

INTEGRATIVE BIOSCIENCE: AN UNDERGRADUATE COURSE FOR BACHELOR OF SCIENCE DEGREE PROGRAM IN UNITED STATES OF AMERICA

Dr. Pankaj Mehrotra

Previous Affiliation: Graduate Student / Lecturer, The University of Southern Mississippi, United States of America

Current Affiliation: Faculty (Biology and Zoology), Gyan Mudra Innovation LLP, Gyan Mudra Group, India

Contact Email Address: mehrotra85pankaj@gmail.com

ABSTRACT

This Integrative Bioscience course was developed as part of SME 700 Science Curriculum Project III (defence and approval) at The University of Southern Mississippi, United States of America as part of graduate program in Science Education (biology). The purpose of this course is to know about the historical development in the field of biological sciences, attain conceptual knowledge, and their applications. The topics covered in this course are cell biology, molecular biology, microbiology, genetics, immunology and biotechnology.

INTRODUCTION

Branch of biology that studies cell physiology, structure of cell, function of organelles of a cell, growth of cell, division of cell and final death of a cell is known as **Cell Biology**. Cells are the basic Unit of Life, and understanding cell biology can be considered one of the most important areas of biological research. The branch of science which deals with understanding molecular basis of biological life is known as **Molecular Biology**. Molecular biology helps us to understand how a cell interact with other cells and how the genetic information is regulated from within a cell i.e. DNA, RNA and Protein synthesis. The branch of science which involves study of genes, heredity genetic materials and genetic variation in a living organism is known as **Genetics**. This field of biology integrated with many organisms' life processes and plays an important role in understanding flow of information. The branch of biology which studies the immune system in all organisms is known as **Immunology**. This field of biology helps us to understand how the invasion by pathogens (microbes) is overcome by any organism immunity. The branch of biology which studies the micro-organism i.e. unicellular and multicellular is known as **Microbiology**. Microorganisms are important for regulating ecological imbalance, cause of various diseases and bridging various biological sciences to understand evolution new microbes. The branch of biology in which use of specific microorganisms as well as living systems is done so as to develop products which are useful for mankind is known as **biotechnology**. The major fields within biotechnology are bioengineering and biomedical engineering.

SAMPLE COURSE AND TEACHING MATERIAL

Microbes

Learning Objectives

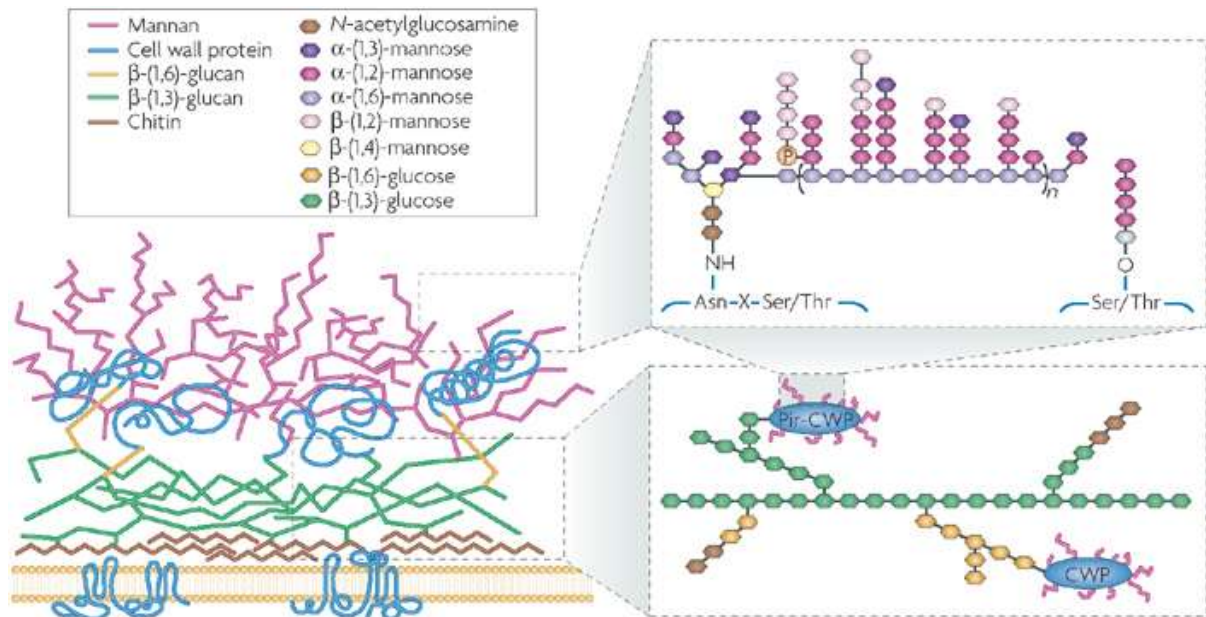
- 1.1 History and Diversity of microorganisms
- 1.2 Mechanism of DNA Exchange in microbes
- 1.3 Difference in Gram Positive Bacteria and Gram Negative Bacteria
- 1.4 Interaction of Bacteria and Fungi with host cells

