# DEPARTMENT OF BIOTECHNOLOGY

## NPTEL/SWAYAM Courses for Honours Degree in Biotechnology Updated in Dec 2024
## (From Admitted Batch: 2020)

| S.No | Course | Subject Code | Duration | Credits | Click here to join the course |
|---|---|---|---|---|---|
| 1 | Introduction to mechanobiology | CBIT/NPTEL/BT H06 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_bt31/preview |
| 2 | Introduction to Dynamical Models in Biology | CBIT/NPTEL/BT H22 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_bt42/preview |
| 3 | Conservation Geography | CBIT/NPTEL/BT H65 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt44/preview |
| 4 | Wildlife Ecology | CBIT/NPTEL/BT H26 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt45/preview |
| 5 | Organic Chemistry in Biology and Drug Development | CBIT/NPTEL/BT H25 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_cy30/preview |
| 6 | Legal and Regulatory Issues in Biotechnology | CBIT/NPTEL/BT H44 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_lw04/preview |
| 7 | Nanomaterials and their Properties | CBIT/NPTEL/BT H68 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_mm38/preview |
| 8 | Ecology and Environment | CBIT/NPTEL/BT H27 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_ge16/preview |
| 9 | Bioreactors | CBIT/NPTEL/BT H37 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_bt28/preview |
| 10 | Transport Phenomena in Biological | CBIT/NPTEL/BT H23 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt40/preview |

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| | Systems | | | | |
| 11 | Technologies For Clean And Renewable Energy Production | CBIT/NPTEL/BT H41 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_ch42/preview |
| 12 | Principles and Practices of Process Equipment and Plant Design | CBIT/NPTEL/BT H42 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc 21_ch52/preview |
| 13 | Patent Law for Engineers and Scientists | CBIT/NPTEL/BT H43 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_hs71/preview |
| 14 | Bio microfluidics | CBIT/NPTEL/BT H08 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_bt24/preview |
| 15 | Biomedical nanotechnology | CBIT/NPTEL/BT H07 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_bt30/preview |
| 16 | Introduction to Biomedical Imaging Systems | CBIT/NPTEL/BT H36 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt50/preview |
| 17 | Biomechanics of Joints and Orthopaedic Implants | CBIT/NPTEL/BT H35 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_me130/preview |
| 18 | Neuroscience of Human Movements | CBIT/NPTEL/BT H24 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_ge17/preview |
| 19 | Current regulatory requirements for conducting clinical trials in India for investigational new drugs/new drug (Version 3.0) | CBIT/NPTEL/BT H40 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_ge25/preview |
| 20 | Introduction to Proteogenomics | CBIT/NPTEL/BT H30 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt25/preview |

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| 21 | Introduction to proteomics | CBIT/NPTEL/BT H31 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_bt26/preview |
| 22 | Computer Aided Drug Design | CBIT/NPTEL/BT H32 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc21_bt29/preview |
| 23 | Drug Delivery: Principles and Engineering | CBIT/NPTEL/BT H33 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc21_bt37/preview |
| 24 | Functional Genomics | CBIT/NPTEL/BT H34 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc21_bt39/preview |
| 25 | Maternal Infant Young Child Nutrition | CBIT/NPTEL/BT H45 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt01/preview |
| 26 | Optical Spectroscopy and Microscopy: Fundamentals of optical measurements and instrumentation | CBIT/NPTEL/BT H46 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt05/preview |
| 27 | Human Molecular Genetics | CBIT/NPTEL/BT H20 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc22bt07/preview |
| 28 | Demystifying The Brain | CBIT/NPTEL/BT H21 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc22bt14/preview |
| 29 | Medical Biomaterials | CBIT/NPTEL/BT H18 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22bt15/preview |
| 30 | Forests And Their Management | CBIT/NPTEL/BT H17 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt24/preview |
| 31 | Nanotechnology In Agriculture | CBIT/NPTEL/BT H12 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22bt25/preview |
| 32 | Bio electrochemistry | CBIT/NPTEL/BT H47 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc22bt26/preview |
| 33 | Plant Developmental Biology | CBIT/NPTEL/BT H48 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc22bt27/preview |
| 34 | Conservation | CBIT/NPTEL/BT H16 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt31/preview |

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| | Economics | | | | |
| 35 | Soft Nano Technology | CBIT/NPTEL/BT H49 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22ch11/preview |
| 36 | Understanding Design | CBIT/NPTEL/BT H50 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc22de01/preview |
| 37 | Design, Technology and Innovation | CBIT/NPTEL/BT H51 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22de05/preview |
| 38 | Emotional Intelligence | CBIT/NPTEL/BT H52 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22hs11/preview |
| 39 | Exploring Survey Data on Health Care | CBIT/NPTEL/BT H53 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22hs40/preview |
| 40 | Material and Energy Balances | CBIT/NPTEL/BT H54 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt04/preview |
| 41 | Bioreactor Design and Analysis | CBIT/NPTEL/BT H55 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22bt19/preview |
| 42 | Waste to Energy Conversion | CBIT/NPTEL/BT H56 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22ch05/preview |
| 43 | Physico-chemical processes for wastewater treatment | CBIT/NPTEL/BT H57 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ch25/preview |
| 44 | Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems | CBIT/NPTEL/BT H58 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ch27/preview |
| 45 | Biomass Conversion and Biorefinery | CBIT/NPTEL/BT H59 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ch28/preview |
| 46 | Environmental Quality | CBIT/NPTEL/BT H60 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ch33/preview |

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| | Monitoring & Analysis | | | | |
| 47 | Bio photonics | CBIT/NPTEL/BT H61 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ee59/preview |
| 48 | Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts | CBIT/NPTEL/BT H62 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22ge06/preview |
| 49 | Computational Systems Biology | CBIT/NPTEL/BT H28 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt03/preview |
| 50 | Interactomics: Basics & Applications | CBIT/NPTEL/BT H63 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc22bt11/preview |
| 51 | Data Analysis for Biologists | CBIT/NPTEL/BT H64 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22bt20/preview |
| 52 | Biointerface Engineering | CBIT/NPTEL/BT H19 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc22bt21/preview |
| 53 | RNA Biology | CBIT/NPTEL/BT H69 | 12 Weeks | 3 | https://nptel.ac.in/courses/102106097 |
| 54 | Biomechanics | CBIT/NPTEL/BT H70 | 12 Weeks | 3 | https://nptel.ac.in/courses/102106098 |
| 55 | Enzyme Sciences and Technology | CBIT/NPTEL/BT H66 | 12 Weeks | 3 | https://nptel.ac.in/courses/102103097 |
| 56 | Metabolic Engineering | CBIT/NPTEL/BT H39 | 8 Weeks | 2 | https://nptel.ac.in/courses/102105086 |
| 57 | Aspects Of Biochemical Engineering | CBIT/NPTEL/BT H29 | 12 Weeks | 3 | https://nptel.ac.in/courses/102105064 |
| 58 | Introduction to Professional Scientific Communication | CBIT/NPTEL/BT H71 | 4 Weeks | 1 | https://nptel.ac.in/courses/102104061 |
| 59 | Bioengineering: An Interface with Biology and Medicine | CBIT/NPTEL/BT H72 | 8 Weeks | 2 | https://nptel.ac.in/courses/102101068 |
| 60 | Interactomics : Basics & Applications | CBIT/NPTEL/BT H73 | 12 Weeks | 3 | https://nptel.ac.in/courses/102101082 |
| 61 | Structural Biology | CBIT/NPTEL/BT H15 | 12 Weeks | 3 | https://nptel.ac.in/courses/102107086 |

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| 62 | Cellular Biophysics: A Framework For Quantitative Biology | CBIT/NPTEL/BT H74 | 8 weeks | 2 | https://onlinecourses.nptel.ac.in/noc22_bt32/preview |
| 63 | Environmental Biotechnology(being offered as Elective in our R20 curriculum) | CBIT/NPTEL/BT H75 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt60/preview |
| 64 | Industrial Biotechnology(being offered as Elective in our R20 curriculum) | CBIT/NPTEL/BT H76 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt61/preview |
| 65 | Introduction To Biostatistics | CBIT/NPTEL/BT H77 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc23_bt58/preview |
| 66 | Medical Image Analysis | CBIT/NPTEL/BT H78 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt40/preview |
| 67 | Introduction To Developmental Biology(being offered as Elective in our R20 curriculum) | CBIT/NPTEL/BT H79 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt43/preview |
| 68 | Tissue Engineering(being offered as Elective in our R20 curriculum) | CBIT/NPTEL/BT H80 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc23_bt46/preview |
| 69 | Organ Printing | CBIT/NPTEL/BT H81 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc23_bt49/preview |
| 70 | Genome Editing And Engineering | CBIT/NPTEL/BT H67 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt51/preview |
| 71 | Next Generation Sequencing Technologies : Data Analysis And Applications | CBIT/NPTEL/BT H82 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt34/preview |
| 72 | Computational Neuroscience | CBIT/NPTEL/BT H83 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc23_bt64/preview |
| 73 | Neurobiology | CBIT/NPTEL/BT H84 | 4 weeks | 1 | https://onlinecourses.nptel.ac.in/noc23_bt65/preview |
| 74 | Neural Science for Engineers | CBIT/NPTEL/BT H85 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_ee01/preview |
| 75 | Classics in Neuroscience | CBIT/NPTEL/BT H86 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc24_bt38/preview |
| 76 | Human Behaviour | CBIT/NPTEL/BT H87 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc24_hs35/preview |

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| 77 | Biointerface Engineering | CBIT/NPTEL/BT H88 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc24_bt16/preview |
| 78 | Microsensors, Implantable Devices and Rodent Surgeries for Biomedical Applications | CBIT/NPTEL/BT H89 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_bt37/preview |
| 79 | Education for Sustainable Development | CBIT/NPTEL/BT H90 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_hs04/preview |
| 80 | Advances in Omics | CBIT/NPTEL/BT H91 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc24_bt42/preview |
| 81 | Statistics for Biomedical Engineers | CBIT/NPTEL/BT H92 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_bt70/preview |
| 82 | Design for Biosecurity | CBIT/NPTEL/BT H93 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_bt77/preview |
| 83 | Advanced Fluorescence Microscopy and Image Processing | CBIT/NPTEL/BT H94 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc25_bt01/preview |
| 84 | Computational Genomics | CBIT/NPTEL/BT H95 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc25_bt13/preview |
| 85 | Microbial Biotechnology | CBIT/NPTEL/BT H96 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc25_bt33/preview |
| 86 | Optical Spectroscopy and Microscopy : Fundamentals of Optical Measurements and Instrumentation | CBIT/NPTEL/BT H97 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc25_bt37/preview |
| 87 | Pharmacognosy & Metabolic Engineering | CBIT/NPTEL/BT H98 | 12 weeks | 3 | https://onlinecourses.nptel.ac.in/noc25_bt38/preview |
| 88 | Biological Data Analysis and Visualization with R | CBIT/NPTEL/BT H99 | 8 Weeks | 2 | https://onlinecourses.nptel.ac.in/noc25_bt43/preview |
| 89 | Experimental Nanobiotechnology | CBIT/NPTEL/BT H100 | 4 Weeks | 1 | https://onlinecourses.nptel.ac.in/noc25_bt44/preview |
| 90 | Algorithms in Computational Biology and Sequence Analysis | CBIT/NPTEL/BT H101 | 12 Weeks | 3 | https://nptel.ac.in/courses/106108571 |
| 91 | Biophotonics | CBIT/NPTEL/BT H102 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_ge11/preview |
| 92 | Comprehensive Molecular Diagnostics and Advanced Gene Expression | CBIT/NPTEL/BT H103 | 12 Weeks | 3 | https://onlinecourses.nptel.ac.in/noc24_ge36/preview |

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| | Analysis | | | | |
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**Note:**

- Students who have completed the listed courses in previous semesters are ineligible to take the same courses in the current semester.
- Both the Honors degree coordinators and students must ensure that if any of the listed subjects is offered as an elective in the student's curriculum, the student does not select the same elective under the R20 regulations and the Honors degree.
- A course with a similar title can be credited only once by a student, whether for Honors, Minors, Internship through MOOCs, or activity points.

## Introduction to Mechanobiology

**Duration: 8 weeks**
**Credits: 2**

**Prerequisites:** B.Sc/B. Tech: Biotech/Biosciences/Bioengineering MSc/M.Tech: Biotech/ Biosciences/ Bioengineering

**Course layout**
**Week 1**
Lecture 1: Need to study Mechanobiology
Lecture 2: Cell as a Tent, individual components
Lecture 3: Cell-ECM crosstalk
Lecture 4: ECM proteins: Collagen
Lecture 5: Measuring properties of collagen networks

**Week 2**
Lecture 6: Properties of collagen networks
Lecture 7: Rheology
Lecture 8: Rheology of biopolymer networks
Lecture 9: Atomic Force Microscopy (AFM)
Lecture 10: Design of protein constructs for AFM

**Week 3**
Lecture 11: Protein unfolding using AFM
Lecture 12: Protein unfolding using AFM
Lecture 13: Focal adhesions: focal adhesion proteins
Lecture 14: Focal adhesion organization
Lecture 15: Focal adhesions: role of forces

**Week 4**
Lecture 16: Cytoskeleton: Actin
Lecture 17: Force-velocity relationships of actin networks
Lecture 18: Mesenchymal cell migration
Lecture 19: Actin dynamics during mesenchymal migration
Lecture 20: Actin dynamics during mesenchymal migration

**Week 5**
Lecture 21: Adhesion Independent Migration
Lecture 22: Adhesion Independent & Collective Cell Migration
Lecture 23: Collective Cell Migration
Lecture 24: Mechanobiology of Stem Cell Fate - I
Lecture 25: Mechanobiology of Stem Cell Fate - II

**Week 6**
Lecture 26: Mechanobiology of Stem Cell Fate - III
Lecture 27: Mechanobiology of Diseases: Cancer I
Lecture 28: Mechanobiology of Diseases: Cancer II
Lecture 29: Mechanobiology of Diseases: Cancer III
Lecture 30: Mechanobiology of Diseases: Atherosclerosis & Hypertension

**Week 7**
Lecture 31: Mechanobiology of Diseases: Muscular Dystrophy
Lecture 32: Nuclear Mechanotransduction: LINC complex
Lecture 33: Nuclear Mechanotransduction: LINC complex in cell migration Lecture 34: Nuclear Mechanotransduction: Gene regulation
Lecture 35: Mechanical Forces & DNA damage

**Week 8**
Lecture 36: Techniques in Mechanobiology: Hydrogels
Lecture 37: Techniques in Mechanobiology: AFM
Lecture 38: Techniques in Mechanobiology: Traction Force Microscopy, Trypson Deadhesion & Laser

Ablation
Lecture 39: Techniques in Mechanobiology: Microfabrication
Lecture 40: Techniques in Mechanobiology: FRE

**Books and references**

1.Introduction to Cell mechanics and Mechanobiology, Christopher. R. Jacobs (Garland Science)
2.Cellular and biomolecular mechanics and mechanobiology, Editors: Gefen, Amit (Springer)

## Introduction to Dynamical Models in Biology

**Duration:4weeks**
**Credits:1**

**Prerequisites:** Must have studied Mathematics at 10+2 level. Have studied graduate-level Biochemistry and Molecular Biology. Knowledge of Computer Programming will be helpful but not a necessity.

**Course layout**

**Week 1:**
1. L1: Introduction to mathematical modeling in biology
2. L2: How to start modeling?
3. L3: Basic concepts of modeling using ODEs: Modeling the spread of infectious disease
4. L4: Basic concepts of modeling using ODEs: Modeling population growth
5. L5: Numerical solution of ODE-based models - I
6. L6: Numerical solution of ODE-based models - II

**Week 2:**
1. L1: Simulating ODE-based models: Introduction to JSim
2. L2: Simulating ODE-based models: Examples of simulation in JSim
3. L3: Steady state and stability analysis: Understanding steady state
4. L4: Steady state and stability analysis: Stability of steady states
5. L5: Phase plane analysis - I
6. L6: Phase plane analysis - II

**Week 3:**
1. L1: Concepts of bifurcation
2. L2: Bifurcation in Biological systems
3. L3: Modeling molecular processes in cell
4. L4: Modeling molecular processes-I: Ligand-receptor binding
5. L5: Modeling molecular processes-II: Enzymatic reaction
6. L6: Modeling molecular processes-III: Transcription and translation

**Week 4:**
1. L1: Modeling a signal transduction circuit: Negative feedback
2. L2: Modeling a signal transduction circuit: Positive feedback
3. L3: Modeling a signal transduction circuit: Incoherent feedforward 4. L4:
Modeling transcriptional circuits – I
5. L5: Modeling transcriptional circuits - II
6. L6: Online resources for mathematical modeling in biology

**Books and references**

1. Mathematical Modeling in Systems Biology: An Introduction, Brian P. Ingalls, MIT Press, 2013.
2. Modeling the Dynamics of Life: Calculus and Probability for Life Scientists, Frederick R. Adler, Brooks/Cole, 2012.
3. Biocalculus: Calculus for Life Sciences, James Stewart, Troy Day, Cengage Learning, 2015.

## Conservation Geography

**Duration: 12 weeks**
**Credits: 2**

**Prerequisites: Nil**

**Course layout**

**Week 1:** Introduction to Conservation Geography

**Week 2:** The Earth

**Week 3:** Lithosphere and landforms

**Week 4:** Atmosphere

**Week 5:** Hydrosphere

**Week 6:** Physical Geography in the Indian context

**Week 7:** Biosphere

**Week 8:** Conservation of biodiversity

**Week 9:** Human population and conservation

**Week 10:** Resources and conservation

**Week 11:** Economic Geography and conservation

**Week 12:**

Special topics in Geography and conservation

**Books and references**


1. Modern Physical Geography, Strahler & Strahler
2. General Climatology, Howard Critchfield
3. Principles of Geomorphology, William Thornbury
4. RS-GIS with free software, Ankur Awadhiya
   Earth's Climate: Past and Future, William F. Ruddiman

## Wildlife Ecology

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Has cleared 10+2 with science**

**Course layout**
**Week 1:** Introduction

**Week 2:** Ecological structure

**Week 3:** Ecological interactions

**Week 4:** Ecological energetics

**Week 5:** Population Ecology

**Week 6:** Community Ecology

**Week 7:** Distribution & abundance

**Week 8:** Management of threatened species

**Week 9:** Human Ecology

**Week 10:** Ecology of change

**Week 11:** Applied Ecology

**Week 12:** Revision

**Books and references:**
1. Krebs, C. J. The experimental analysis of distribution and abundance. Ecology. New York: Harper and Row.

