examination
10	Quantitative Inheritance A. Inheritance of Quantitative Characters 1. Multiple Genes 2. Number of Genes in polygene Systems 3. Regression to the Mean 4. Effects of Dominance and Gene Interactions 5. Effects of Genes in Multiplying Effects B. Analysis of Quantitative Characteristics C. Components of Phenotypic Variance D. Heredity 1. Heritability in the Narrow Sense 2. Heritability in the Broad Sense	Lecture Visualization Oral Discussion	Written Examination
11	Genes in Populations A. Population Genetics B. Gene Frequencies and	Lecture Drill and Practice	Written Examination Homework/Worksheet

	Equilibrium 1. Gene Frequencies 2. Gene Pool 3. Model System for Population Stability (Hardy – Weinberg Law) C. Changes in Gene Frequencies 1. Mutation 2. Selection a. Relative Fitness b. Selections and Variability c. Selection and Mating 3. Systems 4. Migration 5. Genetic Drift D. Race and Species Formation 1. The Concept of Races 2. The Concept of Species a. Reproductive Isolating Mechanisms b. Rapid Speciation	Board work	
12	Genetics and Man A. Cytogenetics B. Inborn Errors of Metabolism C. Behavioral Genetics	Lecture Oral Discussion	Written Examination
13	Genetic Engineering and Biotechnology A. Recombinant DNA/ Genetic Engineering B. Applications of Genetic Engineering 1. Researches on Human Genes 2. Researches on Animal Genes 3. Researches on Plant Genes 4. Researches on Microbial Genes C. The Release of Genetically Engineered Organisms 1. Biosafety and Ecological Implications 1.1 Potential Ecological Concerns 1.2 Regulatory Policies	Lecture Oral Discussion	Written Examination
Laboratory			
1	The Physical Basis of Heredity		Written and Practical Examination Homework/Worksheet
2	Gene Segregation And Integration	Drill and Practice Board work	Written and Practical Examination Homework/Worksheet

3	Linkage and Recombination	Drill and Practice Board work	Written and Practical Examination Homework/Worksheet
4	Molecular Basis of Heredity	Demonstration	Written and Practical Examination Oral Discussion
5	Central Dogma of Molecular Biology – Replication of Genes and Their Products	Demonstration	Written and Practical Examination Group report
6	Regulations of Genes and Their Products	Demonstration	Written and Practical Examination
7	Mutations	Demonstration	Written and Practical Examination Homework/Worksheet
8	Extrachromosomal Inheritance	Drill and Practice Board work	Written and Practical Examination Homework/Worksheet
9	Quantitative Inheritance	Drill and Practice Board work	Written and Practical Examination Homework/Worksheet
10	Genes in Populations	Drill and Practice Board work	Written and Practical Examination Homework/Worksheet
11	Human Genetics	Visualization Drill and Practice Board work	Written and Practical Examination Homework/Worksheet
12	Recombinant DNA Technology	Visualization	Written and Practical Examination Homework/Worksheet

D. Learning Resources

A. Basic glassware and supplies for experiments

Equipment Required:
Microscope good for students in one laboratory section at one unit per student
Measuring tools
Hot plate
Refrigerator
Incubation oven
Fumehood
Homogenizer

Equipment Desired:
Multi hotplate stirrer
Laminar flowhood
Autoclave
Water bath shaker

Micro centrifuge
Electrophoresis apparatus with power supply
Spectrophotometer
pH meter
Vacuum pump
Micropipette
Tran illuminator
Polaroid camera
Microscope with mounted camera assembly

List of Chemicals / Supplies for Genetics

Chemicals Required:
Glacial acetic acid
Carmine powder
Ethyl alcohol
Ether
Colchicine

Supplies Required:
Dissecting needles with curved ends
Alcohol lamp
Blades
Forceps
Cover slip
Glass slides
Refluxing apparatus
Culture bottles
Cotton
Absorbent paper
NA-RNA KIT
Replication kit
Gene action kit
Colored cartolina
Scissors
Seed box
Graphing paper
Calculator
Black and white buttons
Laboratory glassware (beakers, flasks)

Chemical Desired:
Tissue culture media
Electrophoresis buffer and staining systems for isozyme Analysis
Starch or polyacrylamide
Agarose
Chemical reagents for DNA Extraction
Chloroform
SS phenol
Sodium acetate

Restriction endonucleases
Ethidium bromide

Supplies Desired:
Blotting membrane
Non-radioactive labeling & detection kit
Films and developing supplies
Laboratory wares (pipette tips, disposable centrifuge tubes, Saran wrap, plastic trays, etc.)

B. Reference

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- Weaver, R.F. and F.W. Hedrick. 1992. Genetics. 2nd ed or latest edition. W.M & C. Brown Publishers, Dubuque, IA., USA.