Introduction to Microorganisms

- Microorganism are small in size and they can only be seen with the use of a microscope.
- Diversity of microorganisms is the most prominent feature of microorganism.
- Diversity of microorganism ;
- **Archaea** and domain **Bacteria**
 - lack nucleus - prokaryotic
- The phyla within Eukarya - **Protists**

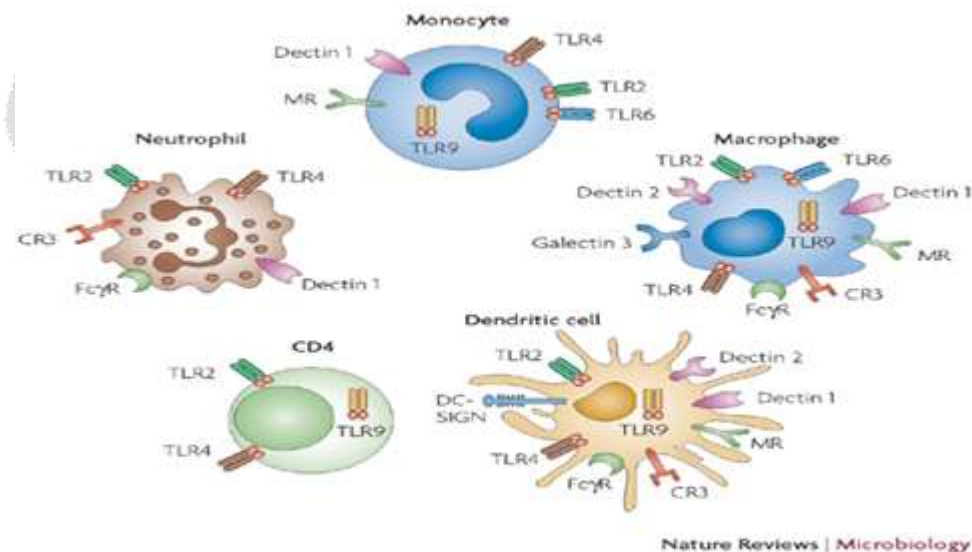
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Figure 1.1 : Lecture Plan including teaching methodology, course material for Microbiology topic.



Nature Reviews | Microbiology

Innate Immune Cells



Pathogen Recognition Receptors (PRR)

Netea, Brown, Kullberg, & Gow, (2008). Nature Reviews Microbiology 6, 67-78

Figure 1.2 Immunology Slides – Visual aids to Engage, Explore and Explain host and pathogen interaction

SAMPLE ASSESSMENT

Sample Question I-Clicker Questions, Written Exams, Poster Presentations, Oral Presentations

1. Translation is part of central dogma of molecular biology which involves;

- a) Movement of DNA into a cell
- b) Integration of foreign DNA into a cell
- c) Conversion of mRNA into amino acid
- d) None of the above

2. What is a Gene?

Gene is made of nucleotides with their respective nitrogen containing bases such as AGG, CTG. The portion of DNA which codes a specific protein.