2. Odum, E. P., & Barrett, G. W. Fundamentals of Ecology. Philadelphia: Saunders

3. Selected articles / papers as referred to in the lectures.

## Organic Chemistry in Biology and Drug Development

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Basic Organic Chemistry**

**Course layout**
**Week 1**: Introduction, Amino Acids, Peptides and proteins

**Week 2**: Peptides and proteins (contd.)

**Week 3**: Peptides and proteins (contd.)

**Week 4**: Proteins as biological catalyst, Concept of inhibition

**Week 5**: Nucleic acids,

**Week 6**: Metabolism, Synthetic biology, Molecular Biology

**Week 7**: Chemistry of cofactors/coenzymes

**Week 8**: Principle of drug design, Modern day drug discovery

**Week 9**: Chemistry of diseases and Drug development

**Week 10**: Chemistry of diseases and Drug development (contd.)

**Week 11**: Proton pump inhibitors, Gene replacement and delivery

**Week 12**: Revision and Problem solving

**Books and references:**


1. Biochemistry by Voet and Voet
2. Drug Design by R. Silverman
3. Medicinal Chemistry by G. L. Patrick

## Legal and Regulatory Issues in Biotechnology

**Duration: 4 weeks**
**Credits: 1**

**Prerequisites: Bachelor degree students Prerequisite: anyone who is interested to know the legal aspects of biotechnology industry**

**Course layout**
**Week-1**: Regulation of Biotechnology Research

**Week-2**: Intellectual Property Rights and Life sciences (Agriculture, Pharma, Biotech)

**Week-3**: Biotech Product commercialization: Regulatory Approval Process

**Week-4**: Understanding technology transfer in biotech sector

**Books and references**


1. Bucknell Duncan (ed.), I Pharmaceutical,Biotechnology and Chemical Inventions (Oxford University Press, 2011).
2. Cook M.Trevor, Pharmaceutical Biotechnology and the Law (Lexis Nexis , 2d ed. 2009).
3. Cook M.Trevor,The Protection Of Regulatory Data In Pharmaceutical And Other Sectors (Sweet and Maxwell, 2000).
4. Hardcastel Rohan, Law and The Human Body; Property Rights, Ownership and Control (Hart Publishing, 2007).
5. Valverde J.L. (ed.), Key Issues in Pharmaceutical Law ( IOS Press, Vol. 9 2009).
6. Drexl Josef, Nari Lee (ed.), Pharmaceutical Innovation, Competition and Patent Law; A Trilateral Perspective (Edward Elgar, 2013).
7. Verkey Elizabeth, Law of Plant Varieties Protection, 30-32 (Eastern Book Company, 1st ed. 2007).
8. Herring Jonathan, Medical Law & Ethics (Oxford University Press, 5th Ed., 2014).
9. Ventose Eddy, Medical Patent law- The Challenges of Medical Treatment (Edward Elgar, 2011).
10. Krattiger Anatole, Mahoney T. Richard, et.al., II Intellectual Property Management in Health and Agricultural Innovation; A handbook of best practices (MIHR, Oxford Center for Innovation, 2007).
11. Emily Jackson, Medical Law, text, cases and Materials , (Oxford University Press, 4th ed. 2013)
12. Holy F Lynch, Effy Vayena and Urs Gasser, Big data, Health Law and Bioethics, Edited by I. G. Cohen, (Cambridge University Press, 2018).

## Nanomaterials and their Properties

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Knowledge of thermodynamics and atomic structure**

**Course layout**

**Week 1**: Introduction, Overview of nanostructures nanomaterials

**Week 2**: Multiscale hierarchical nanostructures

**Week 3**: Thermodynamics of Nanomaterials

**Week 4**: Thermodynamics of Nanomaterials

**Week 5**: Surfaces and interfaces in nanostructures

**Week 6**: Surfaces and interfaces in nanostructures

**Week 7**: Properties of nanomaterials

**Week 8**: Properties of nanomaterials

**Week 9**: Properties of nanomaterials

**Week 10**: Properties of nanomaterials

**Week 11**: Properties of nanomaterials

**Week 12**: Properties of nanomaterials

**Books and references**

1. M. F. Ashby, P.J. Ferreira, D.L. Schodek, Nanomaterials Nanotechnologies and Design, Butterworth-Heinemann.

2. Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, Wiley-VCH.

## Ecology and Environment

**Duration: 8 weeks**
**Credits: 2**

**Prerequisites: Nil**

**Course layout**
**Week 1**: Dr. B.S. Murty -Introduction (1), Sustainability Definition / Goals, Climate Change (2), Case Studies (3) (Eg: Dams, Chemicals, e-waste, IOT, Landfill siting etc)

**Week 2**: Dr. Sudhir Chella Rajan-Sustainability and Economics (3), Sustainability and Ethics (3)

**Week 3:** Dr. Ligy Philip-(Water Quality/ Waste Management), Water Quality and Treatment (3), Waste Management and Treatment (3)

**Week 4**: Dr. B. S. Murty (Water Management/ Resources), Urban Drainage, Water Resource Management, Impact of Climate Change

**Week 5**: Dr. Srinivas Jayanti (Energy)-Energy Demand / Resources (1), Pollution from Energy generation (1), Energy and Climate Change (Global Warming) (1), Energy and Sustainability (1), Long Range and Short Range Solutions (1) (Global vs. India)

**Week 6**: Dr. R. Ravi Krishna-Risk Assessment Definition (1), Pollutant Pathways / Safety/ Exposure (1), Liability /Examples (1), Life Cycle Assessment (2), Environmental Management and LCA (1)

**Week 7:** Dr. Sudhir Chella Rajan-Urban Planning / Sprawl (1), Challenges in Urban Planning, Transport (1), Energy (Smart Grid) (1), Waste (1), Governance (1)

**Week 8**: Dr. Susy Varughese / Dr. Parag Ravindran-Ecology – definitions / Systems (1), Biodiversity (1), Examples of Historical Impact of economy on Ecology, Restoration / Ecological Engineering

**Week 9**: Dr. Ligy Philip / Dr. Ravi Krishna -Solid Waste Management, Hazardous Waste Management

**Books and references:**
Wrap up Emphasis on Climate Change and Adaptation

## Bioreactors

**Duration: 4 weeks**
**Credits: 1**

**Prerequisites: Ability to appreciate simple mathematical analysis**

**Course layout**

**Week 1:** Introduction

**Week 2:** Two important outcomes of a bioprocess: biomass (cells) and bio-products

**Week 3:** Common bioreactor operation modes, factors that affect bioreactor performance

**Week 4:** The cell view of a bioreactor

**Books and references:**
Shuler, M.L. and Kargi, F. 2002. Bioprocess Engineering: Basic Concepts, Prentice Hall, Englewood Cliffs, NJ J. Bailey and D. Ollis, Biochemical Engineering Fundamentals; McGraw Hill, 1986.

1. In addition, the students would be directed to specific sources during the course – they will become available during the course on the course page.

## Transport Phenomena in Biological Systems

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Undergraduate engineering mathematics**

**Course layout**
**Week 1:** Introduction; Mass conservation principle

**Week 2:** Mass flux

**Week 3:** Mass flux contd.; Review

**Week 4:** Momentum flux

**Week 5:** Momentum flux contd.

**Week 6:** Momentum flux contd.

**Week 7:** Momentum flux contd.; Review; Energy (heat) flux

**Week 8:** Energy (heat) flux contd; Review

**Week 9:** Charge flux; Review

**Week 10:** Fluxes under simultaneous, multiple driving forces

**Week 11:** Fluxes under simultaneous, multiple driving forces contd.

**Week 12:** Fluxes under simultaneous, multiple driving forces contd.; Review

**Books and references**

**Textbook:**
1. Suraish kumar GK. 2014. Continuum Analysis of Biological Systems: Conserved Quantities, Forces and Fluxes. Springer, Heidelberg (e-book available free through Springer Link if your Institution has access to it).

**References:**
1. Truskey, GA, Yuan F, Katz DF. 2009. Transport Phenomena in Biological Systems. II ed. Prentice Hall, New Jersey.
2. Bird, RB, Stewart, WE, Lightfoot, EN. 2001. Transport Phenomena, II edition, John Wiley and Sons, New York.

## Technologies for Clean and Renewable Energy Production

**Duration: 8 weeks**
**Credits: 2**

**Prerequisites: Nil**

**Course layout**

**Week 1**: Introduction, characterization of coal and conventional routes for energy production from Coal.

**Week 2**: Cleaner routes for energy production form coal

**Week 3**: Characterization of crude oil and conventional routes for crude oil utilization

**Week 4**: Cleaner routes for energy production form petroleum crude

**Week 5**: Cleaner energy production from gaseous fuels

**Week 6**: Solar and wind energy production

**Week 7**: Production of hydro and geothermal energy

**Week 8**: Energy production from biomass and wastes and energy conservation

**Books and references:**


1. Miller Bruce G., Coal Energy Systems, Elsevier Academic Press, Paris 2005.
2. Twidel, J. and Tony W., Renewable Energy Resources, Second Edition, Taylor & Francis 2006.
3. Kreith F., Goswami D.Y., Energy Management and Conservation, CRC Press 2008.
4. Sukhatme S., J Nayak J., Solar Energy: Principles of thermal Collection and Storage, 3 rd Ed., Tata McGrow-Hill Pulishing Company Ltd. 2008.
5. Mondal P and Dalai A., Sustainable utilization of natural resources, CRC Press 2017.

## Principles and Practices of Process Equipment and Plant Design

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Mass Transfer, Heat Transfer, Fluid Mechanics, Process instrumentation**

**Course layout**

**Week-1**: Introduction to Plant Design (2); Introduction to Mass transfer Equipment (1); Phase Equilibrium (2)

**Week-2**: Distillation – Fractionation (4); Design Problem (1)

**Week-3**: Flash Distillation (1); Batch Distillation (3); Design Problem (1)

**Week-4**: Absorption (2); Adsorption (2); Design Problem (1)

**Week-5**: Liquid-Liquid Extraction - 3; Column Internals – 2 [Sieve (1), Valve (1)]

**Week-6**: Column Internals contd. - Bubble Cap (2); packed column (1); Design Problem (2)

**Week-7**: Heat Exchanger: Introduction (1); Double Pipe HE (2); S&T HE (2)

**Week-8**: S&T HE contd. (1); Design Problem (1+2); Heat Exchanger Network (1)

**Week-9**: Heat Exchanger Network (3); Design Problem (2)

**Week-10**: Plant hydraulics: Pumps (2) Compressors (2), Pipeline (1)

**Week-11**: Pressure Vessels (2); Design Problem (2); Process Utilities (1)

**Week-12**: Safety (2), Process Design Package (3)

**Books and references:**


1. Process Equipment and Plant Design - Principles and Practices", Ray. Subhabrata and Das, Gargi; ISBN: 9780128148853; 1st Edn., May 2020, Elsevier Inc.
2. Smith BD. Design of equilibrium stage processes. McGraw-Hill Companies; 1963.
3. Sinnott, R.K.and Towler, G., 2013.Chemical Engineering Design, Chemical Engineering Design.
4. Shah RK, Sekulic DP. Fundamentals of heat exchanger design. John Wiley & Sons; 2003 Aug 11.
5. Lestina, T. and Serth, R.W., 2007. Process heat transfer: Principles, applications and rules of thumb., Elsevier Ltd.

**Patent Law for Engineers and Scientists**

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: A background degree in Science or Technology is preferable. Students who enroll for this course may also benefit from the course "Patent Drafting for Beginners"**

**Course layout**

**Week 1**: Introduction to the Indian Patent System Patent Laws as Concepts; Understanding the Patents Act, 1970; Understanding the Patents Rules, 2003; Preliminary Sections; Preliminary Rules;What's New in the Patents (Amendment) Rules, 2016; Easy way to read the Patents Act and Rules.

**Week 2**: Patentability of Inventions Statutory Exceptions to Patentability; Novelty and Anticipation; Inventive Step; Capable of Industrial Application; Person Skilled in the Art.

**Week 3**: Patent Specification Provisional and Complete Specifications; Structure of a Patent Specification—Title, Abstract, Description, Claims, etc.; Reading a Patent Specification—Fair basis, Enabling Disclosure, Definiteness, Priority; Introduction to Patent Drafting.

**Week 4**: Patent Prosecution: Patent Applications Patent Application—Who Can Apply, True and First Inventor, How to Make a Patent Application,What to include in a Patent Application, Types of Patent Applications, Patents of Addition, Dating of Application.

**Week 5**: Patent Prosecution: Publication and Examination - I Publication of Application; Request for Examination; Examination of Application—First Examination Report.

**Week 6**: Patent Prosecution: Publication and Examination – II Expedited Examination of Application; Search for Anticipation—Procedure, withdrawal of Application; Consideration of Report of Examiner

**Week 7**: Patent Prosecution: Powers of Controller Powers of Controller—Examination Stage, Consideration of report by examiner, Refuse or Amend Applications, Division of Applications, Dating of Application, Anticipation, Potential Infringement; Putting Applications in Order; Amendments during Prosecution

**Week 8**: Patent Prosecution: Opposition Pre-grant opposition; Post-grant opposition; Wrongful obtaining of invention; Mention of Inventor; Opposition in General.

**Week 9**: Patent Prosecution: Practice at the Patent Office- I Secrecy Provisions; Grant of Patents; Rights Conferred by Grant; Rights of Co-Owners; Term of Patent; Restoration of Lapsed Patents;

**Week 10**: Patent Office and Patent Prosecution, Surrender; Revocation—Grounds for Revocation; Register of Patents, Patent Office and its Establishment; Patent Agents; Use and Acquisition by Government; Penalties.

**Week 11**: Compulsory Licensing Compulsory Licensing—Working of Patents, Grounds for Grant of Compulsory License, Revocation; Patent Licensing;

**Week 12**: Patent Enforcement, International Arrangements and Other Miscellaneous Provisions Intellectual Property Appellate Board; Declaratory Suits, Infringement Suits; International Application—Convention Application, PCT Application, Application Designating India, Multiple Priorities; PCT Timeline; Fees—Application, In Relation to Grant of Patents; Timelines, Application, Examination, Publication etc.

**Books and references**


1. Feroz Ali, The Law of Patents, LexisNexis • Ronald D. Slusky, Invention Analysis and Claiming – A Patent Lawyer's Guide, Second Edition, American Bar Association, 2012.
2. Feroz Ali, the Touchstone Effect – The Impact of Pre-grant Opposition on Patents, LexisNexis, 2009.

## Bio microfluidics

**Duration: 4 weeks**
**Credits: 1**

**Prerequisites: Nil**

**Course layout**

**Week 1:** Introduction to Bio microfluidics Engineers’ guide to the cell Fluidics in living systems and mechanobiology Pressure driven flows

**Week 2:** Surface tension driven flows Modulating surface tension Lab on a CD Introduction to lectrokinetics

**Week 3:** Microfluidic cell culture On-chip cellular assay techniques Microfluidics for understanding biology

**Week 4:** Organ-on-a-chip Lab-on-a-chip for genetic analysis Microfluidic technology for monoclonal antibody production

**Books and references :** Nil

## Biomedical Nanotechnology

**Duration: 4 weeks**

**Credits: 1**

**Prerequisites: Basic Knowledge in biology**

**Course layout**

**Week 1:** Introduction to nano, Nano-biomimicry, Synthesis of nanomaterials by physical and chemical methods, Synthesis of nanomaterials by biological methods, Characterisation of nanomaterials.

**Week 2:** DNA nanotechnology, Protein & glyco nanotechnology, Lipid nanotechnology, Bio nanomachines, Carbon nanotube and its bio-applications.

**Week 3:** Nanomaterials for cancer diagnosis, Nanomaterials for cancer therapy, Nanotechnology in tissue engineering, Nano artificial cells, Nanotechnology in organ printing.

**Week 4:** Nanotechnology in point-of-care diagnostics, Nanopharmacology & drug targeting, Cellular uptake mechanisms of nanomaterials, In vitro methods to study antibacterial and anticancer properties of nanomaterials, Nanotoxicology.

**Books and references**


1. Malsch, N.H., “Biomedical Nanotechnology”, CRC Press. (2005).
2. Mirkin, C.A. and Niemeyer, C.M., “Nanobiotechnology II: More Concepts and Applications”, Wiley-VCH. (2007).
3. Kumar, C. S. S. R., Hormes, J. and Leuschner C., “Nanofabrication Towards Biomedical Applications: Techniques, Tools, Applications, and Impact”, WILEY -VCH Verlag GmbH & Co. (2005).
4. Lamprecht, A., “Nanotherapeutics: Drug Delivery Concepts in Nanoscience”, Pan Stanford Publishing Pte. Ltd. (2009).
5. Jain, K.K., “The Handbook of Nanomedicine”, Humana press. (2008).

## Introduction to Biomedical Imaging Systems

**Duration: 12 weeks**

**Credits: 3**

**Prerequisites: Engineering students from most core branch will be ready to take it in 6th- 8th semester as they would have completed signals and systems and linear algebra.**

**Course layout**

**Week 1**: Introduction, 2D- Signals Systems review, Image Quality metrics

**Week 2**: Introduction, 2D- Signals Systems review, Image Quality metrics

**Week 3**: Projection Radiography

**Week 4**: Projection Radiography

**Week 5**:X-ray CT

**Week 6**: Nuclear Medicine- PET/SPECT

**Week 7**: Nuclear Medicine- PET/SPECT

**Week 8**: Ultrasound Imaging

**Week 9**: Ultrasound Imaging

**Week 10**: MRI

**Week 11**: MRI

**Week 12**: MRI

**Books and references:**

1. Medical Imaging Signals and Systems by J. L. Prince and J. M. Links, Pearson Prentice Hall, 2006, ISBN 0130653535.
2. Webb's Physics of Medical Imaging, 2nd Edition, CRC press

## Biomechanics of Joints and Orthopaedic Implants

**Duration: 8 weeks**

**Credits: 2**

**Prerequisites: Engineering Mechanics, Solid Mechanics**

**Course layout**

**Week 1:** Introduction Musculoskeletal system Bone, Muscle, Ligament, Tendon, Cartilage and Meniscus – structure and function Anatomy of Synovial Joints – Hip, Knee, Shoulder, Elbow

**Week 2:** Biomechanics of Human Joints: (a) Hip Joint; (b) Knee Joint; (c) Shoulder Joint; (d) Elbow Joint

**Week 3:** Biomechanics of Gait cycle Gait Analysis Measurement techniques 3-D Motion analysis system – markers, cameras and force platform Lower extremity – hip musculoskeletal forces.

**Week 4:** Joint Kinematics Principle of Forward and Inverse Dynamics Calculations on joint forces and moments Calculations on muscle forces Model-based estimation of musculoskeletal forces during movements

**Week 5:** Concepts of Stresses and Strain Bone structure **-** Cancellous and Cortical Bone Mechanical Behaviour of Bone Bone Adaptation and Viscoelasticity Bone Anisotropy.

**Week 6:** Biomechanics of Joint Replacement – Hip, Knee, Shoulder, Spine Cemented and Cementless fixation Failure mechanisms of implants Implant Design Considerations

**Week 7:** Biomechanical modelling techniques and analysis Finite Element Analysis of bone and implant Bone Remodelling – formulation, algorithm, simulation Experimental validation of numerical models

**Week 8:** Bone Fracture Healing Tissue Differentiation Mechanoregulatory principle Mechanobiology based simulation of bone ingrowth around implants – acetabular and femoral components

**Books and references:**


1. Basic Biomechanics of the Musculoskeletal System" by Margareta Nordin and Victor H. Frankel
2. Biomechanics and Motor Control of Human Movement" by David A. Winter
3. Orthopaedic Biomechanics” by D.L. Bartel, D.T. Davy and T.M. Keaveny

## Neuroscience of Human Movements

**Duration: 12 weeks**

**Credits: 3**

**Prerequisites: Motivation & open-mindedness is the only pre-requisite**

**Course layout**

**Week 1**: Introduction, Membrane Physiology, Nernst Equation, GHK Equation, Action potential

**Week 2**: Neuromuscular Junction, Skeletal Muscles

**Week 3**: Skeletal muscles, Motor Units

**Week 4**: Receptors, Muscle Spindles, Golgi Tendon Organs, Spinal control

**Week 5:** Monosynaptic, Oligosynaptic & Polysynaptic reflexes

**Week 6**: Preprogrammed reactions, Spinal control, Overview of motor control system, Primary Motor cortex – Part 1

**Week 7**: Primary Motor cortex – Part 2, Lesions, Brain Machine interfaces

**Week 8**: Primary Motor Cortex – Part 3, Role of Cerebellum in movement control

**Week 9**: Role of Cerebellum in movement control

**Week 10**: Parietal & Pre-motor cortex

**Week 11**: Role of Basal Ganglia in movement control

**Week 12**: Role of Basal Ganglia in movement control

**Books and references:**

1. Kandel & Schwartz, Principles of Neural Science, 2012, McGraw-Hill.

**Current regulatory requirements for conducting clinical trials in India for investigational new drugs/new drug (Version 3.0)**

**Duration: 8 weeks**

**Credits: 2**

**Prerequisites: There is no pre-requisite to undertake this course. It is suitable for personnel with scientific/medical background** (BSc/MSc/PhD/BPharm/MPharm/BAMS/BHMS/BDS/MDS/MBBS/MD/DM). Personnel working in the area of drug development/clinical trials/research may benefit from this course.