A. Course Details

COURSE NAME	**General Ecology**
COURSE DESCRIPTION	General Ecology lecture is 3-unit introductory course on the biology and properties of ecological systems. It consists of three lecture hours per week on the general concepts and principles pertaining to the complex pattern of interactions between the physical environment and the communities on Earth. Emphasis is given on the current issues, especially in the Philippine context.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Zoology (5 units lecture and laboratory) General Botany (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	**PROGRAM OUTCOME**																	
At the end of this course, the students should be able to:	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**
define the general principles of ecology and its relation to other sciences.	✓	✓				✓	✓	✓	✓			✓	✓			✓	✓		✓
describe the relationship between the principles of evolution and ecology.	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓	✓	✓		✓
explain the general behavioral ecology (examples: costs and benefits, territorial defense, foraging, migration, group living).	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓
discuss population structure; growth and density; and interactions of organism in a	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

population.																		
explain the concept of community ecology in terms of structure and diversity; habitat and community changes.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
identify basic applications/conservation measures and the impacts of Human populations have had on the environment.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
identify and explain the methods of treating wastes/pollutants and its effects to human health.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
develop the writing skill of the students in writing scientific papers.	✓	✓				✓	✓	✓		✓	✓		✓			✓		✓

C. Course Outline

Weeks	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1-2	Introductions A. Definitions B. Why and How to Study Ecology C. Scientific Method D. The Effects of Scale E. Evolutionary Ecology 1. How Variation Originates 2. How Variation is Maintained 3. How Much Variation Exists in nature 4. Reduction in Variation	Lecture demonstration and Class discussion	Quizzes
3	Natural Selection and Speciation A. Phylogenetics B. The Fossil Record C. Extinction: Causes and Patterns	Lecture demonstration, Film viewing, and Class discussion	Quizzes and Film review
4-5	Behavioral Ecology A. Group Selection B. Altruism C. Living in groups D. Resource Assessment E. Animal Communication	Lecture demonstration, Film viewing, and Class discussion	Quizzes and Film review

	F. Foraging Behavior and Optimality in Individuals G. Maintenance of Sex Ratios H. Sexual Selection 1. Polygyny 2. Polyandry		
6-8	Population Ecology Recombination A. Physiological Ecology B. Abiotic Factors C. Population Growth D. Mutualism and Commensalism E. Competition F. Predation G. Hervivory and Parasitism H. Causes of Population Change	Lecture demonstration, Film viewing, Case method, and Class discussion	Quizzes, Written report (Scientific paper), and Film review
9-11	Community Ecology A. Species Diversity and Community Stability 1. Island Biogeography B. Community Change C. Ecosystems (Main types of Communities)	Lecture demonstration, Film viewing, Case method, and Class discussion	Quizzes, Written report (Scientific paper), and Film review
12-15	Applied Ecology A. The Effects of Humans B. Human Population Growth C. Loss of Wildlife through Human Activity D. How to Solve Ecological Problems E. Patterns of Resource Use 1. Water Catchment Areas 2. Forestry 3. Agricultural Land 4. The Sea F. Waste and Pollution 1. Wastes Emitted in the Atmosphere 2. Economic Poisons 3. Contamination by Organic Substances 4. Eutrophication	Lecture demonstration, Film viewing, Group reporting and Class discussion	Quizzes, Group report, and Film review
16	Introduction to Exotic Species, Epilogue	Lecture demonstration, Film viewing, and Class discussion	Quizzes and Film review

D. Learning Resources

A. Reference

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- Brewer, R. 1994. The Science of Ecology. 2nd ed. or latest edition. Saunders College.
- Bush, M.B. 1997. Ecology of A Changing Planet. Prentice Hall.
- Caldsa, M.P., Cervencia, C.R., Cuevas, V.C. and Z.N. Sierra. 1994. Laboratory Guide in Ecology. 2nd ed or latest edition. UPLB Pub. Center.
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- Krohne, D.T. 2001. General Ecology. 2nd edition. California: Brooks/Cole.
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- Lobbman,C.S., Chapman, D.J. and B.P. Kremer Eds.1988. Experimental Phycology. A Laboratory Manual. Cambridge Uni. Press.
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- Miller, G.T. Jr. 1997. Environmental Science. 6th ed or latest edition. Prentice Hall.
- Molles, M. Jr. 2005. Ecology: Concepts and applications. New York: Mc Graw-Hill.
- Nebel, J.B. and R.TR. Wright. 1998. Environmental Science. The Way the World Works. 6th ed or latest edition. Prentice Hall.
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- Smith, R.L., and T.M. Smith. 2003. Elements of ecology. 5th edition. USA: Benjamin Cummings.
- Umaly, R. and M.L.V. Cuvin. 1988. Limnology Laboratory and Field Guide Physico-chemical Factors. Biological Factors. National Bookstore.
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GENERAL ECOLOGY (LABORATORY)