3. The feature which distinguishes archaea and bacteria is;

- a). Habitat
- b). Presence or Absence of nuclear membrane
- c). Outer membrane as a characteristic of a cell wall
- d). Ribosomes present in cytoplasm which are 70s

4. Enzyme Eco RI is an

- a) Lipase
- b) DNA Polymerase
- c) Topoisomerase
- d) Restriction Enzyme

SAMPLE SUBJECTIVE QUESTION - WRITTEN EXAM

- a) Contributions of scientist in the field of microbiology, molecular biology, genetics, cell biology and biotechnology.
- b) Explain the physiological and morphological changes which may occur during invasion of *Candida albicans*. Also describe how the interaction of *C. albicans* with innate immune cells.

POSTER PRESENTATION

Choose any topic in the area of molecular biology, microbiology, genetics, cell biology and biotechnology for example a review of any disease caused by a pathogenic microbe or a research proposal which you would like to work on as summer undergraduate student. The poster presentation should include abstract, methodology, epidemiology, results, future directions, conclusions and references.

ORAL PRESENTATION (10 minute)

In a group of four prepare protocol / methodology of any biological sciences technique for example cloning of a virulent gene on a vector from *Mycobacterium tuberculosis* starting from extraction of DNA to cloning of gene on a vector.

MINI REVIEW

The whole collectively class should identify few microorganisms and contribute individually 500 words double-spaced discuss about history, genome size, morphology, cell structure and pathogenic mechanism of human and plant pathogens.

JOURNAL ARTICLE READING

Review of research article in the area of molecular biology, microbiology, cell biology, immunology, genetics and biotechnology.

LECTURE SCHEDULE

Lecture 1	.Unit 1.1, 1.2
Lecture 2	Unit 1.3
Lecture 3	Unit 2.1 , Unit 2.2
	Exam 1
Lecture 4	Unit 3.1 , Unit 3.2, Unit 3.3
Lecture 5	Unit 3.3, Unit 3.4
Lecture 6	Unit 3.5, Unit 3.6
	Exam 2
Lecture 7	Unit 4.1, Unit 4.2
Lecture 8	Unit 4.3 , Unit 4.4
Lecture 9	Unit 4.5, Unit 4.6
	Exam 3
Lecture 10	Unit 5.1 – Innate Immunity
Lecture 11	Unit 5.2 – Adaptive Immunity
	Exam 4
Lecture 12	Unit 6.1, Unit 6.2
Lecture 13	Unit 6.3, Unit 6.4
Lecture 14	Unit 6.5, Unit 6.6
	Exam 5
Lecture 15	Virtual Laboratory
Lecture 16	Poster Presentation
Lecture 17	Oral Presentation
Lecture 18	Journal Article Reading
Lecture 19	Mini-Review

FINAL EXAM**SYLLABUS****UNIT(s)****CELL BIOLOGY**

- History and Introduction to Cell Biology and Techniques employed in Cell Biology such as fixation, staining.
- Study of Cell organelles such as Endoplasmic reticulum, Golgi Body, lysosome, mitochondria, nucleolus, exocytosis and endocytosis, division of cell and chromosome.

GENETICS

- History and Introduction to Genetics and Techniques employed in Genetics such as staining of chromosome, DNA etc.
- Understanding - Cytological Basis of Crossing-Over, Linkage Maps. Human, Aves, Honey Bee and Drosophila- Sex determination on genetic basis.
- Allele specificity, rearrange of chromosome, mutation in genes, inheritance of genetic material - extrachromosomal basis, Genetic disorders.

MOLECULAR BIOLOGY

- Molecular Basis of Inheritance- Discovery of Nucleic Acid as a Genetic Material, DNA and RNA structure and function.

- Central Dogma of Molecular Biology- Replication of DNA, Transcription of RNA, Post-transcriptional modifications in proteins.
- Packaging of DNA and RNA - Nucleosome, Nucleosome model, scaffold protein, Chromatid and Chromosome.
- Regulation of Gene and its function – polycistronic, monocistronic and bacteriophage.