**Course layout**

**Week 1:** Lecture 0: Course overview
Lecture 1: Overview of Indian drug regulatory system
Lecture 2: Overview of drugs & cosmetics Act and Rules thereunder
Lecture 3: Overview of New Drug and Clinical Trials Rules Rules, 2019

**Week 2:** Lecture 4: Pre-clinical data requirements
Lecture 5: Rules governing clinical trials
Lecture 6A: Phases of clinical trial, forms, and fees
Lecture 6B: Regulatory pathway and data requirements for NDCT, 2019

**Week 3:** Lecture 7: BA/BE study and study centres: Legal provisions
Lecture 8: Guidelines to conduct BA/BE studies
Lecture 9: Ethics Committee registration and re-registration

**Week 4:** Lecture 10: Ethical considerations
Lecture 11: Good Clinical Practice
Lecture 12A: Requirements for import/manufacture of new drug/IND for conducting clinical trials in India
Lecture 12B: Requirements for import/manufacture of new drug/IND for sale/distribution and unapproved new drug for patients

**Week 5:** Lecture 13: Important issues
Lecture 14: Special concerns
Lecture 15: Clinical trial related guidelines (NDCT Rules)

**Week 6:** Lecture 16: Content of proposed clinical trial protocol
Lecture 17: Content of a clinical trial report
Lecture 18: Post marketing assessment and clinical trial compensation

**Week 7:** Lecture 19: Common observations during submission of CT/BA/BE protocol Lecture

20: Common observations during CT/BA/BE centre inspections Lecture 21: Drug development process: Overview

**Week 8:** Lecture 22: Salient feature of NDCT 2019 (What's new in NDCT?) Lecture
23A: Online submission (SUGAM)
Lecture 23B: Online submission (CTRI)
Lecture 24: Tables given in NDCT 2019 and its content

**Books and references:**
1. Drugs & Cosmetics Act, 1940 and Rules thereunder 1945, New Drugs and Clinical Trial Rules, 2019, Related Guidance documents available at CDSCO website.

## Introduction to Proteogenomics

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: Nil**

**Course layout**

**Week 1**: Proteogenomics overview- Part I, Proteogenomics overview- Part II, Introduction to Genomics- Part I: Gene sequencing and mutations Introduction to Genomics-Part II: Sequence alignment, Introduction to Genomics-Part III: Transcriptome, SL1: Advancement in Cancer Genomics, SL2: Advancement in Cancer Genomics

**Week 2**: Introduction to Genomics IV: Epigenome, Introduction to Genomics: cBioPortal, Genotype, Gene expression & Phenotype - Part I, Genotype, Gene expression & Phenotype Part II, An overview of NGS technology, SH1: NGS-Sequencing by synthesis, SH2: NGS Sequencing by synthesis

**Week 3**: Introduction to Proteomics, Proteomics: Sample Prep & Protein Quantification, Proteomics: Sample Prep & Protein Quantification (Hands-on), Introduction to MS-based Proteomics- Part I, Introduction to MS-based Proteomics- Part II, SL 3: Applications of NGS – Ion Torrent, SL4: Applications of NGS – Ion Torrent

**Week 4**: Introduction to MS-based Proteomics- Part I (Hands-on), Introduction to MS-based Proteomics- Part II (Hands-on), Data analysis: Normalization, Data analysis: Batch Correction and Missing values, Data analysis: Statistical Tests, SH3: NGS- Ion Torrent, SH4: NGS- Ion Torrent

**Week 5**: Machine learning and Clustering, Hypothesis testing, ProTIGY- Part I, ProTIGY- Part II, Proteogenomics approach to unravel proteoforms, SL5: Genomic Analysis using Droplet PCR, SL6: Genomic Analysis using Droplet PCR

**Week 6**: Workflow to Automated Data Processing, Introduction to Fire Cloud, Fire Cloud and Data Model, Bioinformatics solutions for ‘Big Data’ Analysis- Part I, Bioinformatics solutions for ‘Big Data’ Analysis-Part II, SH5: Genomic Analysis using Droplet PCR, SH6: Genomic Analysis using Droplet PCR

**Week 7**: Data Science infrastructure management- Part I, Data Science infrastructure management- Part II, Data Science infrastructure management- Part III, DIA-SWATH Atlas Part I, DIA-SWATH Atlas- Part II, SL7: Introduction to Targeted Proteomics, SH7: Data Analysis using Skyline

**Week 8**: Human Protein Atlas-Part I Clinical, Human Protein Atlas-Part II, Affinity based proteomics & HPA, Clinical Considerations for OMICS-Part I, Considerations for OMICS- Part II, SL8: Proteomics: PTMs, SL9: Clinical Proteomics

**Week 9**: Introduction to Proteogenomics-Part I, Introduction to Proteogenomics-Part II, Sequence centric proteogenomics, Gene Variant Analysis, Proteomics in Clinical studies, SH8: ProTIGY

**Week 10**: Supervised Machine learning- Predictive Analysis Part I, Supervised Machine learning- Predictive Analysis Part II, Supervised Machine learning- Marker Selection, Gene Set Analysis using WebGestalt- Part I, Gene Set Analysis using WebGestalt- Part II, SH9: Supervised Machine Learning

**Week 11**: Biological Network Analysis- Part I, Biological Network Analysis- Part II, Mutation and Signaling - Part I, Mutation and Signaling- Part II, Pathway Enrichment, SH10: Pathway Enrichment and Network Analysis

**Week 12**: Gene Set Enrichment Analysis (GSEA), Pathway enrichment: GSEA, Linked Omics, Linked Omics (Hands-on), Proteogenomics Conclusions, SL10: Topics in Proteogenomics Malaria and Cancer case study

**Books and references:**

1. Proteomics: A Cold Spring Harbor Laboratory Course Manual, A.J. Link and J. LaBaer, Cold Spring Harbor Laboratory Press, 2009. Selected papers from scientific journals

## Introduction to proteomics

**Duration: 8 weeks**
**Credits: 2**

**Prerequisites: The target audiences of this course are required to have a basic introduction to biology.**

**Course layout**
**Week 1:** Basics of Proteins and Proteomics
Lecture 1: Introduction to amino acids
Lecture 2: Introduction to Proteins
Lecture 3: Protein folding & misfolding
Lecture 4: Introduction to Proteomics
Lecture 5: Lab session – Protein-protein interaction using label-free biosensors

**Week 2:** Gel-based proteomics
Lecture 6: Sample preparation and pre-analytical factors
Lecture 7: Sample preparation: pre-analytical factors (contd.)
Lecture 8: Sample preparation: Protein extraction and quantification
Lecture 9: One-dimensional electrophoresis
Lecture 10: Introduction to 2-DE

**Week 3**: Two-dimensional gel electrophoresis (2-DE)
Lecture 11: 2-DE: Second dimension, staining & destaining
Lecture 12: 2-DE: Gel analysis
Lecture 13: 2-DE Applications
Lecture 14: 2-DE Applications (contd.) & Challenges
Lecture 15: Lab session **-** Protein/peptide pre-fractionation using OFFGEL FRACTIONATOR & data analysis

**Week 4**: Difference in gel electrophoresis (DIGE) & Systems Biology
Lecture 16: 2D-DIGE: Basics
Lecture 17: 2D-DIGE: Data analysis
Lecture 18: 2D-DIGE: Applications
Lecture 19: Systems biology and proteomics – I
Lecture 20: Systems biology and proteomics – II

**Week 5**: Basics of mass spectrometry
Lecture 21: Fundamentals of mass spectrometry
Lecture 22: Chromatography technologies
Lecture 23: Liquid chromatography
Lecture 24: Mass spectrometry: Ionization sources
Lecture 25: Mass spectrometry: Mass analyzers

**Week 6**: Basics of mass spectrometry and sample preparation
Lecture 26: MALDI sample preparation and analysis
Lecture 27: Hybrid mass spectrometry configurations
Lecture 28: Lab session **-** Demonstration of Q-TOF MS technology
Lecture 29: In-gel & in-solution digestion
Lecture 30: Lab session **-** Sample preparation: tissue sample preservation technology

**Week 7:** Quantitative proteomics
Lecture 31: Introduction to quantitative proteomics
Lecture 32: SILAC: In vivo labelling
Lecture 33: iTRAQ: In vitro labelling
Lecture 34: TMT: In vitro labelling
Lecture 35: Quantitative proteomics data analysis

**Week 8:** Advancement in Proteomics
Lecture 36: Proteomics applications
Lecture 37: Challenges in proteomics
Lecture 38: OMICS and translational research
Lecture 39: Lab session – Targeted proteomics using triple quadrupole mass spectrometry Lecture 40: Lab session – Targeted proteomics: multiple reaction monitoring

**Books and references**
Nil

## Computer Aided Drug Design

**Duration: 8 weeks**
**Credits: 2**

**Prerequisites: Prior knowledge of biochemistry, bioinformatics**

**Course layout**

**Week 1:** Introduction to drug discovery

**Week 2:** Structure and property

**Week 3**: ADME-rules

**Week 4**: Force field/MM/QM

**Week 5**: Boundary conditions/Conformation

**Week 6**: QSAR/Pharmacophore

**Week 7**: Enzymes/proteins structures/docking

**Week 8**: PK/PD

**Books and references:**

1. Voit E (2012) A First Course in Systems Biology. Garland Science, 1/e. ISBN 0815344678.

2. Klipp E (2009) Systems biology: a textbook. Wiley-VCH, 1/e. ISBN 9783527318742.

3. Newman MEJ (2011) Networks: an introduction. Oxford Univ. Press. ISBN 9780199206650.

## Drug Delivery: Principles and Engineering

**Duration: 12 weeks**
**Credits: 3**

**Prerequisites: A course in biochemistry, molecular biology, anatomy is recommended**

**Course layout**

**Week 1**: Pharmacokinetics: Bioavailability, Elimination, Therapeutic index

**Week 2**: Prodrugs, Controlled release

**Week 3**: Polymers: Synthesis, properties, characterization, crystallinity and amorphousness

**Week 4**: Biopolymers: Natural and Synthetic, biocompatibility, Biodegradation, commonly used biopolymers

**Week 5**: Polymer-Drug conjugates, PEGylation

**Week 6**: Diffusion controlled systems, Ficks laws, Reservoir systems, non-erodible matrix systems, Bio-erodible systems

**Week 7**: Hydrogels: Physical or chemical, pore-size calculation, in-situ crosslinking

**Week 8**: Nano and Micro-particles: Dendrimers, Liposomes, Micelles

**Week 9**: Metal and polymeric particles, effect of particle shape, charge and elasticity

**Week 10**: Protein Adsorption and tissue engineering, Drug delivery in tissue engineering

**Week 11**: Implant associated infections, Route specific delivery: Oral, Subcutaneous, Intramuscular, transdermal, inhalation, intravenous

**Week 12**: Vaccines, Cancer vaccines, Cell and gene delivery, Smart responsive drug delivery, Targeted drug delivery, Nanotoxicology and market translation

**Books and references:**

1. Drug Delivery: Engineering Principles for Drug Therapy, W. Mark Saltzman, Oxford University Press, 2001.
2. Drug Delivery: Fundamentals and Applications, Anya M. Hillery and Kinam Park, 2nd Edition, CRC Press, 2016.

## Functional Genomics

**Duration: 4 weeks**
**Credits: 1**
**Prerequisites: Basic level of understanding in cell and molecular biology is expected**

**Course layout**

**Week 1:** [2.5 hrs; 4 lectures]
*Introduction to Functional Genomics:*
Pre- and post-genomic era; major advancements in genomic approaches; epigenetics and metagenomics; forward versus reverse genetics

**Week 2**: [2.5 hrs; 4 lectures]
*Genome Analyses - Part 1*

Genome editing approaches and their applications; gene expression analyses and applications

**Week 3:** [3 hrs: 4 lectures and 2 tutorial sessions]
*Genome Analyses - Part 2*
Methods for DNA/RNA sequencing, sequence analysis and their applications

**Week 4:** [2.5 hrs: 3 lectures and 2 laboratory sessions]
*Comparative Genomics*
Genomic insight into evolution; power of comparative genomic analysis

**Books and references**
Mostly publically available literature. Will be shared with the participants during the launch of the course.

## Maternal Infant Young Child Nutrition

**Course Duration: 12 Weeks**
**Credits: 3**

**Week 1**: Maternal Infant Young Child Nutrition - Introduction

**Week 2**: Science of nutrition

**Week 3:** Types of malnutrition and hidden hunger

**Week 4**: Importance of first 1,000 days

**Week 5**: Science of Breastfeeding

**Week 6**: Cross cradle hold and 45 points of breastfeeding counselling.

**Week 7**: Other breastfeeding holds

**Week 8**: Manual expression, storage and feeding of the expressed breastmilk. Nipple/Breast Conditions.

**Week 9**: New born care and Kangaroo mother care

**Week 10**: Complementary feeding

**Week 11**: Maternal Nutrition-pre-pregnancy pregnancy-lactating mothers Adolescent Nutrition

**Week 12**: Assessment of anthropometric measurement and growth charts - Percentile & Z Score

**Books and references:**

WHO Growth Charts

## Optical Spectroscopy and Microscopy: Fundamentals of optical measurements and instrumentation

**Course Duration:**12 weeks
**Credits:**3

**Week 1**: Essential Quantum Mechanics: Uncertainty Principle, Probabilistic nature of measurement, postulates of qmech, Stern Gerlach equivalent in light, Photon picture (PMT response), Linear Vector Space.

**Week 2**: Time dependent perturbation theory, Fermi Golden Rule, Transition probability in light matter interaction, Beer Lambert relation, Einstein's phenomenological treatment, A and B coefficients, Spontaneous emission, Origins of fluorescence.

**Week 3**: Nature of Fluorescence, Emission spectrum, Absorption spectrum, Anisotropy, Life time, FRET.

**Week 4**: Second quantization, creation and annihilation operators, Fock states, light matter interaction in Feynman diagrams.

**Week 5**: Spontaneous emission origin, Stimulated Emission origin dependence through Fock states.

**Week 6**: Laser emission, two state, three state and four state laser systems.

**Week 7**: Real world lasers, Characteristics of laser emission, threshold behavior, Laser gain equation, CW operation, Pulsed lasers, Switching, mode locking, Saturable absorber.

**Week 8**: Laser induced fluorescence, optical components (lenses, mirrors, gratings, prisms) and their working principles, Interference filters, dichroic filters, efficiency calculations for SNR improvement, aligning an optical equipment.

**Week 9**: Intro to optical hardware, common opto-mechanical assemblies, setting up a simple laser-based spectrometer using gratings in lab, calibration and acquisition of fluorescein spectra.

**Week 10:** Principles of photo detection, QE, Dynamic range shot noise, photodetectors – PMTs, photodiodes, photo resistors, understanding common metrics and specs. Detection electronics – preamps, A2Ds.

**Week 11**: Area detectors, CCDs, emCCDs, sCMOS, comparison, read noise, speed and other sensor characteristics. Theory of Image formations – widefield microscopy, bright field, phase contrast, DIC and fluorescence microscopy.

**Week 12**: Scanning system: Principles of scanning system, Gaussian light progation and focusing, optical resolution, definition in xy and z. Measurement and characterization in lab. Scanning as time averaged focus, optical hinges, imaging of hinges, Confocal microscope.

**Books and references**

1. Optical Spectroscopy (Demtroder), Quantum Electronics – Yariv, Building Scientific Apparatus – WJ Moore.

# Human Molecular Genetics

**Course Duration: 4 Weeks**

**Credits: 1**

**Week 1:** Fundamentals of central dogma (DNA, RNA and proteins; mutations), Chromosome structure and function (organization; structure- function relationship; chromosome abnormalities).

**Week 2**: Genes in pedigree (Mendelian pedigree patterns, complications to pedigree patterns), DNA cloning and hybridization techniques (vector-based cloning; nuclei acid hybridizations; PCR-based DNA analyses)

**Week 3:** Mutation and instability of human DNA (mutation and polymorphism; pathogenic mutations, repeat expansions), Molecular pathology (types of mutations; animal models for human disease)

**Week 4:** Identifying human disease genes (functional cloning versus positional cloning; mutation screening), Complex diseases; The Human Genome and HapMap projects

**Books and References:**

Human Molecular Genetics 4 Tom Strachan, Andrew P. Read Garland Science/Taylor & Francis Group, 2011

## Demystifying the Brain

**Course Duration: 4 weeks**

**Credits: 1**

**Week 1**: History of neuroscience, Brain through evolution

**Week 2**: Neurons and neural signaling Networks that learn

**Week 3**: Organization of the nervous system Maps in the brain

**Week 4**: Memories and holograms, Emotions in the brain, Theories of Consciousness

**Books and References:**

1. Demystifying the brain, ebook on NPTEL.

2. Valentino Braitenberg, Vehicles.

3. VS Ramachandran, Phantoms in the Brain.Joseph LeDoux, Emotional Brain

## Medical Biomaterials

**Course Duration: 8 weeks**
**Credits: 2**

**Week 1**: Introduction to Biomaterials Background history History Properties (Mechanical and Physico chemical) Properties (Mechanical and Physico-chemical)

**Week 2**: Mechanical properties Mechanical properties Resorbability, biodegradation Resorbability, biodegradation Biofilm

**Week 3**: Biofilm Biofil m Material characterization - Analytical instruments Analytical instruments

**Week 4:** Analytical instruments Analytical instruments Biological responses, compatibility, cytotoxicity Proteins, Tissue and blood Response Cell-biomaterial interaction

**Week 5:** Animal trials (in vivo) Animal trials Metals-types, classifications, applications Metals - properties

**Week 6:** Metals - properties Metals Polymers-types, classifications, applications Polymers

**Week 7:** Blends/composites Biopolymer s Hydrogels Preparation of different morphologies (with experiments) Surface modifications (with experiments)

**Week 8:** Ceramics Drug delivery systems/encapsulation Biomaterials for cardiovascular/pulmonary/ophthalmological applications Biomaterials for urinary/dental/skin applications Sterilization of implants, device failures, unique issues, conclusion

**Books and references** NIL

## Forests and Their Management

**Course Duration: 12 weeks**
**Credits: 3**

**Week 1:** Introduction

**Week 2:** Basics of silviculture

**Week 3:** Forest soils

**Week 4:** Forest mensuration

**Week 5**: Forest surveying

**Week 6:** Forest protection

**Week 7:** Silvicultural management - I

**Week 8:** Silvicultural management - II

**Week 9:** Logging and yield

**Week 10:** Silvicultural practices

**Week 11:** Newer trends in forestry

**Week 12:** Revision

**Books and references:**

**1. Principles and practices of Silviculture by S. S. Bist**

**2. Forest soils by Wilde**

## Nanotechnology in Agriculture

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1:** History of agriculture and the role of chemicals in modern agriculture

**Week 2:** Overview of nanotechnology

**Week 3:** Application of nanotechnology in modern day agriculture practices I

**Week 4:** Application of nanotechnology in modern day agriculture practices II

**Week 5**: Application of nanotechnologies in animal production

**Week 6:** Nanotechnology and shelf life of agricultural and food products

**Week 7:** Nanotechnologies for water quality and availability

**Week 8:** Green nanotechnology and the role of good governance and policies for effective nanotechnology development**.**

**Books and references**

- E-Reference materials will be provided during the course

## Bioelectrochemistry

**Course Duration: 4 weeks**

**Credits: 1**

**Week 1**: Fundamentals of electrochemistry with special references to bioelectrochemistry

**Week 2**: Electrodes & potentiometry

**Week 3**: Redox titrations

**Week 4:** Electro-analytical techniques

**Books and references:**

1. Quantitative chemical analysis by Daniel C Harris
2. D. Bioelectrochemistry: Fundamentals, Applications and Recent Developments Richard C. Alkire (Editor), Dieter M. Kolb (Editor), Jacek Laskowski (Editor), Phil N. Ross (Series Editor).