A. Course Details

COURSE NAME	General Ecology (Laboratory)
COURSE DESCRIPTION	General Ecology laboratory is 2-unit introductory course on the biology of the ecosystems. It consists of 6 laboratory hours per week dealing with the basic principles and methodologies pertaining to population and community structure and the assessment of environmental quality.
NUMBER OF UNITS (Lec/Lab)	2 units
Pre-Requisite	General Zoology (5 units lecture and laboratory) General Botany (5 units lecture and laboratory) Statistical Biology (3 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	PROGRAM OUTCOME																		
At the end of this course, the students should be able to:	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
learn basic ecological methods and theory.	✓	✓	✓			✓	✓	✓	✓			✓				✓	✓	✓	✓
generate ecologically related questions and testable hypotheses .	✓	✓		✓		✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓
develop an understanding of the differences in the structure and function of different types of ecosystems.	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
acquainted with different techniques on assessing aquatic or terrestrial environments.	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

understand how to conduct studies within delicate habitats and measure biodiversity	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
identify the variety of ways that organisms interact with both the physical and the biological environment.	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
understand the dynamics and model that describe population growth and the species/population tolerance to environmental factors.	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
organizing competently data sets, making tables and figures complete with legends and descriptions as well as using statistical tools to compute mathematical equations.	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
write proficiently scientific paper.		✓			✓	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓	✓	✓

C. Course Outline

Weeks	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1-5	Assessment of the Aquatic Environments A. Physical Characteristics of Water 1. Temperature 2. Depth 3. Suspended solids 4. Color 5. Transparency B. Chemical Characteristics of Water 1. pH 2. Dissolved Oxygen 3. Hardness 4. Alkalinity 5. Acidity 6. Salinity 7. Conductivity 8. Nitrate content 9. Orthophosphate content 10. Silicate content C. Biological Characteristics 1. Primary Productivity Studies 1.1 Plankton Productivity Estimation 1.2 1.2 Chlorophyll Analysis 1.3 Light and Dark Bottles Technique 2. Population and Community Structure Studies/ Plankton Cell Count using the Sedgwick Rafter method or the haemocytometer method	Demonstration, Visualization, and Laboratory Activity	Practical Examination and Written Report
6-10	Assessment of the Terrestrial Environment A. Climatological Measurements 1. Light Intensity 2. Wind Velocity 3. Atmospheric Pressure 4. Air Temperature B. Physical Properties of the Soil	Demonstration, Visualization, and Laboratory Activity	Practical Examination and Written Report

	1. Soil Temperature 2. Soil Texture 3. Composition C. Chemical Properties of the Soil 1. pH 2. N, P, Ca and humus content D. Biological Properties 1. Primary Productivity Studies 1.1 Macrophyte Productivity Estimate and Harvest 2. Population and Community Structure 2.1 Plant Population Studies (line intercept, transect and point quarter methods)		
11-13	Field Study	Fieldwork	Practical Exam and Scientific Paper
14-15	Biodiversity Studies	Fieldwork and Laboratory Activity	Practical Examination and Written Report
16	Tolerance to Environmental Factors	Demonstration, Visualization, and Laboratory Activity	Practical Examination and Written Report

D. Learning Resources

A. References

- Environmental Guidelines for Selected Infrastructure Projects. Asian Development Bank, 1990.
- Environmental Impact Assessment: Cutting Edge for the 21st Century. Allan Gilpin. 1995.
- Integration of Environmental Considerations in the Program Cycle. Asian Development Bank, 1990.
- Philippine EIS System guide: Policies and Procedure. Environmental Management Bureau, Department of Environmental and Natural Resources, 1994.
- Public Participation in EIA: An Environmental Monitoring Manual. Cardenas et al.' Environmental Management Bureau, 1992.
- Strengthening Environmental Impact Assessment Capacity in Asia: A case Study on the Philippine EIS System. Balagot, Beta and Briones, Nicomedes, Environmental Resource Management Project, UP Los Baños, 1994.

A. Course Details

COURSE NAME	**Microbiology**
COURSE DESCRIPTION	Microbiology Lectures cover the anatomy, physiology and genetics of microorganisms, such as bacteria, algae, fungi, protozoans. This course involves the study of the roles of microorganisms in the environment and their applications in industry and in medicine. Discussions on viruses, viroids and prion particles are also included. The laboratory course provides the students with practical experience in the study of microorganisms. Experiments are designed to include techniques for the identification of microorganisms based on their physical (e.g. colony and cellular morphology), and physiological characteristics (e.g. growth patterns, antibiotic resistances). Students will be trained in the use aseptic techniques for basic microbial applications. These applications include procedures for control of microbial growth, screening for microbial contamination of food and water samples and the use of microorganisms for production in industry.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Zoology (5 units lecture and laboratory) General Botany (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	**PROGRAM OUTCOME**																		
At the end of this course, the students should be able to:	**a**	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**
identify the basic structural features of microorganisms and discuss how these relate to their classification and functions.	✓	✓		✓	✓	✓	✓	✓								✓			✓
identify the roles played by different microorganisms in	✓	✓		✓	✓	✓	✓	✓						✓		✓			✓