MICROBIOLOGY

- Diversity, history and application of microbiology (economic importance)
- Classification, structural organization and reproduction in microorganisms such as bacteria, fungi and viruses.
- Transmission and Epidemiology of diseases caused to human and plants by fungi, bacteria and viruses. Also defence mechanism against microbial attack.
- Virulence factors of microbes and their interaction with host immune cells.

IMMUNOLOGY

- History and introduction to immune system of human, animals and plants.
- Innate and adaptive immune system of humans.
- Characteristics of Monocytes, Neutrophils and Macrophages, T and B lymphocytes. Interaction of innate and adaptive immune cells with microbes.
- T and B lymphocytes features, antigen specificity and attributes of the B-lymphocyte system-humoral immunity and the antibodies, nature of antibodies, mechanism of action antibodies, special attributes of T-lymphocytes system-cellular immunity and sensitized lymphocytes.

BIOTECHNOLOGY

- History and introduction and growth of Biotechnology, and modern biotechnology.
- Cloning, Restriction Enzyme and expression of genes cloned in cloning and expression vectors in prokaryotic systems.
- Cell Culture principles and application. Production of monoclonal and polyclonal antibody – Hybridoma Technology Microbes of industrial importance, commercial, environmental and economic value.

VIRTUAL LABORATORY

- Electron Micrographs of bacteria, fungi, viruses
- Plant and Animal specimens showing infection by bacteria, fungi and viruses.
- Electron micrographs of bacterial and fungal cells showing structure of cell wall and cell division.
- Apparatus and methodology used in laboratory experiments such as preparation of liquid and solid media, pouring and streaking of microbes on medium, counting of colonies, isolation of immune cells, detection of cytokine restriction digestion, agarose gel electrophoresis etc.

GRADING

I-clicker questions

I-Clicker Questions	50 (10 points each lecture)
Exam	50 each point - 250
Poster	100
Oral Presentation	50
Journal Article Reading	50
Mini review	50
Final Exam	100
Total	750

JUSTIFICATION

- This course will introduce students to historical development and scientific discoveries in the diverse area of biological sciences
- This course increase student conceptual understanding of topics in the area of cell biology, molecular biology, microbiology, genetics, biotechnology and immunology.

- c) Student will understand basic techniques employed in biological sciences research and in industry via lectures and virtual laboratories.
- d) In this course student will develop independent thinking ability by receiving continuous assessment during class room lectures (I-clicker questions and Exams).
- e) Written, Oral and collaborative scientific communication skills will be improved in the form of individual and group presentations.
- f) Overall this course will increase student learning and provide a platform to attempt to write a collective review article.

RESOURCES AND REFERENCES

1. Essentials of Molecular Biology (Jones and Bartlett Series in Biology) Hardcover March, 1992- by David Freifelder (Author), George M. Malacinski (Editor)
2. Kuby Immunology (Kindt, Kuby Immunology) Paperback – January 25, 2013 by Judy Owen (Author), Jenni Punt (Author), Sharon Stranford (Author).
3. History of Microbiology: Milton Wainwright, University of Sheffield Joshua Lederberg, The Rockefeller University.
<http://profiles.nlm.nih.gov/ps/access/bbabon.pdf>
4. A short History of Molecular Biology, Hans Jorge Rheinberger, Max Planck Institute for History of Science, Berlin.
<http://www.eolss.net/sample-chapters/c05/E6-89-06-00.pdf>
5. Virtual laboratories enhance traditional undergraduate biology laboratories , Deanna Raineri
<http://onlinelibrary.wiley.com/doi/10.1111/j.1539-3429.2001.tb00107.x/pdf>
6. Principle of Genetics, 8th Edition, Gardner, Simmons, Snustad
7. Lewin's GENES XI Jocelyn E. Krebs (Author), Elliott S. Goldstein (Author), Stephen T. Kilpatrick (Author)
8. American Association for the Advancement of Science, Vision and Change report 2012.
9. An integrated model of the recognition of *Candida albicans* by the innate immune system. Mihai G. Netea, Gordon D. Brown, Bart Jan Kullberg & Neil A. R. Gow Nature Reviews Microbiology 6, 67-78 (January 2008)