## Plant Developmental Biology

**Course Duration: 4 weeks**

**Credits: 1**

**Week 1**: Introduction: Life cycle of an angiosperm plant, Plant growth and development, Embryonic and post-embryonic development, Characteristics of plant development

**Week 2**: Molecular Genetics of Plant Development: Generation and characterization of developmental mutants, studying temporal and spatial expression pattern of developmental regulators, Functional genomics, Genetic manipulation of plant for studying development

**Week 3**: Root development: Organization and maintenance of root apical meristem, radial patterning during vascular development, Root branching; lateral root development

**Week 4**: Shoot development: Organization and maintenance of shoot apical meristem, Organogenesis and organ polarity, Floral transition, Floral organ patterning and determinacy, Cell-to-cell communication during development.

**Books and references:**


1. Leyser, O. and Day, S. Mechanisms in plant development. John Wiley & Sons. 2009.
2. Howell, S.H. Molecular genetics of plant development. Cambridge University Press. 1998.
3. Taiz, L. and Zeiger, E. Plant Physiology. Sinauer Associates. 2010 5th Eds.
3. Raven, P.H. Evert, R.F. and Eichhorn, S.E. Biology of plants. Macmillan. 2005 8th Eds.

# Conservation Economics

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1** What is Economics?

**Week 2** What is Conservation?

**Week 3** Modern impacts necessitating conservation

**Week 4** Threats to wildlife

**Week 5** How can Economics help?

**Week 6** Markets: Places where Economics works

**Week 7** Markets, welfare and conservation

**Week 8** Public sector and conservation

**Week 9** Industrial organization and conservation

**Week 10** Labour market economics and conservation

**Week 11** Practical issues in Economics and Conservation

**Week 12** Case Studies

**Books and references:**


1. Economics, Krugman and Wells

2.Economics, Hubbard & O'Brien

3. Principles of Economics, N. Gregory Mankiw

4. Basic Economics, Thomas Sowell

## Soft Nano Technology

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1:** Introduction to Patterning of Thin Films Application of Nano Patterned Films and Surfaces Basic Concepts of Wetting: Cassie and Wenzel Regimes Basic Concepts of Surface Tension

**Week 2**: Different Nano Fabrication Regimes including self-assembly Micelle formation Introduction to Photo Lithography

**Week 3**: Discussion on Photo Lithography: Photo Resists Spin Coating Exposure Development

**Week 4**: Nano Imprint Lithography

**Week 5**: Soft Lithography: Introduction Different Techniques

**Week 6**: Soft Lithography Techniques

**Week 7**: Basic Concepts of Atomic Force Microscopy

**Week 8**: Different Imaging Modes of Atomic Force Microscopy

**Books and references :**


1. Alternative Lithography”, C. M. Sotomayor Torres (Ed.), Kluwer Academic Press, 2003.
2. Creating Micro and Nano Patterns on Polymeric Materials”, A del Campo and E. Arzt (Ed), Wiley, 2011.
3. “Micro Fluidics and Micro Scale Transport Process”, Suman Chakraborty (Ed), CRC Press, 2013

## Understanding Design

**Course Duration: 4 weeks**

**Credits: 1**

**Week 1:**
Module 1- An Introduction to Design,
Module 2- Users and Context

**Week 2:**
Module 3-Design and Society,
Module 4 - Design and Sustainability

**Week 3:**
Module 5 - Design and Industry,
Module 6 - Design and collaboration

**Week 4:**
Module 7 - Innovation by Design

**Books and references :**


1. Ansell, C & Torfing J (eds) (2014). Public Innovation through Collaboration and Design.London and New York:
2. Routledge. Antonelli, Paola (2005). Humble Masterpieces: everyday marvels of Design. Harper Collins Publishers.
3. Baxter, Mike (1995). Product Design. London Glasgow New York:
4. Chapman & Hall. Brown, Dan M (2013). Designing Together. New Riders.
5. Doordan, Dennis (ed) (2000). Design History: An Anthology. Cambridge, London: MIT
6. Press. Heskett, John (2002). Design: a very short introduction. Oxford University Press.
7. Geist, Valerius (1978). Life Strategies, Human Evolution, and Environmental Design: towards a biological theory of health. New York, Heidelberg, Berlin: Springer-Verag
8. Lawson, Brian (2006). How Designer's Think: The design process demystified.
9. Routledge. Highmore, Ben (ed) (1975). The Design Culture Reader. London and New York:
10. Routledge. Kepes, Gyorgy (ed) (1966). The Man-Made Object. Studio Vista
11. London. Norman, Don (2013). The Design of Everyday Things. Hachette UK.
12. Papanek, Victor J (1984). Design for the Real World: Human Ecology and Social Change. Academy Chicago. Essi Salonen Designing Collaboration Link
13. Gupta, Anil K, Grassroots Innovation: Minds On The Margin Are Not Marginal Minds
14. Link Brown Tim, Change by Design: How Design Thinking Transforms Organizations
15. and Inspires Innovation Link D'Source, IDC, IITBombay: http://www.dsource.in/

## Design, Technology and Innovation

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1:** i. Jaipur Foot - A classic innovation by Prof. B. K. Chakravarthy

ii.User Centered Helmet Design by Prof. B. K. Chakravarthy

**Week 2:** Challenges of Reaching a Million Users by Prof. Chetan Solanki and Prof Jayendran V

**Week 3:** i. Technology to Solution by Prof. Ramesh Singh ii. Collaborative Excellence by Prof. B. Ravi & Prof. B. K. Chakravarthy

**Week 4:** Collaborative Innovation Methods by Prof B. K. Chakravarthy

**Week 5:** Learnings from Grassroot Innovation by Prof. Anil Gupta

**Week 6:** Systemic Approach to Biomed Innovations by Prof. B. Ravi

**Week 7:** Research to Innovation by Prof. Amaresh Chakrabarti

**Week 8** : Smartcane for the Blind- A Success Story by Prof. P. V. Madhusudhan Rao

**Books and references :**

Nil

## Emotional Intelligence

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1**: Introduction to emotion, intelligence & wisdom

**Week 2**: Concept, theory, measurement and applications of intelligence

**Week 3**: Emotional intelligence: concept, theory and measurements

**Week 4**: Correlates of emotional intelligence

**Week 5**: Emotional intelligence, culture, schooling and happiness

**Week 6**: For enhancing emotional intelligence EQ mapping

**Week 7**: Managing stress, suicide prevention, through emotional intelligence, spirituality and meditation

**Week 8**: Application of emotional intelligence at family, school and workplace

**Books and references :**

NIL

## Exploring Survey Data on Health Care

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1**: Introduction to Health Care Data

**Week 2**: Preparation for Field Survey on Health Care

**Week 3**: Testing of Sample Data

**Week 4**: Handling of Data Software

**Week 5**: Survey Data using STATA

**Week 6**: Analysis of Data

**Week 7**: Panel Survey Data

**Week 8:** Policy Evaluation of Health Care

**Books and references :**


1. William H Greene: Econometric Analysis, Pearson 8th Edn.
2. Freedman & Pisani & Purves: Statistics 4th Edn
3. Cameron & Trivedi: Micro econometrics using STATA, Revised Edn.
4. Damodar Gujarati, Econometrics: By example, 2nd edition
5. Wooldridge: Econometric Analysis of Cross-section and Panel Data, MIT Press
6. Consoli, S; Recupero, D; Petkovic, M (2019), Data Science for Healthcare: Methodologies and applications
7. Drummond, M; Sculpher, M; Torrance, G (2005), Methods for the Economic
8. Evaluation of Health Care Programmes Other Readings during lecture ppts.

## Material and Energy Balances

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Introduction; Units and dimensions; Basic terminologies

**Week 2**: Fundamentals of Material Balances; Material Balances for Single Units Without Reactions

**Week 3**: Material Balances for Multiple Units Without Reactions; Material Balances for Reactive Processes

**Week 4:** Material Balances for Reactive Processes; Combustion Reactions

**Week 5**: Material Balances for Systems with Recycle, Bypass, and Purge

**Week 6**: Energy Balance Terminologies; Introduction to Energy Balances

**Week 7**: Mechanical Energy Balances; Objectives and Procedures for Energy Balances

**Week 8**: Energy Balances on Nonreactive Processes without Phase Change

**Week 9**: Energy Balances on Nonreactive Processes with Phase Change

**Week 10**: Mixing and Solutions; Fundamentals for Energy Balances on Reactive Processes

**Week 11**: Energy Balances on Reactive Processes

**Week 12:** Material and Energy Balances for Unsteady State Processes

**Books and references :**


1. David M. Hummable and James B. Riggs, Basic Principles and Calculations in Chemical Engineering, 7th Edition, Publisher: Prentice Hall India
2. Richard M. Felder and Ronald W. Rousseau, Elementary Principles of Chemical Processes, 3rd edition, Publisher: John Wiley & Sons
3. Pauline Doran, Bioprocess Engineering Principles, 2nd Edition, Publisher: Academic Press Ann Saterbak, Ka-Yiu San, Larry V. McIntire, Bioengineering Fundamentals, Publisher: Pearson

**Bioreactor Design and Analysis**

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1**: Introduction to the course

**Week 2**: Design of batch bioreactors

**Week 3**: Design of fed-batch bioreactors

**Week 4**: Design of continuous mode of bioreactors

**Week 5**: Mass transfer in bioreactors, Rheology of fermentation broths, Heterogeneous reactions in bioprocesses

**Week 6**: Heterogeneous reactions in bioprocesses (contd.), Heat transfer in bioreactors

**Week 7**: Heat transfer in bioreactors (contd.) Scale-up of bioreactors: criteria for scale-up, scale-up parameters

**Week 8**: Scale-up of bioreactors (contd.), non-ideal reactors: design and analysis

**Books and references :**


1. Michael L. Shuler and Fikret Kargi, Bioprocess Engineering: Basic Concepts, Prentice Hall, 1992
2. James M. Lee, Biochemical Engineering, Prentice Hall, 1992
3. Pauline Doran, Bioprocess Engineering Principles, 2nd Edition, Academic Press 2012
4. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill
5. 1986.
6. S. Liu, Bioprocess Engineering: Kinetics, Biosystems, Sustainability, and Reactor Design, Elsevier, 2016
7. Octave Levenspiel, Chemical Reaction Engineering, Wiley 2016.

## Waste to Energy Conversion

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1 -** Introduction, characterization of wastes.

**Week 2 -** Energy production form wastes through incineration, energy production through gasification of wastes.

**Week 3 -** Energy production through pyrolysis and gasification of wastes, syngas utilization.

**Week 4 -** Densification of solids, efficiency improvement of power plant and energy production from waste plastics.

**Week 5 -** Energy production from waste plastics, gas cleanup.

**Week 6 -** Energy production from organic wastes through anaerobic digestion and fermentation, introduction to microbial fuel cells.

**Week 7 -** Energy production from wastes through fermentation and transesterification.

**Week 8 -** Cultivation of algal biomass from wastewater and energy production from algae.

**Books and references :**


1. Rogoff, M.J. and Screve, F., "Waste-to-Energy: Technologies and Project Implementation", Elsevier Store.
2. Young G.C., "Municipal Solid Waste to Energy Conversion processes", John Wiley and Sons.
3. Harker, J.H. and Backhusrt, J.R., "Fuel and Energy", Academic Press Inc.
4. EL-Halwagi, M.M., "Biogas Technology- Transfer and Diffusion", Elsevier Applied Science.
5. Hall, D.O. and Overeed, R.P.," Biomass - Renewable Energy", John Willy and Sons. Mondal, P. and Dalai, A.K. eds., 2017. Sustainable Utilization of Natural Resources. CRC Press.

## Physico-chemical processes for wastewater treatment

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Introduction to Water Pollution and Control

**Week 2**: Pre-treatment & Physical treatment: Flow equalization & Aeration

**Week 3:** Pre-treatment & Physical treatment: Coagulation and Flocculation

**Week 4**: Setting and Sedimentation & Settling Chamber Design

**Week 5**: Filtration & Filtration System Design

**Week 6**: Wastewater treatment by Adsorption & Ion Exchange

**Week 7**: Wastewater treatment by Membrane Based Technologies

**Week 8**: Advanced Oxidation Processes: Introduction

**Week 9**: Advanced Oxidation Processes: Fenton and catalytic treatment

**Week 10**: Advanced Oxidation Processes: Photo-induced processes

**Week 11**: Advanced Oxidation Processes: Sono- and Electro-chemical Treatment

**Week 12**: Case studies on wastewater treatment in various process, chemical and allied industries

**Books and references**


1. Weber, W.J., "Physico-chemical Processes", Wiley Interscience, 1983.
2. Eckenfelder W.W., "Industrial Water Pollution Control", 2nd Ed., McGraw Hill, 1999.
3. Tchobanoglous G., Burton F.L., Stensel H.D., "Metcalf and Eddy Inc.- Waste Water Engineering Treatment and Reuse", Tata McGraw-Hill, 2017
4. Arceivala S.J. and Asolekar S.R., "Wastewater Treatment for Pollution Control and Reuse", 3rd Ed., Tata McGraw Hill, 2007.
5. Sincero A.P. and Sincero G.A., "Environmental Engineering – A Design Approach", Prentice Hall, 1996.
6. R.L.Droste, "Theory and Practice of Water and Wastewater Treatment", John Wiley, 1997.
7. S. Vigneswaran and C. Visvanathan, "Water Treatment Processes: Simple Options", CRC Press, 1995.

**Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems**

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Solar Energy: Basics and Concepts

**Week 2:** Non-Concentrating Solar Collectors

**Week 3**: Non-Concentrating Solar Collectors: Practice Problems

**Week 4**: Concentrating Solar Collectors

**Week 5:** Storage Systems

**Week 6:** Biomass types and characterization

**Week 7:** Biochemical conversion processes

**Week 8:** Biochemical conversion processes (Contd.)

**Week 9**: Bioconversion of substrates into alcohol and thermo-chemical conversion of Biomass

**Week 10:** Bioconversion of substrates into alcohol and thermo-chemical conversion of biomass (Contd.)

**Week 11:** Wind Energy: Basics: Turbine terms, types and theories

**Week 12**: Characteristics and Power Generation from Wind Energy

**Books and references :**


1. Sukhatme S. P., Nayak J. K., Solar Energy: Principles of thermal Collection and Storage, 3 rd Ed., Tata McGraw-Hill Education Pvt. Ltd 2008.
2. Twidell, J. and Tony W., Renewable Energy Resources, 2 nd Edition, Taylor & Francis 2006.
3. Khan B. H., Non-Conventional Energy Resources, 2 nd Edition, Tata McGraw-Hill Education Pvt. Ltd. 2009.
4. Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.

## Biomass Conversion and Biorefinery

**Course Duration: 12 weeks**
**Credits: 3**

**Week 1**: Introduction: World energy scenario, consumption pattern, fossil fuel depletion and environmental issues

**Week 2**: Biomass: Availability and abundance, photosynthesis, composition and energy potential, virgin biomass production and selection, waste biomass (municipal, industrial, agricultural and forestry) vailability, abundance and potential, biomass as energy resources: dedicated energy crops, annual crops (maize, orghum sugar beet, hemp), perennial herbaceous crops (sugarcane, switchgrass, miscanthus), short rotation woody crops (poplar, willow), oil crops and their biorefinery potential, microalgae as feedstock for biofuels and biochemical, enhancing biomass properties for biofuels, challenges in conversion

**Week 3**: Biorefinery: Basic concept, types of biorefineries, biorefinery feedstocks and properties, economics

**Week 4**: Biomass Pretreatment: Barriers in lignocellulosic biomass conversion, pretreatment technologies such as acid, alkali, autohydrolysis, hybrid methods, role of pretreatment in the biorefinery concept

**Week 5:** Physical and Thermal Conversion Processes: Types, fundamentals, equipment's and applications; thermal conversion products, commercial success stories

**Week 6**: Microbial Conversion Process: Types, fundamentals, equipment's and applications, products, commercial success stories

**Week 7**: Biodiesel: Diesel from vegetable oils, microalgae and syngas; transesterification; FT process, catalysts; biodiesel purification, fuel properties

**Week 8:** Biooil and Biochar: Factors affecting biooil, biochar production, fuel properties, biooil upgradation

**Week 9**: Bioethanol and Biobutanol: Corn ethanol, lignocellulosic ethanol, microorganisms for fermentation, current industrial ethanol production technology, cellulases and their role in hydrolysis, concepts of SSF and CBP, advanced fermentation technologies, ABE fermentation pathway and kinetics, product recovery technologies

**Week 10**: Hydrogen, Methane and Methanol: Biohydrogen generation, metabolic basics, feedstocks, dark fermentation by strict anaerobes, facultative anaerobes, thermophilic microorganisms, integration of biohydrogen with fuel cell; fundamentals of biogas technology, fermenter designs, biogas purification, methanol production and utilization

**Week 11**: Organic Commodity Chemicals from Biomass: Biomass as feedstock for synthetic organic chemicals, lactic acid, polylactic acid, succinic acid, propionic acid, acetic acid, butyric acid, 1,3-propanediol, 2,3-butanedioil, PHA

**Week 12**: Integrated Biorefinery: Concept, corn/soybean/sugarcane biorefinery, lignocellulosic biorefinery, aquaculture and algal biorefinery, waste biorefinery, hybrid chemical and biological conversion processes, techno- economic evaluation, life-cycle assessment

**Books and references :**


1. Donald L. Klass, Biomass for Renewable Energy, Fuels, and Chemicals, Academic Press, Elsevier, 2006.
   Prabir Basu, Biomass Gasification, Pyrolysis and Torrefaction, Academic Press, Elsevier, 2013.

2. A.A. Vertes, N. Qureshi, H.P. Blaschek, H. Yukawa (Eds.), Biomass to Biofuels: Strategies for Global Industries, Wiley, 2010.

3. S. Yang, H.A. El-Enshasy, N. Thongchul (Eds.), Bioprocessing Technologies in Biorefinery for Sustainable Production of Fuels, Chemicals and Polymers, Wiley, 2013.

4. Shang-Tian Yang (Ed.), Bioprocessing for Value Added Products from Renewable Resources, Elsevier, 2007.

## Environmental Quality Monitoring & Analysis

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Introduction; Definition of Environment; Link between source/environment/receptor; Exposure; Health effects; Toxicology; Defining the need for fate and transport.

**Week 2**: Chemicals of concern; relevant properties for environmental fate and transport; Definition of Equilibrium – partition constants, solubility, vapor pressure, henry's constant, Koc, Kow etc. Equilibrium partitioning of chemicals between different phases of the environment.

**Week 3**: Parameters for environmental water/ air / soil / sediment – screening parameters, priority air pollutants – definitions of PM

**Week 4:** Monitoring of environmental parameters – screening parameters – BOD, COD, TOC, TDS; Environmental sampling – definition and synthesis of a monitoring/sampling/analysis method. Quality Assurance and quality control (QA/QC).

**Week 5**: Methods for sampling/processing/analysis of organic and inorganic constituents in air/water/soil/sediment.

**Week 6**: Introduction to environmental transport – BOX Models and the application to multimedia transport of pollutants

**Week 7:** Atmospheric Dispersion – Gaussian Dispersion model

**Week 8:** Fundamentals of mass transport – definition of intraphase and inter-phase chemical flux; interphase mass transport, diffusion coefficient and convenction mass transfer coefficients. **Week 9**: Chemical Exchange between air-water

**Week 10:** Chemical Exchange between sediment-water

**Week 11**: Chemical exchange between soil-air

**Week 12:** Overall transport model and scenarios

**Books and references :**

1. Environmental Chemodynamics - Louis J Thibodeaux, 2nd Edition, Wiley Interscience Environmental Engineering – Peavy, Rowe and Tchobanoglous, McGraw-Hill.