relation to man and his environment																		
discuss the physiology and genetic mechanisms of microorganisms and their applications in industry and medicine.	✓	✓		✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓	✓
formulate applications of microorganisms in industry and medicine based on their characteristics.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
At the end of the laboratory course, the students should be able to:																			
perform the basic techniques used in microbiology, e.g. aseptic techniques, culture media preparation, staining, microscopy, etc.			✓	✓		✓	✓	✓	✓			✓				✓	✓	✓	
identify microorganism samples based on their structure, morphology and physiological characteristics			✓	✓	✓	✓	✓	✓			✓	✓				✓	✓		
identify and discuss the useful and harmful effects of microorganisms on man and his environment.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			
formulate applications of microorganisms in industry and medicine based on their characteristics.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C. Lecture Course Outline (2013 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1	Origin and Evolution of Life A. History of Microbiology	Lecture Classes	Written Examination
2	Microbial Diversity/Survey of Microbial World A. Cellular 1. Prokaryotes: archaebacteria, eubacteria 2. Eukaryotes: fungi, algae, protozoans B. Acellular 1. Viruses 2. Viroids 3. Prions C. Classification Schemes 1. Two-Kingdom System 2. Three-Kingdom System 3. Four-Kingdom System 4. Five-Kingdom System 5. Six-Kingdom System	Lecture Classes	Written Examination
3-4	Microbial Anatomy	Lecture Classes Exercises Group Reporting	Written Examination Exercises Reports
5	Microbial Growth Requirements A. Microbial Nutrition B. Physical Factors Affecting Growth C. Microbial Reproduction	Lecture Classes	Written Examination
6-8	Microbial Metabolism A. Aerobic Metabolism B. Anaerobic Metabolism 1. Anaerobic respiration 2. Fermentation C. Photosynthesis	Lecture Classes	Written Examination
9-11	Microbial Genetics A. Inheritance of Genetic Information (Central Dogma) 1. Replication 2. Transcription 3. Reverse Transcription 4. Translation B. Genetic Variation 1. Mutation 2. Genetic Recombination	Lecture Classes Exercises Group Reporting	Written Examination Exercises Reports

	C. Epigenetic Factors D. Applications in Biotechnology		
12	Viruses	Lecture Classes	Written Examination
13	Viroids Prions	Lecture Classes	Written Examination
14	Microbial Infections and their Treatment A. Chemotherapeutic Agents B. Physical Agents	Lecture Classes	Written Examination
15	Microbial Applications in Environmental Science A. Role in Geochemical Cycles B. Role in Biodegradation of Solid Wastes, Liquid Wastes	Lecture Classes	Written Examination
16	Microbial Applications in Industry	Lecture Classes Exercises Group Reporting	Written Examination Exercises Reports

D. Laboratory Course Outline (2005 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1	Microscopy	Laboratory Experiments	Laboratory Report Practical Examinations
2	Culture Media Preparation/Sterilization		
3	Aseptic Techniques: Study of Microorganisms from the surroundings: • Normal Body Flora • Common Items	Laboratory Experiments	Laboratory Report Practical Examinations
4	Microscopic Examination of Microorganisms A. Wet Mount B. Staining Techniques 1. Gram Stain 2.Special Stains (spore stain, capsule stain, flagellar stain)	Laboratory Experiments	Laboratory Report Practical Examinations
5	Physical Factors Affecting Microbial Growth A. Temperature B. Media Components C. Media pH	Laboratory Experiments	Laboratory Report Practical Examinations
6	Antibiotic Susceptibility Testing	Laboratory Experiments	Laboratory Report Practical Examinations

7-8	Auxotrophy (Specific experiment?)	Laboratory Experiments	Laboratory Report Practical Examinations
9	Bacteriology(Specific experiment?)	Laboratory Experiments	Laboratory Report Practical Examinations
10-12	Fermentation 1.Wine making 2.Yoghurt production 3.Kimchi or sauerkraut production	Laboratory Experiments	Laboratory Report Practical Examinations
13-14	Recombinant DNA Technology A. Plasmid Extraction B. Transformation C. Conjugation	Laboratory Experiments	Laboratory Report Practical Examinations

E. Learning Resources

A. Basic glassware/materials for experiments: test tubes, petri dishes, Erlenmeyer flask, serological pipettes, inoculating loops, inoculating needles

B. Required Equipment

Compound microscope one per student

Balance, one unit per lab

Oven, one unit per lab

Incubator, one unit per lab

Stove, one unit per lab

Refrigerator, one unit per lab

Bunsen burner or alcohol lamp

Autoclave

C. Recommended Equipment

Television and media player, one unit

Overhead projector, one unit

D. Required Chemicals and Supplies

Culture Media

Biochemical Test Media

Staining reagents

E. Suggested References (2005 version)

- Alcano, E. 1991. Fundamentals of Microbiology. 3rd ed. or latest edition. Benjamin/Cummings Publishing Company, Inc.