**Additional References**:

1. Atmospheric Chemistry and Physics – Seinfeld and Pandis.

## Bio photonics

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Introduction of Biophotonics

**Week 2**: Fundamentals of Light and Matter

**Week 3**: Basics of Biology

**Week 4**: Basics of light-matter interactions in molecules, cells and tissues

**Week** 5: LASERs for Biophotonics

**Week 6**: Bioimaging: Principles and Applications

**Week 7**: Optical Biosensors

**Week 8**: Light Activated Therapy: Photo Thermal and Photo Dynamic Therapy

**Week 9**: Tissue Engineering with Light

**Week 10**: Optical Tweezers, Scissors and Traps

**Week 11**: Nanotechnology for Biophotonics: Nano Bio Photonics

**Week 12**: Optogenetics & Neurophotonics

**Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts**

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1**: Sustainability Concepts – Innovations and Challenges

**Week 2**: Environmental Measurements from Different Disciplines

**Week 3**: Ecology, Population & Environmental Chemistry

**Week 4**: Physical Process in Environment

**Week 5:** Environmental Biological Concepts

**Week 6**: Environmental Risk Assessments with Concepts of EIA and LCA

**Week 7**: Water – Quantity and Quality

**Week 8**: Water Treatment Basics

**Week 9**: Basics of Wastewater Collection, Treatment & Resource Recovery

**Week 10**: Basics of Solid Waste, Soil and Noise Pollution

**Week 11**: Basics of Air Pollution Issues – Global and Local

**Week 12**: Case Studies and Course Wrap-up

**Books and references :**


1. Introduction to Environmental Engineering and Science by Gilbert M Masters and Wendell P Ela, Paperback: 696 pages, Publisher: Pearson Education India; 3rd edition, ISBN-10:9332549761, ISBN-13: 978-9332549760 .
2. Environmental Engineering, by Howard Peavy, Donald Rowe, and George Tchobanoglous, Paperback: 736 pages, Publisher: McGraw Hill Education; ISBN-10: 9351340260,ISBN-13: 978- 9351340263

## Computational Systems Biology

**Course Duration: 12 weeks**

**Credits: 3**

**Week 1:** Introduction to Mathematical Modelling

**Week 2:** Introduction to Static Networks

**Week 3:** Network Biology and Applications

**Week 4:** Reconstruction of Biological Networks

**Week 5**: Dynamic Modelling of Biological Systems: Introduction, Solving ODEs & Parameter Estimation

**Week 6:** Evolutionary Algorithms, Guest Lectures on Modelling in Drug Development

**Week 7:** Constraint-based approaches to Modelling Metabolic Networks

**Week 8:** Perturbations to Metabolic Networks

**Week 9:** Elementary Modes, Applications of Constraint-based Modelling

**Week 10**: Constraint-based Modelling Recap, 13C Metabolic Flux Analysis

**Week 11**: Modelling Regulation, Host-pathogen interactions, Robustness of Biological Systems

**Week 12**: Advanced topics: Robustness and Evolvability, Introduction to Synthetic Biology, Perspectives & Challenges

**Books and references:**


1. Raman K (2021) An Introduction to Computational Systems Biology: Systems-Level Modelling of Cellular Networks. 1/e ISBN 9781138597327 (Chapman and Hall/CRC)
2. Voit E (2012) A First Course in Systems Biology. Garland Science, 1/e. ISBN 081534467
3. Klipp E (2009) Systems biology: a textbook. Wiley-VCH, 1/e. ISBN 9783527318742
4. Newman MEJ (2011) Networks: an introduction. Oxford Univ. Press. ISBN 9780199206650

**Interactomics: Basics & Applications**

**Course Duration: 12 weeks**
**Credits: 3**

**Week 1-** Interactomics: Basics and Applications
Lecture 1: Introduction to Proteomics
Lecture 2: Introduction to Interactomics
Lecture 3: High throughput platforms of interactomics: Protein arrays
Lecture 4: Cell-free expression-based protein microarrays
Lecture 5: NAPPA: Recombinational Cloning, Basic workflow, Surface Chemistry, Printing and Assessment

**Week 2-** Interactomics: Basics and Applications
Lecture 6: NAPPA Technology and Protein Arrays-I
Lecture 7: NAPPA Technology and Protein Arrays-II
Lecture 8: Biomarkers: Harnessing the immune system for early detection of disease-I Lecture 9: Biomarkers: Harnessing the immune system for early detection of disease-II Lecture 10: Biomarkers: Harnessing the immune system for early detection of disease-III

**Week 3-** Interactomics: Basics and Applications
Lecture11: NAPPA & its applications in study of antibody immune response in disease & in drug screening-I
Lecture12: NAPPA & its applications in study of antibody immune response in disease & in drug screening-II
Lecture13: NAPPA & its applications in study of antibody immune response in disease & in drug screening-III
Lecture 14: Using functional proteomics to identify biomarkers and therapeutic targets-I Lecture 15: Using functional proteomics to identify biomarkers and therapeutic targets-II

**Week 4-** Interactomics: Basics and Applications
Lecture 16: Applications of protein microarrays in Malaria Research-I
Lecture 17: Applications of protein microarrays in Malaria Research-II
Lecture 18: Introduction to Bioprinting and Iris™ Optical QC Benefits-I
Lecture 19: Introduction to Bioprinting and Iris™ Optical QC Benefits-II
Lecture 20: Screening of autoantibody signatures in cancer patients: Lab demonstration

**Week 5-** Interactomics: Basics and Applications
Lecture-21: Basics of Image Scanning and data acquisition
Lecture-22: Applications of protein arrays in the identification of autoantibody signatures-I Lecture-23: Applications of protein arrays in the identification of autoantibody signatures-II Lecture-24: Applications of protein microarrays in deciphering PTMs and biological networks Lecture-25: Basics and Applications of Reverse Phase Protein Arrays-I

**Week 6-** Interactomics: Basics and Applications
Lecture-26: Basics and Applications of Reverse Phase Protein Arrays-II
Lecture-27: Basics and Applications of Reverse Phase Protein Arrays-III
Lecture-28: An overview of label-free technologies
Lecture-29: An overview of label-free technologies
Lecture-30: Surface Plasmon Resonance- Principles and Assays-II

**Week 7-** Interactomics: Basics and Applications

Lecture-31: Basics of SPR: Surface chemistry
Lecture-32: Basics of SPR: Experimental design
Lecture-33: Protein immobilization for protein-protein interaction studies
Lecture-34: Protein-protein interaction study: Binding analysis
Lecture-35: Protein-protein interaction study: Kinetic analysis

**Week 8-** Interactomics: Basics and Applications
Lecture-36: Use of SPR in unravelling domain motif interactions of proteasomal assembly chaperones
Lecture-37: Protein-small molecule interaction study: Immobilization & binding analysis
Lecture-38: Protein-small molecule interaction study: Kinetic analysis
Lecture-39: An introduction to biolayer interferometry (BLI) and its applications in protein research Lecture-40: Biomolecular interactions using Bio-Layer Interferometry (BLI)-I

**Week 9-** Interactomics: Basics and Applications
Lecture 41: Biomolecular interactions using Bio-Layer Interferometry (BLI)-II Lecture 42: Lab session- An introduction to Bio-Layer Interferometry (BLI) and its applications in protein research
Lecture 43: Applications of label-free technologies-II
Lecture 44: Biomolecular interaction analytics using Microscale Thermophoresis Lecture 45: Mass Spectrometry coupled Interactomics-I

**Week 10-** Interactomics: Basics and Applications
Lecture 46: Mass Spectrometry coupled Interactomics-II
Lecture 47: Next-Generation Sequencing Technology- Ion Torrent™
Lecture 48: NGS Technology - Bioinformatics and data analysis-I
Lecture 49: NGS Technology - Bioinformatics and data analysis-II
Lecture 50: Next-Generation Sequencing Technology- Illumina

**Week 11-** Interactomics: Basics and Applications
Lecture 51: Agilent complete NGS target enrichment workflow for exomes, targeted panels and beyond
Lecture 52: The Human Pathology Atlas: A Pathology Atlas of the Human Transcriptome-I Lecture 53: The Human Pathology Atlas: A Pathology Atlas of the Human Transcriptome-II Lecture 54: Statistical Analysis-I
Lecture 55: Statistical Analysis-II

**Week 12-** Interactomics: Basics and Applications
Lecture 56: Secondary Data Analysis
Lecture 57: Pathway Enrichment and Network Analysis
Lecture 58: Data Repositories and Databases
Lecture 59: Application of multi-omics approach for better understanding of cancers Lecture 60: Integrated Omics and Systems Biology- Conclusion

**Books and references:**
Proteomics: A Cold Spring Harbor Laboratory Course Manual, A.J. Link and J. LaBaer, Cold Spring Harbor Laboratory Press, 2009. Selected papers from scientific journals
Instructor bio

## Data Analysis for Biologists

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1**: Basic concepts of probability and statistics

**Week 2**: Basic concepts of linear algebra

**Week 3**: Basics of R

**Week 4**: Data visualization

**Week 5**: Correlation and regression

**Week 6**: Clustering and classification, Correlation and regression

**Week 7**: Clustering and classification

**Week 8**: Analysis of higher-dimensional data

**Books and references :**

1. Reading materials, links for online resources, Excel files and R codes will be provided by the instructor and will be adequate enough for this course.

**Reference books:**


1. Whitlock, Michael C.; Schluter, Dolph. The Analysis of Biological Data (2nd edition). Freeman, W. H. & Company, 2014.
2. Yang, Zheng R.; Machine Learning Approaches to Bioinformatics. World Scientific, 2010.
3. Moses, Alan; Statistical Modeling and Machine Learning for Molecular Biology. Chapman and Hall/CRC, 2016.
4. Hartvigsen, Gregg. A Primer in Biological Data Analysis and Visualization Using R, (1st Edition). . Columbia University Press, 2014.
5. Stewart, James; Day, Troy; Biocalculus: Calculus for Life Sciences. Cengage Learning, 2015
6. James, Gareth, etal. An introduction to statistical learning with application in R. Vol. 112. New York: springer, 2013.


First edition can be downloaded from the website https://www.statlearning.com/

## Biointerface Engineering

**Course Duration: 8 weeks**

**Credits: 2**

**Week 1:** Intermolecular Forces

**Week 2:** Adhesion and Wetting phenomena

**Week 3:** Characterization of interfaces

**Week 4:** Protein-surface interactions

**Week 5:** Protein Aggregation

**Week 6:** Cell-surface interactions

**Week 7:** Surface modification and characterization

**Week 8:** Surface modification and characterization

**Books and References:**


1. J. N. Israelachvili, Intermolecular and Surface Forces, 3rd edition, Academic Press, 2011
2. Willem Norde, Colloids and Interfaces in Life Sciences and Bio nanotechnology, 2nd edition, CRC Press, 2011.
3. W. Adamson, and A. P. Gast, Physical Chemistry of Surfaces, John Wiley, New York, 1997.

## RNA Biology

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES: Minimum qualification is bachelors in Science. Post graduation in Science is desirable.**

**Week 1:** Introduction to RNA Biology and RNA world (Lectures 1-6)

**Week 2:** RNA as enzymes: The Ribozymes (Lectures 7-9)

**Week 3:** RNA Transcription (Lectures 10-14)

**Week 4:** RNA Processing and Life cycle (Lectures 15-17)

**Week 5:** Alternative RNA processing and editing (Lectures 18-23)

**Week 6:** RNA splicing, export and stability (Lectures 24-27)

**Week 7:** snRNA, rRNA, miRNA, siRNA processing, export and function (Lectures 28-33)

**Week 8:** Mechanisms of RNA decay and Non coding RNAs (lectures 34-39)

**Week 9:** Dosage compensation and X-inactivation (Lectures 40-44)

**Week 10:** Dosage compensation, Xist and ncRNA in imprinting (lectures 45-51)

**Week 11:** Telomere, telomerase and impact on genomes (lectures 52-57)

**Week 12:** Epitranscriptome and protein synthesis (Lectures 58-62)

**Books and references:**


1.John F. Atkins et al (ed.), RNA Worlds: From Life's Origins to Diversity in Gene Regulation CSHL press (2011).
2.Gunter Meister (ed.), RNA Biology: An Introduction Wiley press (2011).
3. David Elliott and Michael Ladomery (ed.), Molecular Biology of RNA Oxford University Press (2011).
4. James Darnell (ed.), RNA: Life's Indispensable Molecule CSHL press (2011).

## Biomechanics

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES: High school physics & mathematics. Kindly note that this course does NOT assume knowledge of Engg Mechanics and Strength of Materials**

**Week 1:** Introductory Mechanics – Statics and Dynamics – Basic Principles.

**Week 2:** The human body as a biomechanical system – basic terminologies

**Week 3:** Kinematics of muscles and joints **-** free-body diagrams and equilibrium, forces and stresses in joints

**Week 4:** Biomechanical analysis of joints of upper limb **-** Shoulder, Elbow, wrist, hand and fingers

**Week 5:** Upper limb as a mechanical system – analysis of reaching as movement of a multi-link serial chain – forward kinematics, analysis of fingertip forces as a parallel manipulator

**Week 6:** Biomechanical analysis of joints – Spine, Hip, Knee, Ankle.

**Week 7:** Introduction to Postural stability and Gait analysis.

**Week 8:** Gait analysis in health and disease - basics.

**Week 9:** Mechanics of Hard Tissues **-** Definition of Stress and Strain, Deformation Mechanics, structure and mechanical properties of bone **-** cortical and cancellous bones, Wolff's law of bone remodeling;

**Week 10:** Soft Tissues **-** Structure, functions, material properties – tendon function, elasticity in a tendon, models of non-linear elasticity in a tendon – physiological and non-physiological regimes, Davis' law of soft tissue remodeling.

**Week 11:** Visco-elastic properties of soft tissues, Models of visco-elasticity: Maxwell & Voight models.

**Week 12:** Basic Biofluid mechanics **-** Flow properties of blood in the intact human cardiovascular system.

### Books and references

1.David A. Winter, Biomechanics and Motor Control of Human Movement .
2.Margareta Nordin and Victor H. Frankel, Basic Biomechanics of the Musculoskeletal System.
3.Francisco Valero-Cuevas, Fundamentals of Neuromechanics.
4.Susan Hall, Basic Biomechanics.
5.Irving Hermann, Physics of Human Body.

## Enzyme Sciences and Technology

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES: Basic Biochemistry**

**Week 1:** Introduction to Enzymes
Lecture 1: Introduction to Enzymes
Lecture 2: Basics of Enzyme
Lecture3: Enzyme Classification (Part-I)
Lecture4:Enzyme Classification(Part-II)
Lecture 5: Enzyme Nomenclature

**Week 2:** Structure of enzyme
Lecture 6: Enzyme Structure (Part 1)
Lecture 7: Enzyme Structure (Part 2)
Lecture 8: Enzyme Structure (Part 3)

**Week 3:** Enzyme Production (Part 1)
Lecture 9: Cloning of Enzyme (Part 1)
Lecture 10: Cloning of Enzyme (Part 2)
Lecture 11: Over-expression in Host

**Week 4:** Enzyme Production (Part 2)
Lecture 12: Extraction of enzyme
Lecture 13: Purification Strategies (Part 1)
Lecture 14: Purification Strategies (Part 2)

**Week 5:** Enzyme Production (Part 3)
Lecture 15: Purification Strategies (Part 3)
Lecture 16: Purification Strategies (Part 4)
Lecture 17: Enzyme Characterization Approaches

**Week 6:** Enzyme catalyzed Biochemical reactions
Lecture 18: Enzyme Catalyzed reactions (Part 1: Carbohydrate Metabolism)
Lecture 19: Enzyme Catalyzed reactions (Part 2: Lipid and Protein Metabolism)
Lecture 20: Enzyme Catalyzed reactions (Part 3: Detoxification)

**Week 7:** Enzyme-Substrate interaction
Lecture 21:Enzyme-Substrate interaction (Part 1: Spectroscopic approaches)
Lecture 22:Enzyme-Substrate interaction (Part 2: Isothermal Calorimetry)
Lecture 23: Enzyme-Substrate interaction (Part 3: Surface plasma resonance)

**Week 8:** Enzyme assay system and Kinetics
Lecture 24: Enzyme assay system
Lecture 25: Enzyme Kinetics (Part 1)
Lecture 26: Enzyme Kinetics (Part 2)

**Week 9:** Enzyme Inhibitor Designing
Lecture 27: Inhibitor designing (Part 1: Traditional approach)

Lecture 28: Inhibitor designing (Part 2: Modern approach)
Lecture 29: Inhibitor designing (Part 3: Computational approaches)

**Week 10:** Enzyme Inhibition kinetics
Lecture 30: Enzyme Inhibition kinetics (Part 1)
Lecture 31:Enzyme Inhibition kinetics (Part 2)
Lecture 32: Enzyme Inhibition kinetics (Part 3)

**Week 11:** Enzyme Applications (Part 1)
Lecture 33: Enzymes in Industrial setup (Part 1)
Lecture 34: Enzymes in Industrial setup (Part 2)
Lecture 35: Enzymes in catalyzing chemical reactions

**Week 12:** Enzyme Applications (Part 2)
Lecture 36: Enzymes in medical field
Lecture 37: Enzymes in environment field
Lecture 38: Enzymes in drug discovery

**Books and references:**
**Text book:**
1. Enzyme Kinetics: Behavior and analysis of rapid equlibraium and steady state enzyme systems. Irwin H SEGEL. ISBN: 978-0-471-30309-1.
2. Biochemistry. 5th edition, Berg JM, Tymoczko JL, Stryer L. publisher: W H Freeman
3. Biochemistry, 2nd edition Reginald Garrett and Charles Grisham
4. Cornish-Bowden, A., Fundamentals of Enzyme Kinetics (revised ed.), Portland Press (1995).
5. Nelson, David L. (David Lee), 1942-. Lehninger Principles of Biochemistry. New York :W.H. Freeman, 2005.
6. Voet, D., Voet, J. G., & Pratt, C. W. (2008). Fundamentals of biochemistry: Life at the molecular level. Hoboken, NJ: Wiley.
7. Tymoczko, Lubert Stryer,and LubertStryer. Biochemistry. New York: W.H. Freeman, 2002. Print.

**Reference Book:**
1. Enzymes Biocatalysis: Principles and Applications. ISBN 978-1-4020-8361-7.
2. Enzyme : Catalysis, kinetics and mechanisms. N.S. Punekar. ISBN 978-981-13-0784-3.
3. Enzymes 2nd Edition Biochemistry, Biotechnology, Clinical Chemistry by T Palmer P L Bonner
4. Color Atlas of Biochemistry 2nd edition by Jan Koolman and Klaus-Heinrich Roehm

## Metabolic Engineering

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES : Basics of Microbiology, Biochemistry, Genetics**

**Week 1:**Introduction to Metabolic Engineering, Basic concepts; Scopes and Applications; Metabolism overview _1 (Cellular Transport processes, Fueling Reactions)

**Week 2:**Cellular Metabolism Overview_2 (Biosynthetic reactions, Polymerization, Growth Energetics); Regulation of Metabolic Pathways

**Week 3:** Reconstruction of Genome-scale metabolic network

**Week 4:** Examples of pathway manipulations by metabolic engineering : Ethanol, Aminoacids, antibiotics, vitamines, biopolymers, etc.