- Finegold, SX.M. and E.J. Baron. 1995. Bailey and Scott's Diagnostic Microbiology. The C.V. Mosby Company. Joklik, W.M., H.P. Willet, D.B. Amos and C.M. Wilfert.1992. Zinsser Microbiology. 20th ed. or latest edition. Prentice-Hall Interantional Inc.
- Kimball, J.W. 1994. Biology. 6th ed. or latest edition. Wm. C. Brown Communications, Inc.
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CELL AND MOLECULAR BIOLOGY

A. Course Details

COURSE NAME	**Cell and Molecular Biology**
COURSE DESCRIPTION	This course covers discussions on the cell, the basic unit of life. Emphasis will be placed on the structural features of the different cellular organelles, the connections of the basic cellular processes and the importance of biomolecule properties for their control and regulation.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Zoology (5 units lecture and laboratory) General Botany (5 units lecture and laboratory) Biomolecules (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	PROGRAM OUTCOME																		
At the end of this course, the students should be able to:	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
identify and describe the different cellular organelles	✓	✓	✓			✓		✓		✓						✓			✓
identify and connect the different cellular processes.	✓	✓	✓			✓	✓	✓		✓						✓			✓
discuss the key concepts involved with the different cellular processes.	✓	✓	✓			✓	✓	✓		✓			✓			✓			✓
discuss the important structural features of these key components that determine their required functions	✓	✓	✓			✓	✓	✓	✓	✓			✓			✓		✓	✓
discuss methods and techniques used to study cellular structures and their functions.	✓	✓	✓	✓		✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
design experiments that apply the fundamental properties of cell structure and function to relevant research problems.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

C. Lecture Course Outline (2013 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1	Introduction (Overview) A. The Cellular Basis of Life B. Different Cell Types C. Techniques and Methods of Studying Cells	Lecture Classes	Written Examination
2-3	Biochemistry of the Cell A. Water, the Aqueous Environment B. Biomolecules and their properties 1. Nucleic Acids 2. Proteins 3. Lipids 4. Carbohydrates	Lecture Classes Exercises	Written Examination Exercises
4-6	The Cell Surface and the Extracellular Matrix A. Nature and Composition of Plasma Membrane B. Functions and Activities of Cell Membrane 1. Cell Adhesion 2. Signal Transduction 3. Vacuole formation C. The Extracellular Environment 1. Extracellular Matrix 2. Adhesion Molecules 3. Signalling Complexes	Lecture Classes	Written Examination
7-8	The Nucleus A. Chromosome Structure and Genes B. Cell Cycle and DNA Replication C. Transcription and RNA Processing D. Organization and Evolution of the Nuclear Genome E. Regulation of Gene Expression	Lecture Classes	Written Examination
9-11	Membrane-bound Organelles A. The ER and its Derivatives B. The Golgi Complex C. Lysosomes and Peroxisomes D. Membrane-bound organelle functions 1. Translation 2. Post-Translational	Lecture Classes Exercises Group Reporting	Written Examination Exercises Reports

	Modification 3. Protein Transport 4. Membrane Flow and Sorting (Trafficking)		
12	The Cytoskeleton and Cell Motility A. Microtubules B. Microfilaments C. Intermediate Filaments D. Cell Motility	Lecture Classes	Written Examination
13-14	Cellular Metabolism A. Mitochondria and Cellular Respiration B. Chloroplast and Photosynthesis	Lecture Classes	Written Examination
15-16	Current Trends in Cellular and Molecular Biology (Suggested Topics) A. Recombinant DNA Technology B. RNA interference C. Nanotechnology	Lecture Classes Journal Article Discussions Reporting	Written Examination Reports

D. Laboratory Course Outline (2005 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
2	Primary Cell Culture (Duck Embryo)	Laboratory Exercise	Laboratory Reports
1	Microscopy and Vital Staining of Different Tissue Types	Laboratory Exercise	Laboratory Reports
1	Centrifugation and Fractionation of different cellular organelles	Laboratory Exercise	Laboratory Reports
1	Bacterial Cell Cultures	Laboratory Exercise	Laboratory Reports
2	Eukaryotic Cell Culture (Yeast, Insect, or Mammalian Cell Cultures)	Laboratory Exercise	Laboratory Reports
1	DNA Extraction and Electrophoresis	Laboratory Exercise	Laboratory Reports
2	Transformation and Recombinant Protein Expression	Laboratory Exercise	Laboratory Reports
2	Protein Purification by Column Chromatography	Laboratory Exercise	Laboratory Reports

E. Learning Resources

A. Laboratory Equipment, Facilities, Chemicals and Supplies

Shaker Incubators
CO2 Incubators
Biosafety Cabinet/s
Microscopes
Inverted Microscopes
Centrifuge
DNA Extraction Kits/Reagents
Plasmid Transformation Kits/Reagents (e.g. pGLO plasmid kits from Biorad)
Centrifuge Tubes (1.5ml, 15ml, 50ml)
Agarose
Electrophoresis Apparatus (for Agarose Gels and Polyacrylamide Gels)
Affinity Columns / Resins for Chromatography
Target-specific Primary Antibodies
Enzyme-conjugated Secondary Antibodies
Enzyme substrate (e.g. DAB for HRP-linked secondary antibodies)

B. Suggested References (2013 version)

- Alberts, B; Johnson, A; Lewis, J; Raff, M; Roberts, K; and Walter, P. Molecular Biology of the Cell. 5th Edition. 2007. Garland Science.
- Lodish, H; Berk, A; Kaiser, C; Krieger, M; Bretscher, A; Ploegh, H; Amon, A; Scott, M; Molecular Cell Biology. 7th Edition. 2012. W.H. Freeman.

Sample Specialization Course Syllabi

PLANT PHYSIOLOGY

A. Course Details

COURSE NAME	**Plant Physiology**
COURSE DESCRIPTION	Principles and fundamental aspects of vital plant functions, including nutrition, photosynthesis, absorption and translocation of materials, growth and development, with emphasis on adaptive mechanism.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Physiology (5 units) Biomolecules (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	PROGRAM OUTCOME																		
At the end of this course, the students should be able to:	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
expose students to what plants do and what physical and chemical factors cause them to respond as they do.		✓				✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓
explain the physiology of plants, i.e., their functions, from seed germination to vegetative growth, maturation, flowering and senescence.		✓					✓		✓		✓	✓	✓			✓	✓		✓
provide the student with a firm foundation in the major concepts of plant physiology, in the context of traditional and contemporary biology.	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓	✓		✓	✓		✓
the information derived from the course will be useful for careers in agronomy, horticulture, forestry, seed science and plant pathology.	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓		✓

C. Course Outline

No. mtgs. / no. hrs.	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1 /1*	Plant and Cell Architecture: The Bio-organization A. Plant Life: Unifying Principles B. The Plant: An Overview of Structure C. The Plant Cell: Attributes and Functions	Lecture; Student participation in discussions	Quizzes
4 / 2	Plant-Water Relations A. Water and Plant Cells 1. The Structure and Properties of Water 2. Importance of Water in Plant Life 3. Transport Processes and Driving Forces	Assigned advance readings and discussion vis-à-vis lectures	Submission of assignment ; and quizzes
/ 2	B. Water Balance of the Plant 1. Water in the Soil 2. Water Absorption by Roots 3. Transpiration	Assigned advance readings and discussion vis-à-vis lectures ; video/film showing followed with a discussion	Student participation in discussions; Quizzes
2 / 1	Mineral Nutrition A. The Plant Root System and Its Interaction with the Soil B. Mycorrhizal Fungi and their Association with Plant Roots.	Assigned advance readings and discussion vis-à-vis lectures ; video/film showing followed with a discussion; Lecture	Quizzes
/ 1	C. Essentially of Elements: concepts, criteria, problems D. Uptake and Assimilation of Mineral Elements E. Functions of Mineral Elements and Symptoms of Deficiencies	Assigned advance readings and discussion vis-à-vis lectures ; video/film showing followed with a discussion; Lecture	Quizzes
2 / 1	Solute Transport A. Passive, Facilitated Diffusion and Active Transport B. Transport Across Biological	Assigned advance readings and discussion vis-	Quizzes

1	Membranes C. Phloem Translocation 1. Phloem Loading and Unloading 2. Mechanism of Sieve Tube Translocation	à-vis lectures ; video/film showing followed with a discussion; Lecture	
1 / 1	FIRST EXAMINATION Total 10 meetings; 10 hours		
7 / 2 2 2 1	Photosynthesis: the Chemical Basis of Life A. The Light Reaction 1. Photophosphorylation 2. Reduction of NADP 3. Photolysis of water B. Carbon Metabolism 1. C_3 cycle 2. C_4 pathway 3. Crassulacean Acid Metabolism C. Factors Regulating the Process D. Photorespiration E. Physiological and Ecological Considerations	Assigned advance readings and discussion vis-à-vis lectures ; video/film showing followed with a discussion; Lecture	Long Examination Quizzes
2 / 1 1	Respiration: The Maintenance of Life A. Aerobic and Anaerobic Pathways B. Energy Production: Oxidative Phosphorylation C. Factors Controlling the Process D. Lipid Metabolism	Assigned advance readings and discussion vis-à-vis lectures ; video/film showing followed with a discussion; Lecture	Long Examination Quizzes
1 / 1	Secondary Plant Products A. Terpenes B. Phenolic Compounds C. Nitrogen-Containing Compounds D. Chlorophylls and Haems	Lecture	Long Examination Quizzes
1 / 1	SECOND EXAMINATION Total 11 meetings; 11 hours		
10 / 2 1 1 1 1	Growth and Development A. Cellular Basis of Growth and Development B. Phytohormones and Related Compounds 1. Auxins 2. Gibberellins 3. Cytokinins 4. Abscisic Acid 5. Ethylene 6. Other Plant Growth Regulators	Lecture	Long Examination Quizzes