**Week 5:** Examples of pathway manipulations by metabolic engineering : Improvements of cellular properties, Biodegradation,

**Week 6:** Metabolic Flux Analysis: Flux Balance Analysis (FBA), Flux Variability Analysis, Flux Map

**Week 7:** Experimental determination of Metabolic Fluxes: Isotope labeled substrate, Isotope mapping Mapping Matrix, Isotope Distribution Vector

**Week 8:**Application of metabolic Flux Analysis

**Books and references:**

1. Metabolic Engineering, Principles and Methodologies; G N Stephanopoulos, A A Aristidou, J Nielsen

2. Advances in Biochemical Engineering/Biotechnology; Metabolic Engineering, Volume Editor: Jens Nielsen

3. Systems Metabolic Engineering, Methods and Protocols; H S Alper

4. Metabolic Pathway design, A Practical Guide; P Carbonell

## Aspects of Biochemical Engineering

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITES: Mathematics in 10+2**

**Week 1:** Microbiology, Biochemistry and Bioproducts

**Week 2:** Stoichiometry and Thermodynamics of biochemical reactions

**Week 3:** Kinetics of homogeneous chemical reactions

**Week 4:** Different types of bioreactors and reactor analysis

**Week 5:** Kinetics of enzyme catalyzed reactions using free enzymes

**Week 6:** Kinetics of enzyme catalyzed reactions using immobilized enzymes

**Week 7:** Kinetics of substrate utilization, product formation and biomass production of microbial cells

**Week 8:** Kinetics of substrate utilization, product formation and biomass production of microbial cells

**Week 9:** Design and analysis of activated sludge process and anaerobic digester. Scale up of bioreactor

**Week 10:** Transport phenomenon in bioprocess

**Week 11:** Air and medium sterilization

**Week 12:** Operation and Process control, Downstream processing, Economic analysis of biochemical processes and summary & conclusion

**Books and references:**


1. Chemical Reaction Engineering, Octave Levenspiel

2. Biochemical Engineering Fundamentals by Bailey and Ollis

3. Bioprocess Engineering Principles by Doran

4. Bioprocess Engineering Basic Concepts by Shular and Kargi

5. Biochemical Engineering by Blanch and Clark

6. Biochemical Engineering by Aiba, Humphrey and Millis

## Introduction to Professional Scientific Communication

**Course Duration: 4 weeks**

**Credits: 1**

**PREREQUISITES: Basic level of understanding on concept and methodology in scientific research**

**Week 1:** Introduction to Professional Scientific Communication, Discussion of creativity, research ideas and where to find them, Inductive reasoning versus deductive reasoning

**Week 2:** Hypothesis, reasoning and testing the hypothesis, Peer review process, Structure of a scientific report

**Week 3:** Structure of a Research article, Title, abstract, methods, results, and discussion

**Week 4:** Structure of a Research article contd., Schematic diagrams, figures, tables and flow charts – rationale and usage, Ethics in biomedical research, Different forms of writing: scientific report, proposal, and reviews, Presentations-thumb rules and good practice

**Books and references:**
Mostly publically available literature. Will be shared with the participants during the launch of the course.

## Bioengineering: An Interface with Biology and Medicine

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES: NIL**

**Week 1 :** Why biology for engineers: Part-I, Why biology for engineers: Part-II, Life processes & Cell, Cell and its properties, Clinician's Perspective-I

**Week 2 :** DNA Tools-Gene cloning, DNA Tools-Gene cloning-II, DNA Tools & Biotechnology, DNA Tools & Biotechnology-II,

**Week 3 :** DNA Tools & Biotechnology-III, DNA Tools & Biotechnology-IV, DNA Tools & Biotechnology-V, DNA Tools & Biotechnology-VI, Clinician's Perspective-III

**Week 4 :** Genetics-I, Genetics-II, Genetics-III, Genetics-IV, Clinician's Perspective-IV

**Week 5 :** Chromosomal basis of inheritance, Linkage, chromosomal disorders, Classical Genetics experiments, Bacteria and Viruses, Clinician's Perspective-V

**Week 6 :** Cell cycle, Cell cycle disregulation & Cancer, Developmental Biology, Principles and application of Animal Cloning, Evolution & Bioinformatics

**Week 7 :** Amino acids & proteins, Proteins & Proteomics, Techniques to Study Protein & Proteome-I, Techniques to Study Protein & Proteome-II, Techniques to Study Protein & Proteome-III

**Week 8 :** Techniques to Study Protein & Proteome-IV, Protein Interactions & Microarrays, Protein interactions & Systems biology, Bioinformatics, Ethics in Research and Publications

**Books and references:**

Campbell Biology

**Interactomics : Basics & Applications**

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES : None**

**Week 1-** Interactomics: Basics and Applications
Lecture 1: Introduction to Proteomics
Lecture 2: Introduction to Interactomics
Lecture 3: High throughput platforms of interactomics: Protein arrays
Lecture 4: Cell-free expression based protein microarrays
Lecture 5: NAPPA: Recombinational Cloning, Basic workflow, Surface Chemistry, Printing and Assessment

**Week 2-** Interactomics: Basics and Applications
Lecture 6: NAPPA Technology and Protein Arrays-I
Lecture 7: NAPPA Technology and Protein Arrays-II
Lecture 8: Biomarkers: Harnessing the immune system for early detection of disease-I
Lecture 9: Biomarkers: Harnessing the immune system for early detection of disease-II
Lecture 10: Biomarkers: Harnessing the immune system for early detection of disease-III

**Week 3-** Interactomics: Basics and Applications
Lecture11: NAPPA & its applications in study of antibody immune response in disease & in drug screening-I
Lecture12: NAPPA & its applications in study of antibody immune response in disease & in drug screening-II
Lecture13: NAPPA & its applications in study of antibody immune response in disease & in drug screening-III
Lecture 14: Using functional proteomics to identify biomarkers and therapeutic targets-I
Lecture 15: Using functional proteomics to identify biomarkers and therapeutic targets-II

**Week 4-** Interactomics: Basics and Applications
Lecture 16: Applications of protein microarrays in Malaria Research-I
Lecture 17: Applications of protein microarrays in Malaria Research-II
Lecture 18: Introduction to Bioprinting and Iris™ Optical QC Benefits-I
Lecture 19: Introduction to Bioprinting and Iris™ Optical QC Benefits-II
Lecture 20: Screening of autoantibody signatures in cancer patients: Lab demonstration

**Week 5-** Interactomics: Basics and Applications
Lecture-21: Basics of Image Scanning and data acquisition
Lecture-22: Applications of protein arrays in the identification of autoantibody signatures-I
Lecture-23: Applications of protein arrays in the identification of autoantibody signatures-II
Lecture-24: Applications of protein microarrays in deciphering PTMs and biological networks
Lecture-25: Basics and Applications of Reverse Phase Protein Arrays-I

**Week 6-** Interactomics: Basics and Applications
Lecture-26: Basics and Applications of Reverse Phase Protein Arrays-II
Lecture-27: Basics and Applications of Reverse Phase Protein Arrays-III
Lecture-28: An overview of label-free technologies
Lecture-29: An overview of label-free technologies
Lecture-30: Surface Plasmon Resonance- Principles and Assays-II

**Week 7-** Interactomics: Basics and Applications
Lecture-31: Basics of SPR: Surface chemistry

Lecture-32: Basics of SPR: Experimental design
Lecture-33: Protein immobilization for protein-protein interaction studies
Lecture-34: Protein-protein interaction study: Binding analysis
Lecture-35: Protein-protein interaction study: Kinetic analysis

**Week 8-** Interactomics: Basics and Applications
Lecture-36: Use of SPR in unravelling domain motif interactions of proteasomal assembly chaperones
Lecture-37: Protein-small molecule interaction study: Immobilization Immobilisation & binding analysis
Lecture-38: Protein-small molecule interaction study: Kinetic analysis
Lecture-39: An introduction to biolayer interferometry (BLI) and its applications in protein research
Lecture-40: Biomolecular interactions using Bio-Layer Interferometry (BLI)-I

**Week 9-** Interactomics: Basics and Applications
Lecture 41: Biomolecular interactions using Bio-Layer Interferometry (BLI)-II
Lecture 42: Lab session- An introduction to Bio-Layer Interferometry (BLI) and its applications in protein research
Lecture 43: Applications of label-free technologies-II
Lecture 44: Biomolecular interaction analytics using MicroScale Thermophoresis
Lecture 45: Mass Spectrometry coupled Interactomics-I

**Week 10-** Interactomics: Basics and Applications
Lecture 46: Mass Spectrometry coupled Interactomics-II
Lecture 47: Next-Generation Sequencing Technology- Ion Torrent™
Lecture 48: NGS Technology - Bioinformatics and data analysis-I
Lecture 49: NGS Technology - Bioinformatics and data analysis-II
Lecture 50: Next-Generation Sequencing Technology- Illumina

**Week 11-** Interactomics: Basics and Applications
Lecture 51: Agilent complete NGS target enrichment workflow for exomes, targeted panels and beyond
Lecture 52: The Human Pathology Atlas: A Pathology Atlas of the Human Transcriptome-I
Lecture 53: The Human Pathology Atlas: A Pathology Atlas of the Human Transcriptome-II
Lecture 54: Statistical Analysis-I
Lecture 55: Statistical Analysis-II

**Week 12-** Interactomics: Basics and Applications
Lecture 56: Secondary Data Analysis
Lecture 57: Pathway Enrichment and Network Analysis
Lecture 58: Data Repositories and Databases
Lecture 59: Application of multi-omics approach for better understanding of cancers
Lecture 60: Integrated Omics and Systems Biology- Conclusion

**Books and references:**
Proteomics: A Cold Spring Harbor Laboratory Course Manual, A.J. Link and J. LaBaer, Cold Spring Harbor Laboratory Press, 2009.

**Selected papers from scientific journals**

## Structural Biology

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES: This is an introductory course so anyone should follow it, basic knowledge of biology might be helpful**

**Week 1:** Introduction: Flow of the history of biological inventions, basic Biological Macromolecules of life, i.e., Protein, Nucleic Acid, Carbohydrates & Lipid/Fat, and a comparison between polymers and "3C"ecrets of covalent bond, nucleic acid, DNA sequencing, PCR innovation, gene sequencing to genome sequencing, introduction to NGS and its different platforms, arrival of Post Genomic Era, the effect of HGP, and experimental three-dimensional structure determination techniques.

**Week 2:** Protein: Amino acids and their properties, Protein Chemistry, Chirality, Peptide bond, and Levels of protein structures, Dihedral angles, Peptide bond, and Ramachandran Plot, Super Secondary Structures, Motif, Domains, Non-covalent interactions, Folding of Protein, Thermodynamics, and Kinetics of protein folding, Characterization of Proteins.

**Week 3:** Introduction to Structural Biology Techniques: cellular organization, resolution structure determining technique with their ranges of the resolution, the success of X-ray crystallography from single molecule to a crystal, X-ray Crystallography, Crystallization in X-ray Crystallography, Crystal mounting in X-ray Crystallography.

**Week 4:** X-ray Crystallography: Production of X-ray and its properties, unit cell, symmetry, and lattice, the geometry of the crystal system, Crystal Symmetry, Instrumentation in X-ray Crystallography, Data collection, and processing

**Week 5:** X-ray Crystallography: Data Analysis of X-ray Crystallography - Diffraction Patterns, Indexing, Bragg's Law, Laue equation, Relation between "Laue equation and Bragg's Law", Lattice Transformation, Ewald Sphere, Laue Condition for Diffraction and Ewald Sphere, Structure Factors and Diffraction Pattern, Atomic Scattering Factor, Anomalous Dispersion, Analytical expression of the phase, Fourier Transformation, introduction to Phase Problem. Phase problem - Phase Problem, Patterson Function, How to solve phase problem, Heavy atom replacement methods, Isomorphous replacement, Anomalous dispersion, phase problem associated with crystal diffraction and common techniques to recover phase resolving different phase improvement methods. Refinement and Structure deposition to PDB - aspects of structure refinement, motivation, application, the procedure of simulated annealing, PDB repository, atomic model deposition as well as different PDB validation suites.

**Week 6:** NMR: Introduction to NMR, basic Principles of NMR and Instrumentation, NMR Sample Preparation and Chemical Shift related concepts, Factors effecting NMR Spectra (1D & 2D), 2D & 3D NMR Spectroscopy focusing on protein structure.

**Week 7:** Spectroscopy: Introduction to Spectroscopy, UV-Vis and CD spectroscopy, Fluorescence Spectroscopy and Green Fluorescence Protein (GFP), Infrared & Raman Spectroscopy for protein, Raman Spectroscopy, Raman Microscopy and Raman Crystallography for studying protein.

**Week 8:** Microscopy: Introduction to Microscopy, Functioning details of Cryo-Electron Microscopy (Cryo-EM), Cryo-Electron Microscopy: Data Collection and Analysis, A concise story of advancement Cryo-EM, Protein Data Bank.

**Week 9:** Molecular Visualizations: History of Molecular Visualizations of Biological Macromolecules, Description of structure-related files (.pdb, .mmcif, .mtz, etc.), Demonstration of COOT, 3D visualization using Pymol, Demonstration of Pymol.

**Week 10:** Molecular Dynamic Simulation: Why we need MD Simulation, Molecular Dynamic Simulation Process, Build a realistic atomistic model of the system, the algorithm behind simulation process, Concept of Topology and Parameter files, Major components in a force field, the concept of solvation, solvent models, Periodic Boundary Condition, Concept of Central Simulation Box, Phase Space, Concept of Ensembles, Energy Minimization (EM), potential energy surface (PES), Determination of EM, types of EM methods and their algorithms, Steps in MD Simulation, Application of Molecular Dynamic Simulation.

**Week 11:** Protein Engineering: What, How & Which of Protein Engineering, How to make logical Protein Engineering: Process of Rational design, a success story of Rational Protein designing: Focusing on De Novo Process, Designing Protein by mimicking nature: Process of Directed Evolution, Achievement, Challenges, and Future direction in the field of Protein Engineering.

**Week 12:** Structure-Based Drug Discovery: Introduction to Structure-Based Drug Discovery (SBDD), Rational Drug Discovery, Docking Based Virtual Screening: Progress, Challenges and Future perspective, What makes a small molecule an ideal drug: Developing in silico ADMETox Model, Structure-Based Drug Discovery: Case study and Conclusion

**Books and references:**


1. Carl Ivar Branden and John Tooze., “Introduction to Protein Structure” 2nd 2001 Edition,
2. Taylor and Francis Voet, D. and Voet, J. G., “Biochemistry” 3rd edition,
3. John Wiley and Sons.Introduction to Protein Architecture: The Structural Biology of Proteins, 2001 Arthur M. Lesk, Oxford University Press; 1st edition
4. Lubert Stryer, Biochemistry, 4th Edition, WH Freeman & CoCreighton.
5. T.E., Proteins, Structure and Molecular Properties, 2nd Edition, 1993
6. W.H. Freeman and Co McPherson, A. “Introduction to Macromolecular Crystallography", 2nd 2009 edition,
7. Wiley-Blackwell.Drenth, J., "Principles of Protein X-Ray Crystallography", 3rd edition, 2007 Springer.
8. Rhodes, G., "Crystallography Made Crystal Clear", 3rd edition, Academic Press

**Cellular Biophysics: A Framework For Quantitative Biology**

**Course Duration: 8 weeks**

**Credits: 2**

**PRE-REQUISITES: BSc/BE/BTech 2nd year; BSc level knowledge of Classical mechanics; MSc level knowledge of Cell and molecular biology; MSc level knowledge of Biochemistry; Basic python programming**

Course layout

**Week 1:** Concepts in fluid dynamics as they apply to cellular scale life

**Week 2:** Diffusion & Macromolecular crowding

**Week 3:** Dynamics of macromolecules: Cytoskeleton

**Week 4:** Molecular motors and Brownian Ratchets

**Week 5:** The rate equation paradigm and genetic networks

**Week 6:** Noise in biological systems

**Week 7:** Turing patterns in embryogenesis

**Week 8:** Mechanics in embryogenesis and Future directions

Books and references


1. Howard Berg (1993) Random Walks in Biology Princeton Univ. Press. ISBN 9780691000640
2. Philip Nelson (2007) Biological Physics: Energy, Information, Life. W. H. Freeman. ISBN-13: 978-0716798972
3. Rob Philips, Jane Kondev, JulieTheriot, Hernan Garcia (2013) Physical Biology of the cell. CRC Press. ISBN 9780815344506
4. David Boal (2012) Mechanics of the Cell. 2nd edition, Cambridge University Press. Online ISBN: 9781139022217
5. Gabor Forgacs and Stuart Newman (2005) Biological Physics of the Developing Embryo. Cambridge University Press. Online ISBN: 9780511755576

**Environmental Biotechnology**
**(being offered as elective in our R20 curriculum)**

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITE : Microbiology, Biochemistry, Genetics/Genomics**

**Course layout**

**Week 1:** Environmental Biotechnology and Sustainability. Scope and applications of the subject. Basics of ecosystem structure and function

**Week 2:** Microbial Ecology and Environmental Biotechnology: Concepts and importance of microbial ecology in Environmental Biotechnology

**Week 3:** Microbiology of Environmental Engineering System: Microbial diversity, growth and decay. Stoichiometry of microbial energetics and kinetics.

**Week 4:** Resource Exploitation by Microorganisms: Functions of various microbial groups relevant to environmental systems, including waste treatment and resource recovery, implications in biogeochemistry.

**Week 5:** Methods in Microbial Ecology with relevant to Environmental Biotechnology: Culture dependent and -independent analyses of microbial communities; PCR based methods, Microarray, Environmental genomics

**Week 6:** Microbial Principles of Biodegradation, Bio detoxification and other processes relevant for Environmental Applications: Microbial engines, (metabolism), Requirements for biodegradation, acclimation, Common biotransformation mechanisms; Effect of organic contaminant structure on biodegradability; Cooperation between different microbial species for enhanced biodegradation; Applying biodegradation kinetics to fate and transport modeling

**Week 7:** Bioremediation Technologies: Concepts, methods and applications of natural attenuation and engineered bioremediation (e.g bioaugmentation and biostimulation)

**Week 8:** Microbial Interactions with Heavy Metals and Metalloids: Bioremediation, Biohydrometallurgy and other aspects of Environmental Biotechnology

**Week 9:** Aerobic and Anaerobic Degradation of Aliphatic and Aromatic Compounds. Microbial interaction with plastics, antibiotics and others emerging pollutants.

**Week 10:** Microbially Enhanced Phosphorus and Nitrogen Removal

**Week 11:** Microbially Enhanced Oil Recovery; Microbial role in Carbon Storage and Capture (sequestration, conversion to useful biopolymers, etc.).

**Week 12:** Case studies : Bioremediation, Carbon Storage and Capture, Bioenergy.

Books and references


1. Environmental Biotechnology, Principles and Applications by Bruce E Rittman and Perry L McCarty, McGrawhill Higher education.
2. Environmental Biotechnology Edited by Hans-Joachim Jördening and J Winter, WILEY-VCH Verlag Gmbh & Co.
3. Bioremediation and Natural Attenuation by Pedro J J Alvarage and Walter A Illman, Wiley Interscience.
4. Environmental Biotechnology, Vol 10 Handbook of Environmental Engineering, Edited by L K Wang et al, Humana Press.