/ 1 1 1 1	C. Secondary Messengers and Signal Transduction Pathways D. Phytochrome, Photomorphogenesis and Photoperiodism E. Control of Flowering F. Seed Germination and Dormancy G. The Biological Clock: Rhythms of Life H. Senescence	Lecture; film viewing and followed by discussion session	Long Examination Quizzes
1 / 1	THIRD EXAMINATION Total 11 meetings; 11 hours		
Laboratory Week			
1 -4	Cell and Plant Water Relations	Laboratory Experiments	Laboratory Report Practical Examinations
3-6	Mineral Nutrition	Laboratory Experiments	Laboratory Report Practical Examinations
7-10 9-12	Plant Biochemistry A. Photosynthesis B. Respiration	Laboratory Experiments	Laboratory Report Practical Examinations
10-13	Hormones and Leaf Abscission	Laboratory Experiments	Laboratory Report Practical Examinations
11-14	Seed Germination: Light & Hormones	Laboratory Experiments	Laboratory Report Practical Examinations
12-15	Plant Movements & Differential Growth	Laboratory Experiments	Laboratory Report Practical Examinations
13-16	Apical Dominance	Laboratory Experiments	Laboratory Report Practical Examinations
	Report preparation and submission: At the end of 4 weeks (= period for 1 lab exercise)		

D. Learning Resources

2.1.1.1 Laboratory Equipment, Facilities, Supplies and Chemicals

Basic glassware for experiments
Burets
250 ml and 500 ml graduated cylinders
Test tubes and caps / stoppers
Funnels
50 ml, 100 ml, 200 ml, 500 ml, 1 000 ml beaker
1 000 ml brown bottles
Petri dishes

Minimum Laboratory Equipment / Materials (Required)
analytical balance
pH meter
UV-VIS spectrophotometer with appropriate cuvettes

refrigerator
rough platform / pan balance
magnetic stirrer / hot plate with magnetic bars
mortar and pestle
water bath
autoclave
centrifuges (varying speeds / temperature ranges)
oven
light meter
cold cabinet
leaf area meter
growth chambers
pipettors, variable volume capacities
cork borer, a set (variables sizes)Equipment:
Blender
Thermometers
Latex gloves
Aspirators
Forceps

Desired Equipment
Shaker
Fume hood
Clark Type Probes (Multi Probes)

Required chemicals
Petroleum Ether
Acetone, 100%
Chloroform
Resazurin Dye
Potassium Cyanate (KCN)
Carbonyl Cyanide-Chlorophenyl
Hydrozone (CCCP) in de-methyl sulfide (DMSO)
Petroleum Jelly / Paraffin
Sodium Phosphate (Na_2PO_4)
Potassium diphosphate (KH_2PO_4)
mannitol
Potassium chloride (KCl)
Magnesium chloride ($MgCl_2$)
succide acid
Adenosine triphosphate (ATP)
2, 4-dinitrophenol (DNP)
thanol, 95%
sucrose
Sodium chloride (NaCl)
Chloride bleach
Indole-3-acetic acid (IAA)
Naphthalene acetic acid (NAA)
Tween 20
lanolin
6-benzylaminopurin (BA)

Trilodobenzoic acid (TBA)
Abscisic acid (ABA)
cytokinin (CK)
gibberellic acid (GA)

2.1.1.2 References

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- Raven, P.H., R.F. Evert and S.E. Eichlorn. 1992. Biology of Plants. 5th ed or latest edition. Worth Publishers, Inc.: New York.
- Goodwill, T.W and E.I Mercer. 1988. Introduction to Plant Biochemistty. 2nd ed or latest edition. Pergamon Press (or the latest edition) Oxford, New York, Beijing, Frankfurst, Sao Paulo, Sydney, Tokyo, Toronto.
- Lea, P.J. and R.C. Leegood (Eds). 1993. Plant Biochemistry and Molecular Biology. John Wiley and Sons Ltd.: England.

2.1.1.3 Journals

- Plant Physiology
- Planta
- Physiologica Plantarum
- Plant Cell Physiology
- Annual Review of Plant Physiology and Molecular Biology

2.1.1.4 Laboratory Manual

- Reisss, C. 1994. Experiments in Plant Physiology. Prentice-Hall, Inc. A Simon & Schuster Co.: Englewood Cliffs, New Jersey.

ANIMAL PHYSIOLOGY

A. Course Details

COURSE NAME	**Animal Physiology**
COURSE DESCRIPTION	Animal Physiology deals with the fundamental principles of biological functions observed for members of the Animal Kingdom. Particular emphasis is placed on the processes involved with regulation and adaptation to different stimuli.
NUMBER OF UNITS (Lec/Lab)	5 units (lecture and laboratory)
Pre-Requisite	General Physiology (5 units lecture and laboratory) Biomolecules (5 units lecture and laboratory)
Co-Requisite	

B. Course Outcome and Relationship to Program Outcome

COURSE OUTCOMES	PROGRAM OUTCOME																		
At the end of this course, the students should be able to:	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
discuss the major differences between animal and plant cells.	✓	✓				✓	✓			✓			✓			✓			

identify the major processes required for maintaining animal cell functions.	✓					✓	✓	✓							✓			
discuss the interconnectivity of these different cellular processes.	✓	✓				✓	✓	✓		✓		✓	✓			✓	✓		✓
identify the molecular components important for maintaining and regulating these processes.	✓					✓	✓	✓				✓				✓	✓		
relate the physical characteristics of the different components to their required functions.	✓	✓				✓	✓	✓	✓	✓		✓				✓	✓	✓	✓
perform basic laboratory techniques designed to study physiological phenomena.			✓	✓		✓	✓	✓	✓			✓					✓	✓	
infer important industrial/medicinal applications of the concepts learned in class.	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓

C. Lecture Course Outline (2013 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1	Introduction A. The Animal and its Environment B. Concept of Homeostasis and Physiologic Mechanisms C. Biological Control Systems/Regulatory Mechanisms Review A. Cell Physiology B. Cellular Transport C. Signal Transduction	Lecture	Long Examination Quizzes

2	Nerve Physiology A. Nerves and their Properties B. Resting Membrane Potential C. Depolarization and Transmission of Nerve Impulses	Lecture	Long Examination Quizzes
3-4	Neurophysiology A. Basic Organization B. Sensory Physiology C. Motor and Integrative Physiology D. Neural Control of Muscle Contraction	Lecture	Long Examination Quizzes
5-6	Movement A. Non-muscular Movement B. Different Muscle Types C. Structural Basis of Contraction D. Chemistry of Muscle Contraction E. Mechanical Properties of a Contracting Muscle	Lecture	Long Examination Quizzes
7-8	Circulation A. General System B. Types of Heart and their Circulatory Patterns C. Physiologic Properties of the Heart D. Cardiac Cycle E. Body Fluids and the Blood F. Regulation of Cardiovascular Functions	Lecture	Long Examination Quizzes
9	VII. Respiration A. General System B. Respiratory Mechanisms of Aquatic and Terrestrial Animals C. Phases of Respiration D. Regulation of Respiration	Lecture	Long Examination Quizzes
10-11	Digestion 1. General System 2. Nutritional Requirements and Feeding Types 3. Digestion 4. Movement of the Alimentary Tract 5. Secretory Functions of the Alimentary tract and Digestive glands 6. Absorption 7. Egestion	Lecture	Long Examination Quizzes

	8. Coordination and Regulation of Digestive Processes		
12-14	Metabolism and Thermoregulation A. Energy Metabolism 1. Glycolysis 2. Kreb's Cycle 3. Electron Transport Chain B. Major Metabolic Pathways 1. Carbohydrates 2. Proteins 3. Lipids 4. Nucleic Acids C.Metabolic Rate and Thermoregulation 1. Temperature Relations of Ectotherms 2. Temperature Relations of Endotherms 3. Thermostatic Regulation of Body Temperature	Lecture	Long Examination Quizzes
15	Osmoregulation and Excretion A. Osmoregulation 1. Aquatic and Terrestrial Animals 2. Osmoregulatory Organs B. Excretion 1. Vertebrate Renal Systems 2. Urine Function 3. Renal Regulatory Organs	Lecture	Long Examination Quizzes
16	Endocrine Systems A. The Concept of First and Second Messengers B. Chemical Regulators and their functions 1. Neurotransmitters 2. Neurosecretions 3. Hormones 4. Others	Lecture	Long Examination Quizzes Group Reporting

D. Laboratory Course Outline (2005 version)

Week	Topic/s	Common Teaching Strategies	Common Assessment/Evaluation
1-2	Structure and Function in a Unicellular Animal	Laboratory Experiments	Laboratory Report Practical Examinations
3	Transport through Membranes	Laboratory Experiments	Laboratory Report Practical Examinations
4	Nerve Physiology A. Reflex Action	Laboratory Experiments	Laboratory Report Practical Examinations
5	Nervous Physiology	Laboratory Experiments	Laboratory Report Practical Examinations
6	Nervous-Muscle Physiology A. Skeletal Muscle B. Cardiac Muscle C. Smooth Muscle	Laboratory Experiments	Laboratory Report Practical Examinations
7-8	Vascular Physiology A. Circulation B. Control of Blood Vessels	Laboratory Experiments	Laboratory Report Practical Examinations
9	Blood	Laboratory Experiments	Laboratory Report Practical Examinations
10	Enzyme Kinetics	Laboratory Experiments	Laboratory Report Practical Examinations
11-12	Respiration A. Oxygen Utilization CarbonDioxide Functions B. Respiration in the Frog C. Respiration in Man	Laboratory Experiments	Laboratory Report Practical Examinations
13	Renal Physiology A. Osmoregulation in the Earthworms	Laboratory Experiments	Laboratory Report Practical Examinations
14	Endocrine Physiology	Laboratory Experiments	Laboratory Report Practical Examinations

E. Recommendations

- Animal physiology must be offered as a 5-unit course, 3 units for the lecture (3 hours/week) and 2 units for the laboratory (6 hours/week) as to accommodate necessary discussions on mammalian/human systems.
- The general outline given, including sequencing should be followed as much as possible but flexibility as to details of discussions is allowed.
- Perform at least one experiment per general topic as outlined.

F. Learning Resources

Textbooks:

- Best and Taylor. Physiological Basis of Medical Practice (Latest Edition)
- Bullock, J., J. Boyle, M.B. Wang. 1995. Physiology. (3rd ed. or latest edition). U.S.A.: Williams & Wilkins, Co.
- Eckert, R. 1988. Animal Physiology Mechanisms and Adaptations. New York: W.H. Freeman & Company.
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