**Industrial Biotechnology**

**(Being offered as elective in our R20 curriculum)**

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITES:**

**Knowledge in microbiology**

**Biochemistry and mathematics in 10+2 level**

**Course layout**

**Week 1:** Introduction, Microbes and enzymes of industrial importance

**Week 2:** Different types of bioreactors and bioreactor design

**Week 3:** Microbial growth, substrate degradation and product formation kinetics, Tutorial 1

**Week 4:** Instrumentation, Sterilization of air, media and reactor

**Week 5:** Upstream and Downstream processing

**Week 6:** Production of Oxy Chemicals I: Tax and non-tax alcohol, Brewing industry, Tutorial 2

**Week 7:** Production of Oxy Chemicals II: Wine making, Vinegar and citric acid production, Tutorial 3

**Week 8:** Production of Oxy Chemicals III: Antibiotics: Penicillin; Streptomycin

**Week 9:** High fructose corn syrup, Cheese making, and Single cell production

**Week 10:** Vaccines production and Metal leaching

**Week 11:** Bioenergy- Gaseous fuels: Biohydrogen, Biomethane and Microbial fuel cell;

Liquid fuels: Bioethanol, Biodiesel and Biobutanol

**Week 12:** Aerobic and Anaerobic wastewater treatment processes, Tutorial 4

**Books and references:**

1.Industrial Microbiology by Samuel Cate Prescott and Cecil Gordon Dunn
2.Biochemical Engineering Fundamentals by Bailey and Ollis
3.Bioprocess Engineering Principles by Doran
4.Bioprocess Engineering Basic Concepts by Shular and Kargi
5.Biochemical Engineering by Blanch and Clark
6.Biochemical Engineering by Aiba, Humphrey and Millis
7.A textbook of Industrial Microbiology by Wulf Crueger and Anneliese Cruegen

## Introduction to Biostatistics

**Course Duration: 8 weeks**

**Credits: 2**

**PRE-REQUISITES: Basic knowledge of 12th standard mathematics is sufficient.**

**Course layout**

**Week 1:** Lecture 1. Introduction to the course
Lecture 2. Data representation and plotting
Lecture 3. Arithmetic mean
Lecture 4. Geometric mean
Lecture 5. Measure of Variability, Standard deviation
**Week 2:** Lecture 6. SME, Z-Score, Box plot
Lecture 8. Kurtosis, R programming
Lecture 9. R programming
Lecture 10. Correlation
**Week 3:** Lecture 11. Correlation and Regression
Lecture 12. Correlation and Regression Part-II
Lecture 13. Interpolation and extrapolation
Lecture 14. Nonlinear data fitting
Lecture 15. Concept of Probability: introduction and basics
**Week 4:** Lecture 16. counting principle, Permutations, and Combinations
Lecture 17. Conditional probability
Lecture 18. Conditional probability and Random variables
Lecture 19. Random variables, Probability mass function, and Probability density function
Lecture 20. Expectation, Variance and Covariance
**Week 5:** Lecture 21. Expectation, Variance and Covariance Part-II
Lecture 22. Binomial random variables and Moment generating function
Lecture 23. Probability distribution: Poisson distribution and Uniform distribution Part-I
Lecture 24. Uniform distribution Part-II and Normal distribution Part-I
Lecture 25. Normal distribution Part-II and Exponential distribution
**Week 6:** Lecture 26. Sampling distributions and Central limit theorem Part-I
Lecture 27. Sampling distributions and Central limit theorem Part-II
Lecture 28. Central limit theorem Part-III and Sampling distributions of sample mean
Lecture 29. Central limit theorem - IV and Confidence intervals
Lecture 30. Confidence intervals Part- II
**Week 7:** Lecture 31. Test of Hypothesis - 1
Lecture 32. Test of Hypothesis - 2 (1 tailed and 2 tailed Test of Hypothesis, p-value)
Lecture 33. Test of Hypothesis - 3 (1 tailed and 2 tailed Test of Hypothesis, p-value)
Lecture 34. Test of Hypothesis - 4 (Type -1 and Type -2 error)
Lecture 35. T-test
**Week 8:** Lecture 36. 1 tailed and 2 tailed T-distribution, Chi-square test
Lecture 37. ANOVA - 1
Lecture 38. ANOVA - 2
Lecture 39. ANOVA - 3
Lecture 40. ANOVA for linear regression, Block Design

**Books and references**


1. Introduction to Probability & Statistics - Medenhall, Beaver, Beaver 14th Edition
2. Introduction to Probability and statistics for engineers and scientists, S M Ross, 3rd Edition

## Medical Image Analysis

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITES:** Knowledge of calculus, Linear Algebra, introductory optimization and introductory matrix computations

### Course layout

**Week 1:** Introduction to medical imaging

**Week 2:** Basic image processing techniques

**Week 3:** Image registration – 1- Rigid models

**Week 4:** Image registration – 2- Non-Rigid models

**Week 5:** Image registration – 3- Application and demonstration

**Week 6:** Image segmentation **-** Statistical shape model

**Week 7:** Image segmentation – PDE based methods

**Week 8:** Image segmentation – application and demonstration

**Week 9:** Computer Aided Diagnosis – Case Study 1

**Week 10:** Computer Aided Diagnosis – Case Study 2

**Week 11:** Deep Learning for Medical image analysis – 3D Convolutional Neural Networks

**Week 12:** Deep Learning for Medical image analysis – Generative models for synthetic data

**Introduction to Developmental Biology**

**(Being offered as elective in our R20 curriculum)**

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES: Knowledge of basic biology, molecular biology and genetics will be essential.**

**Course layout**

**Week 1:** Developmental Anatomy – life cycle; comparative and evolutionary embryology; fate mapping

**Week 2:** Differential gene expression

**Week 3:** Differential gene expression; Basic concepts of genetics

**Week 4:** The concept of model organisms; Core genetic techniques

**Week 5:** Cell-Cell communication in Development – basic concepts of morphogenesis and cell signaling

**Week 6:** Cell-Cell communication in Development – the signaling pathways

**Week 7:** Axis specification during Drosophila embryogenesis

**Week 8:** Axis specification during Drosophila embryogenesis

**Week 9:** Plant Development

**Week 10:** Early mammalian development – Cleavage and gastrulation

Week 11: Early mammalian development – Axis formation

Week 12: Developmental mechanisms of evolutionary change

**Books and references:**

Developmental Biology (9th or later editions) Author: Scott Gilbert

**Tissue Engineering**

**(Being offered as elective in our R20 curriculum)**

**Course Duration: 8 weeks**

**Credits: 2**

PREREQUISITES : Understanding of basic cell biology would be helpful

**Course layout**

**Week 1:** Introduction to tissue engineering

**Week 2:** Scaffolds: extracellular matrix, natural and synthetic polymers

**Week 3:** Hydrogels, bioceramics, scaffold fabrication

**Week 4:** Material characterization

**Week 5:** Cell source, isolation, growth, differentiation

**Week 6:** Cell adhesion, migration, signaling, bioreactors and challenges in tissue engineering

**Week 7:** Host integration, bioethics, Applications: Skin tissue engineering

**Week 8:** Applications: Bone tissue engineering, Vascular tissue engineering, and Corneal tissue engineering

**Books and references**


1. Bernhard O. Palsson, Sangeetha N. Bhatia, Tissue Engineering, 2004, Pearson
2. Robert A Brown, Extreme Tissue Engineering: Concepts and Strategies for Tissue Fabrication, 2013, Wiley Blackwell
3. W Mark Saltzman, Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues, 2004, Oxford University Press
4. John P Fisher, Antonios G Mikos, Joseph D Bronzino, Tissue Engineering, 2006, CRC Press
5. Robert Lanza, Robert Langer, Joseph Vacanti, Principles of Tissue Engineering, Third Edition, 2007, Elsevier Academic Press

## Organ Printing

**Course Duration: 8 weeks**

**Credits: 2**

**PRE-REQUISITE:** Knowledge on Biomaterials and Human Anatomy and Physiology.

**Course layout**

**Week 1:** Introduction to Bioprinting; different types of bioprinting techniques and their advantages and disadvantages

**Week 2:** 3D tissue designing and 3D tissue/organ printing; various process parameters and their role in bioprinting

**Week 3:** Introduction to bioinks; biomaterials used for bioink development with their merits and demerits

**Week 4:** Critical parameters of bioink formulations for bioprinting, modulation of bioink properties to control different processing conditions

**Week 5:** 3D bioprinted in vitro, in vivo, and ex vivo research models and techniques; in vitro manipulation of cells and biomaterials with a bioprinter to engineer tissues for regenerative medicine or in vitro tissue/organ models

**Week 6:** In situ bioprinting and 4D bioprinting with examples from recent literature

**Week 7:** Biofabrication-based strategies from bench-to-bed to address specific clinical problems

**Week 8:** Next step in bioprinting (challenges and future direction); ethical issues related to bioprinting

**Books and references:**


1. Atala et al., Essentials of 3D Biofabrication and Translation. 1st edition, ISBN-13: 978-0128009727.
2. Zhang et al., 3D Bioprinting and Nanotechnology in Tissue Engineering and Regenerative Medicine. 1st edition, ISBN 9780128005477.
3. Forgacs et al., Biofabrication - Micro- and Nano-fabrication, Printing, Patterning and Assemblies, 1st Edition, ISBN 9781455728527.
4. Derby B. Printing and prototyping of tissues and scaffolds. Science. 2012. 338:921-6.
5. Seliktar D. Designing cell-compatible hydrogels for biomedical applications. Science. 2012. 336:1124-8.
6. Murphy SV, Atala A. 3D bioprinting of tissues and organs. Nature Biotechnology. 2014. 32:773-85.
7. Pati F, Gantelius J, Svahn HA. 3D Bioprinting of Tissue/Organ Models. Angewandte Chemie International Edition. 2016.55:4650-65.

## Genome Editing and Engineering

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** 10+2 with Biology and Chemistry

**Course layout**

**Week 1:**Introduction to genetics and genetic engineering

**Week 2:**Breakage and Repair Of Genomic DNA

**Week 3:**Recombination

**Week 4:**Targeted genetic modification

**Week 5:**Zinc Finger Nuclease (ZFN) Technology

**Week 6:**Transcription activator-like effector nuclease (TALEN) Technology

**Week 7:**Clustered regularly interspaced short palindromic repeats (CRISPR)/Cas9 technology

**Week 8:**Applications of genome editing in treating human diseases

**Week 9:**Genome engineered Disease modeling

**Week 10:**Engineered immune cells for cancer therapy

**Week 11:**Personalized therapy; Challenges: safety and specificity

**Week 12:**Ethical concerns: Germ line gene editing

**Books and references:**


1. Harber , J. E., Genome Stability: DNA Repair and Recombination , Garland Science, 2013.
2. Yamamoto, T. , Targeted Genome Editing Using Site-Specific Nucleases, Springer, 2015.
3. Zlatanova, J. and Holde, K. van, Molecular Biology: Structure and Dynamics of Genomes and Proteomes. Garland Science, 2015.
4. Yamamoto, T.(Ed.), Targeted Genome Editing Using Site-Specific Nucleases: ZFNs, TALENs, and the CRISPR/Cas9 System , Springer 2015.
5. Barrangou , R. and Oost, J. van der, CRISPR-Cas Systems: RNA-mediated Adaptive Immunity in Bacteria and Archaea , Springer, 2013.
6. Addgene, CRISPR 101:A Desktop Resource , January 2016
7. Alberts , B. , Johnson , A., Lewis , J., Morgan, D., Raff, M., Roberts, K.and Walter, P., Molecular Biology of the Cell, $6^{th}$ Edn., Garland Science, 2014.

**Next Generation Sequencing Technologies: Data Analysis and Applications**

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** Basic knowledge of programming and statistics

**Course layout**

**Week 1:** Next Generation Sequencing (NGS) Technologies

**Week 2:** NGS data formats and data quality check (QC)

**Week 3:** Hands-on tutorial 1 - NGS data and quality check

**Week 4:** Read Mapping Algorithms

**Week 5:** Read Mapping Tool Hands-on and SAM files

**Week 6:** Variant detection and CNV analysis

**Week 7:** RNA sequencing experiment and data processing

**Week 8:** Differential expression analysis and multiple hypothesis testing corrections

**Week 9:** Gene Ontology (GO) and pathway enrichment analysis

**Week 10:** Hands-on tutorial 2 – RNA-seq data processing and differential expression analysis

**Week 11:** Genome assembly algorithms

**Week 12:** Application of NGS in epigenomic studies

**Books and references**

1. High-Throughput Next Generation Sequencing, Methods and Applications. (Springer). Editors: Kwon, Young Min, Ricke, Steven C. (Eds.)
2. Next Generation Sequencing, Methods and Protocols, 2018, Volume 1712, Steven R. Head, Phillip Ordoukhanian, Daniel R. Salomon (Eds), Humana Press. ISBN : 978-1-4939-7512-9
3. Next Generation Sequencing and Data Analysis 2021, Melanie Kappelmann-Fenzl, Springer.ISBN : 978-3-030-62489-7

## Computational Neuroscience

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** 1st year college Mathematics and Biology

**Course layout**

**Week 1: Introduction to Neurons**

1) Neuron structure

2) Networks of Neurons and Synapses

3) System of neural processing

4) Basic structures in the brain

5) Sensory - Executive - Behavior systems

**Week 2: Excitable Membranes and Neural Activity**

1) Membrane Potential and All or None Spike

2) Patch Clamp Techniques, Membrane Potential

3) Ion Channels

4) Current Injection - Synapses

5) Single neuron activity

**Week 3: Point models: Hodgkin Huxley Equations (HHE)**

1) Point and Compartmental Models of Neurons

2) Hodgkin Huxley Equations - I

3) Hodgkin Huxley Equations - II

4) Reducing the HHE and Moris-Lecar Equations (MLE) 5) Properties of MLE

**Week 4: Analysis of Neural Models**

1) Phase Plane Analysis - I

2) Phase Plane Analysis - II

3) Analyzing HHE

4) Bifurcations

5) Other Point Models

**Week 5: Spike Trains: Encoding and Decoding - I**

1) Random Variables and Random Processes

2) Spike Train Statistics and Response Measure

3) Receptive fields and Models of Receptive Fields

4) The Spike Triggered Average (Coding)

5) Stimulus Reconstruction (Decoding)

**Week 6: Spike Trains: Encoding and Decoding - II**

1) Nonlinear approaches: Basics of Information Theory

2) Maximally Informative Dimensions

3) Discrimination based approaches

4) Measuring Spike Train Distances

5) Statistical Methods in Discrimination

**Week 7: Spike Trains: Encoding and Decoding - III**

1) Examples-I: Encoding/Decoding in Neural Systems

2) Examples-II: Encoding/Decoding in Neural Systems

3) Neural Population Based Encoding/Decoding - I

4) Neural Population Based Encoding/Decoding - II

5) Examples: Population Based Encoding/Decoding

**Week 8: Plasticity - I**

1) Synaptic Transmission and Synaptic Strength

2) Ways of Modification of Synaptic Strength

3) Types of Plasticity

4) Short Term Plasticity - I

5) Short Term Plasticity - II

**Week 9: Plasticity - II**

1) Implications of Short Term Plasticity

2) Long Term Plasticity - I

3) Long Term Plasticity - II

4) Modeling Long Term Plasticity

5) Computational Implications

**Week 10: Plasticity - III, Modeling Phenomena with Plasticity**

1) Adaptation

2) Attention

3) Learning and Memory - I

4) Learning and Memory - II

5) Developmental Changes

**Week 11: Plasticity - IV, Modeling Phenomena with Plasticity**

1) Conditioning and Reinforcement Learning

2) Reward Prediction (Error)

3) Decision Problems

4) Learning and Memory - II

5) Developmental Changes

**Week 12: Theoretical Approaches and Current Research**

1) Optimal Coding Principles - I

2) Optimal Coding Principles - II

3) Theoretical Approaches to Understanding Plasticity

4) Current Topics - I

5) Current Topics - II

**Books and references**

1. Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems,, Dayan and Abbott
2. Signal and Systems, Oppenheim and Wilsky
3. Information Theory and Coding, Cover and Thomas 4. Nonlinear Dynamics and Chaos, Strogatz
5. Methods in Neuronal Modeling, Editors: Koch and Segev
6. Ion Channels of Excitable Membranes, Hille
7. Principles of Neural Science, Kandel and Schwartz

## Neurobiology

**Course Duration: 4 weeks**

**Credits: 1**

**PREREQUISITES:** Basic Class 10th level knowledge of biology and mathematics is sufficient. No pre-requisite courses are required.

**Course layout**

1: Introduction

- History of Neuroscience
- Evolutionary perspective
- Methods and tools in neuroscience
- Brain structures

2: Electrical activity in the brain

- Conductance and capacitance
- Time constant and length constant
- Equilibrium potential

3: Active conductances

- Ion Channels,
- Active conductances
- Action potential

4: Synapses

- Chemical synapses
- Gap-junctions
- Synaptic integration

5: Sensory systems

- Tuning curves
- Perception
- Olfactory system

**Books and references:**

Principles of Neural Science, 5th edition (Eric Kandel & colleagues)

## Neural Science for Engineers

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITE:** Preferable, but not essential, to have taken the NPTEL Sensors and Actuators

**Course layout**

Week 1: Introduction to the Nervous System and Basic Structure of the Nervous System
Week 2: Evolutionary Lessons in Nervous System Function and Hierarchy of Neural Function from the Cell to Large Networks
Week 3: Signal Transmission, Analog Signal Processing, and Digital Signal Processing in the Nervous System
Week 4: The OS, Servomechanisms, and Control Systems in the Nervous System
Week 5: Theories of Learning and Mechanisms of Learning
Week 6: Biological Basis of Contemporary Neural Networks and Neural Substrates for Contemporary Neural Networks
Week 7: Computational Neurobiology, Brain-Computer Interfaces: Neuromodulation and Recordings: Brain-Computer Interfaces (BCI) Devices and Systems, Introduction to BCI Devices for Neural Recording and Stimulation.
Week 8: Introduction to Neuro-biopotentials: EEG, EMG and ECoG: Introduction to biopotentials, Data Acquisition, Signal Acquisition, Conditioning, and Processing.
Week 9: Introduction to the development of BCI devices I
Week 10: Introduction to the development of BCI devices II
Week 11: Microdevices for Neural Stimulation and Recording: Flexible Devices for ECoG Recordings and Neural Stimulation, Microneedles for Measuring Local Field Potentials (LFPs), and Bioresorbable Devices for ECoG Recordings.
Week 12: Demonstration of BCI Devices: Packaging, Implantation, and Recording: Packaging Techniques for BCI devices, Implantation of BCI devices, Interfacing with Read-out Electronics and Recording ECoG Signals.

**Books and references:**

1. Fundamentals of Microfabrication by Madou Marc J.
2. Silicon VLSI Technology: Fundamentals, Practice, and Modeling by James D. Plummer, Michael Deal, and Peter D. Griffin.
3. Fundamentals of Semiconductor Fabrication by S M Sze
4. VLSI Fabrication Principles: Silicon and Gallium Arsenide by S K Gandhi
5. VLSI Technology by S M Sze
6. Fundamentals of Microelectronics by B Razavi
7. Franco, S., 2002. Design with operational amplifiers and analog integrated circuits. New York: McGraw-Hill.
8. Pallas-Areny, R. and Webster, J.G., 2012. Sensors and signal conditioning. John Wiley & Sons.
9. An Introduction to the Event-Related Potential Technique
10. The Oxford Handbook of Event-Related Potential Components
11. The Art of Electronics, Horowitz & Hill, 3rd Edition.
12. Principles of Neural Science, Fifth Edition. Eric R. Kandel, Edited, James H. Schwartz, Edited, Thomas M. Jessell, Edited, Steven A. Siegelbaum, Edited, A. J. Hudspeth, Edited, Sarah Mack, Art Editor Instructor
bio

## Classics in Neuroscience

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES:** Basic course in neuroscience can help

**Course layout**

**Week 1:**
Topic 1: Introduction: Why Study History? Why the 1940s and 1950s?
Topic 2: Genes: Starting with DNA

**Week 2:**
Topic 1: Signaling Molecules: The First Growth Factor
Topic 2: Signaling Molecules: The First Neurotransmitters in the Brain

**Week 3:**
Topic 1: Cell Biology and the Synapse
Topic 2: Physiology: The Action Potential

**Week 4:**
Topic 1: Physiology: Synaptic Potentials and Receptor Potentials
Topic 2: Functional Organization of Neurons and Dendrites

**Week 5:**
Topic 1: Neural Circuits: Spinal Cord, Retina, Invertebrate Systems
Topic 2: Neural Circuits: Cortical Columns and Cortical Processing

**Week 6:**
Topic 1: Neural Systems: The Neural Basis of Behavior
Topic 2: Learning and Memory: Donald Hebb, Brenda Milner, and H. M.

**Week 7:**
Topic 1: Neurology: Foundations of Brain Imaging
Topic 2: Neurosurgery: From Cushing to Penfield

**Week 8:**
Topic 1: Neuropsychiatry: The Breakthrough in Psychopharmacology
Topic 2: Theoretical Neuroscience: The Brain as a Computer and the Computer as a Brain

**Books and references:**

Creating Modern Neuroscience: The Revolutionary 1950s by Gordon M Shepherd

## Human Behaviour

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES: NIL**

**Course layout**

**Week 1** : Introduction to the science of human behavior

**Week 2** : Sensation & Perception-I

**Week 3** : Perception-II, Learning

**Week 4** : Memory and Language-I

**Week 5** : Language-II and Emotion

**Week 6** : Intelligence

**Week 7** : Personality

**Week 8** : Social influence and cognition

**Books and references:**


1. Attkinson and Hillgard, Psychology: An introduction, Cengage Press
2. Cacioppo, J, Discovering Psychology, Cengage Learning
3. Baron, R, Psychology, Pearson Press.

## Biointerface Engineering

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES :** Bachelor Degree in any Engineering discipline

**Course layout**

**Week 1:**Intermolecular Forces

**Week 2:**Adhesion and Wetting Phenomena

**Week 3:**Characterization of interfaces

**Week 4:**Protein-surface interactions

**Week 5:**Protein Aggregation

**Week 6:**Cell-surface interactions

**Week 7:**Surface modification and characterization

**Week 8:**Surface modification and characterization

**Books and references:**

- J. N. Israelachvili, Intermolecular and Surface Forces, 3rd edition, Academic Press, 2011.
- Willem Norde, Colloids and Interfaces in Life Sciences and Bionanotechnology, 2nd edition, CRC Press, 2011.
- W. Adamson, and A. P. Gast, Physical Chemistry of Surfaces, John Wiley, New York, 1997.

**Microsensors, Implantable Devices and Rodent Surgeries for Biomedical Applications**

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES :** Preferable, but not essential, to have taken the NPTEL Sensors and Actuators.

**Course layout:**

**Week 1 : Logistics in rodent experiments:** Personal Protective Equipment, Procurement and quarantine of laboratory animals, Husbandry and Handling of rodents, Breeding and Care of Rats and Mice.

**Week 2 : Rodents for Neural experiments:** Species of rodents used in neural experiments, Rodent identification, and selection for experiments

**Week 3:** Rodent Neural Sensors and Data acquisition systems, Epileptic Seizure Detection and Classification

**Week 4 :** Microbial and Health monitoring for chronic neural experiments.

**Week 5 :** Neural system models in rodents – Epilepsy, Stroke, Motor movements, Parkinsonian models and application of rodent neural experiments, Microfabrication for neural engineering, PVD, CVD, Lithography, Etching

**Week 6 :** Behavioral setups for neural experiments, Different Brain-Computer Interfaces, Micro Electrode Array

**Week 7 : Rodent Micro Neurosurgery I:** Rodent anesthesia techniques, Introduction, Neuroanatomy – Applied and Comparative (rodent /monkey/ human) Equipments, Sterility and sterilization, Craniotomy, Microneurosurgical instruments and techniques, Sensor implantation and head mounting techniques, Closure techniques and challenges, Implant care for chronic recordings

**Week 8 : Rodent Micro Neurosurgery II:** Spinal anatomy, Spinal cord sensors and implantation surgeries, Peripheral neural anatomy, Peripheral neural surgeries, Peripheral neural sensors, and implantation, Different neural experiments as an example, Recovery process, Biological Basis of Contemporary Neural Networks and Neural Substrates for Contemporary Neural Networks

**Week 9 : Rodent neuropathology:** Euthanasia and Brain harvesting techniques. Neuropathological processing of the harvested brain, Electronic System Development for neural experiments

**Week 10 :** Challenges in neural signals and synchronization of behaviors, Brain Stimulation: Introduction and Applications, Experimental Protocol for Neural Experiments

**Week 11 :** Neural signal processing and post-processing, EEGLAB, ERPLAB, Event-Related Potentials: Introduction and Applications, ERP Extraction, Time-Frequency Analysis, Signal Interpretation

**Week 12 :** Decoding techniques and challenges, Recent Trends in Neural Engineering

**Books and references:**

1. Pallas-Areny, R. and Webster, J.G., 2012. Sensors and signal conditioning. John Wiley & Sons.
2. An Introduction to the Event-Related Potential Technique
3. The Oxford Handbook of Event-Related Potential Components
4. The Art of Electronics, Horowitz & Hill, 3rd Edition.
5. Principles of Neural Science, Fifth Edition. Eric R. Kandel, Edited, James H. Schwartz, Edited, Thomas M. Jessell, Edited, Steven A. Siegelbaum, Edited, A. J. Hudspeth, Edited, Sarah Mack, Art Editor
6. Paxinos and Watson: The Rat Brain

## Education for Sustainable Development

**Course Duration: 12 weeks**

**Credits: 3**

**Course layout**

**Week 1 :** 1: Introduction to ESD

a) Introduction to UNESCO 17 Sustainable Development Goals (SDG)

**Week 2 :** b) SD Goal-4- Quality Education for all

c) Education for Sustainable Development (ESD)

**Week 3 :** 2: ESD & SDGs ESD for achieving SDG- 4.7

a)Sustainable lifestyle

b) Human rights

**Week 4 :** c) Gender equality

d) Promotion of peace & non-violence

e) Global citizenship

**Week 5 :** f) Leveraging cultural diversity for SDGs

3. ESD & Sustainability ESD for achieving SDG-4.4

a) Technical & vocational skills for employability

**Week 6 :** b) 21st Century competencies for global & decent jobs
c) Sustainable entrepreneurship

**Week 7 :** d) Promoting good mental health & wellbeing

e) Inclusive education & social transformation

**Week 8 :** 4: ESD & Social Transformation ESD for promotion of

a) Responsible consumption & production

b) Peace & justice in the society

**Week 9 :** c) Sustainable cities & communities

d) Sustainable health practices & social wellbeing

**Week 10 :** 5: ESD & Sustainable education Sustainable education & global partnership

a) Educational policy & curriculum

b) Pedagogical practices & ICT

**Week 11 :** c) Educational research & social benefits

d) Educational ecosystem & management

**Week 12 :** Guest Lecture by International Faculty

**Books and references:**


1. Issues and trends in Education for Sustainable Development: UNESCO Publication
2. Digital Pedagogy for Building Peaceful & Sustainable Societies: Blue Dot Publication
3. https://www.mdpi.com/journal/sustainability/ special_issues/Entrepreneurship_Education

**Advances in Omics**

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES:** Basics of biological molecules

**Course layout**

**Week 1:** Introduction to genomics: Historical perspective with examples from Human genome project and Advent of NGS. Genomic assembly approaches.

**Week 2:** Detailed discussion of the principles of sequencing technologies and comparison of advantages and disadvantages. Applications and Challenges in the use of NGS technologies

**Week 3:** Omics data avalanche: 1000 genomes project, ENCODE project, ExAC, TCGA

**Week 4:** Importance of evolutionary viewpoint in genomics, Signatures of selection in primates (with prominent examples from Human studies), Whole-genome duplication, comparative and population genomics, tests of selection (codon based and site frequency-based tests).

**Week 5:** Introduction to transcriptomics, proteomics and Integration of Multi-Omic data. Other types of omic datasets resulting from high-throughput use of assays (Ex: Repli-Seq, Ribo-Seq, Tag-Seq)

**Week 6:** Omics databases organization and utility. NCBI, UCSC genome browser, Short Read Archive, Proteome Exchange, Peptide Atlas, KEGG

**Week 7:** Introduction to linux, use of command line interface, Tutorial on analysis of NGS data (Genomics, Transcriptomics)

**Week 8:** Course summary and Exam

**Books and references:**


1. Selected Readings: Latest papers and review articles in each topic (from journals including, but not limited to, Nature, Curr. Opin. Chem. Biol., Cell, Nature Biotech., Science, Trends series). This will be provided in the class.

## Statistics for Biomedical Engineers

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** Preferably Masters/Senior Undergraduate students with engineering/mathematics background

Course layout

**Week 1:** Introduction to Biostatistics, applications of biostatistics, discussion of few use cases.

**Week 2:** Introduction to statistics, Need for statistics, Role of probability, Discussion of descriptive statistics

**Week 3:** Discussion of Mean, Median and mode, Introduction to probability theory, probability distributions, Expectations, Population variance, sample statistics, Inferential statistics

**Week 4:** Central limit theorem, Confidence intervals, Introduction to Hypothesis testing, Elements of Hypothesis testing, Large sample test, p-values

**Week 5:** Small sample test, T-distribution, Type I error, Type II error, Power of test, Chi-Square distribution, Hypothesis test using variance, Contingency test, Test of Independence, Probability plots

**Week 6:** Hypothesis test for two independent population, paired T test, F-distribution, Detailed discussion on ANOVA, Derivation of Mean Squared Treatment and Mean Squared Error in ANOVA, Sample problems

**Week 7:** Joint distribution, Covariance & Correlation between random variables, Simple Linear Regression, R-squared statistic, Confidence intervals for regression parameters, Multiple Linear Regression, Adjusted R-Squared statistic

**Week 8:** Logistic Regression, logit function, Derivation of log-likelihood function, Revisit ANOVA using linear regression, Derivation of ANOVA equations, Sample problems

**Week 9:** Introduction to Blocking, Randomized Complete Block Design, Latin square design, Sample Problems

**Week 10:** Graeco-Latin Square design, Introduction to factorial design, $2^2$ factorial design, Discussion on interactions

**Week 11:** $2^3$ factorial design, Derivation of relevant equations, Sample problems

**Week 12:** 2-Way ANOVA, Use cases, Derivations, Sample problems

**Books and references:**


1.Biostatistics: A foundation for analysis in the health sciences, Daniel, W. W. and C, L. Cross 9ed Wiley. 2013.
2. Biostatistics for the Biological and Health Sciences, Triola and Triola, Pearson Addison Wesley
3. Montgomery, Douglas C., and George C. Runger. *Applied statistics and probability for engineers.* John wiley & sons, 2020.
4. Montgomery, Douglas C. Design and analysis of experiments. John wiley & sons, 2017.

Design for Biosecurity

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** High school with science

**Course layout**

**Week 1 : Challenges of biosecurity**

- Agriculture Security
- Livestock production
- Human health
- Pandemics
- Bioterrorism

**Week 2 : Need for economic sensors to meet the emerging threats of biosecurity**

- Case study for Filoviruses (Ebola, Marburg) sensor
- Case study for Bacillus anthracis (Anthrax) sensor
- Case study of botulism toxin
- Case study of insulin

**Week 3 : Design of electrochemical sensors**

- Galvanic cells
- Nernst equation
- Equilibrium constant
- Cells as a chemical probe
- Concepts of $E^0$ and $E^{0'}$

**Week 4 : Electrode design and printing of electrodes**

- Selection of electrode materials for rapid sensing
- Bio-inspired electrode materials

**Week 5 : Electrode design and printing of electrodes**

- Processing of electrode materials
- Printing of electrodes
- Design challenges of electrode integration in protective technical textiles and defence gears

**Week 6 : Electrodes, potentiometry**

- Reference electrode
- Indicator electrode

**Week 7 : Electrodes, potentiometry**

- Junction potential
- Ion-selective electrode
- Solid-state chemical sensors (Fields effect transistors)

**Week 8 : Redox titrations in electrochemical sensors**

- Redox titration curves
- Determination of endpoints
- The oxidation state of the analyte

**Week 9 : Electro-analytical methods**

- Basic electrolysis
- Electro-gravimetric analysis

**Week 10 : Electro-analytical methods**

- Coulometry
- Amperometry
- Voltammetry

**Week 11 : Designing human-on-a-chip platforms for toxin detection, neurocomputing, robotics, and rehabilitation**

- Concepts of whole cell biosensors
- Neuro-technology
- Action potential shape analysis in toxin detection & role of voltage gating molecules
- Micro-electrode arrays
- Field effect transistors

**Week 12 : Designing of a biosecurity facility**

- Infrastructure
- Instrumentation
- Sample handling, quarantine protocols, biosafety levels, personnel safety and security
- In-house fabrication, printing, and micro-machining facility
- Data analysis & storage

**Books and references:**

1. *The Problems of Biological Weapons*, Milton Leitenberg, Swedish National Defence College, Department of Security and Strategic Studies, ISBN: 9789189683273, 9189683277 (2004)

2. *Biotechnology Research in an Age of Terrorism*, Committee on Research Standards and Practices to Prevent the Destructive Application of Biotechnology, National Academic Press, ISBN: 9780309089777, 0309089778 (2004)

3. Popular Reading: *A Taste for Poison: Eleven Deadly Molecules and the Killers Who Used Them*, Neil Bradbury, St. Martin's Press, ISBN-10: 1250270758 (2022)

4. Popular Reading: *Hot Zone*, Richard Preston, Anchor, ISBN: 0-385-47956-5 (1994)

5. *Measurement, Instrumentation, and Sensors Handbook, Electromagnetic, Optical, Radiation, Chemical, and Biomedical Measurement*, Volume 2, Compilers: Halit Eren, John G. Webster; CRC Press (2017)

6. *Principles of Instrumental Analysis*, Douglas A Skoog, James Holler, Stanley R Crouch, ISBN: 9781337468039, 1337468037 (2017)

7. *Instrumentation*, Franklyn W Kirk & Nicholas R Rimboi, American Technical Society, ISBN: 9780826934208, 082693420X (1966)

8. *Quantitative Chemical Analysis* (Edition 8), Daniel C. Harris, Freeman Palgrave Macmillan International Edition, ISBN- 13: 978-1-4292-1815-3 (2010)

9. *A Textbook of Quantitative Inorganic Analysis including elementary Instrumental Analysis* (Edition 3), Arthur I Vogel, The English Language Book Society & Longmans, Green & Co Ltd (1961)

10. *The electrochemical detection of bioterrorism agents: a review of the detection, diagnostics, and implementation of sensors in biosafety programs for Class A bioweapons*, Connor O Brien, Kathleen Varty, Anna Ignaszak, Microsystems & Nanoengineering, Volume 7, Article Number: 16 (2021)

11. *Nanoelectronics & Nanosystems, From Transistors to Molecular & Quantum Devices*, Karl Goes, Peter Glosekotter, Jan Dienstuhl, Springer, ISBN: 3-540-40443-0 (2004)

12. *Enabling Technologies for Cultured Neural Networks*, Volume 1, Editors: David A. Stenger, Thomas M. McKenna, ISBN: 9780126659702, 0126659702 (1994)

13. *Nanobioelectronics - for Electronics, Biology, and Medicine*, Editors: Andreas Offenhausser, Andreas Offenhäusser, Ross Rinaldi, Springer, ISBN: 9780387094595, 0387094598 (1979)

## Advanced Fluorescence Microscopy and Image Processing

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** A Bachelor's degree in any area of life sciences (zoology, botany, biochemistry, biotechnology, microbiology, medical biotechnology, genetics, etc.) is preferred. However, final year B.Sc./B.Tech/B.E. students in life sciences/Biotechnology can also enroll.

**Course layout**

**Week 1:**
Lecture 1: Introduction to fluorescence microscopy and its applications
Lecture2:Introduction to Microscope Optics

**Week 2**:
Lecture3: Design of a Fluorescence Microscope
Lecture 4: Fluorescent proteins, organic dyes, and protein labeling strategies

**Week 3:**
Lecture 5: 6D imaging, live cell imaging, time-lapse imaging, FRAP, FRET, FLIM
Lecture 6: Illumination strategies (Epi, TIRF, HILO, light sheet, multi-photon)

**Week 4:**
Lecture 7: Confocal Microscopy
Lecture 8: Super-resolution microscopy (SIM, STED, STORM/PALM)

**Week 5:**
Live demonstration of a fluorescence microscope, 6D imaging of live cells

**Week 6:**
Lecture 9: Immunofluorescence (IF), Immunohistochemistry (IHC)
Lecture 10: Fluorescence in-situ Hybridization (FISH), RNAFISH

**Week 7:**
Lecture 11: Digital images and camera technologies for microscopy
Lecture 12: CCD, EMCCD, sCMOS camera

**Week 8:**
Lecture13: ImageJ/FIJI-based image processing and data analysis (workshop, basic operations of ImageJ/FIJI)

**Week 9:**
Lecture14: ImageJ/FIJI-based image processing and data analysis (workshop, image segmentation)

**Week 10:**
Lecture 15: ImageJ/FIJI-based image processing and data analysis
(workshop, macros, intensity measurement, scale bar, time scale, montage preparation, colocalization)

**Week 11:**
Lecture 16: Single-molecule imaging and tracking
Lecture 17: Optical tweezers and traction force microscopy

**Week 12:**
Lecture 18: Spatial Transcriptomics and Proteomics (RNAscope, MERFISH, CODEX)
Lecture 19: High-content imaging

**Books and references:**

1) Microscope Image Processing by Qiang Wu, Fatima Merchant and Kenneth Castleman, Academic Press, ISBN: 012372578X
2) Fundamentals of Light Microscopy and Electronic Imaging by Douglas Murphy and Michael Davidson, Second Edition, Wiley-Blackwell publisher, ISBN: 047169214X.
3) Introduction to optical microscopy by Jerome Mertz, Cambridge University Press, 2nd Edition, doi: 10.1017/9781108552660, ISBN: 9781108552660
4) Fluorescence Microscopy: From Principles to Biological Applications by Ulrich Kubitscheck, 2nd edition, John Wiley & Sons publisher, eBook ISBN 9783527687725

e-resource: https://www.microscopyu.com/

e-resource: https://www.ibiology.org/online-biology-courses/microscopy-series/

e-resource: http://zeiss-campus.magnet.fsu.edu/index.html

e-resource: https://www.leica-microsystems.com/science-lab/topics/basics-in-microscopy/

e-resource: https://www.olympus-lifescience.com/en/microscope-resource/

e-resource: https://imagej.nih.gov/ij/docs/examples/index.html

## Computational Genomics

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** Basic Biology Knowledge such as courses in Molecular Biology, Microbiology, Biochemistry, Genetics, etc

**Course layout**

**Week 1:**

Day 1: Introduction to Computational genomics, Transcriptomics, Proteomics, Epigenomics, Metagenomics and their applications, The BIG data of biological sciences

Day 2: Organization of genetic information in prokaryotic and eukaryotic cell, genome maps, Eukaryotic genome structure, High-throughput technologies to translate this information into genomic data

Day 3: How genomic data is organized in public databases, Genomics web resources, Nucleic acid and protein sequence databases, gene expression databases, Metabolic and metabolomic databases. Examples: NCBI GenBank and Expasy, EBI, Ensembl, UCSC, KEGG

**Week 2:**

Day 1: First, second generation sequencing technologies including Sanger and Illumina and their data output
Day 2: Long read sequencing and linked read sequencing (Nanopore, PacBio, TELL-Seq)
Day 3: Sequence formats: FASTA, GenBank, EMBL, XML, Fastq, fast5, etc., genomic database versions and archives, NCBI SRA, bio-project, accessions, data retrieval using wget, FTP, FileZilla, and scripts provided by the database team for genomic analysis

**Week 3:**

Day 1: Introduction to Linux, basic commands for file handling
Day 2: Running jobs on Linux, processing, installation of genomic packages
Day 3: Introduction to R, commonly used packages, applications in genomic analysis

**Week 4:**

Day 1: Introduction to genomes and packages for genomic analysis such as EMBOSS; Specifications of workstations needed for genomic analysis, Introduction to High Performance Computing and servers, and their need in genomic analysis
Day 2 : Overview and concepts in genomic and transcriptomic analysis of an organism with examples and case studies
Day 3: Sample collection, DNA extraction and quantification, and species identification of the species to be sequenced. RNA extraction and transcriptome sequencing approaches

**Week 5:**

Day 1: Methods to estimate the amount of sequencing coverage needed for genomic assembly, use of hybrid sequencing approaches for appropriate coverage and assembly
Day 2: Short and long reads, paired-end reads, quality filtering of sequence data, Genome complexity assessment, Jellyfish and GenomeScope for generating k-mer count histograms and calculating genomic heterozygosity
Day 3: Concept of genome assembly, contigs, scaffolds, complete genome, draft genome, chromosomal level assembly, Genome assembly algorithms such as De-Bruijn graph, Overlap layout consensus (OLC), Hybrid assembly

**Week 6:**
Day 1: Introduction to common assembly tools ABySS, SOAPdeneno, Flye, Supernova
Day 2: 10X genomic linked-read sequencing, use of proc10xG set of python scripts to pre-process the 10x Genomics raw reads, removal of barcode sequences
Day 3: Nanopore long reads analysis: Guppy for base calling of raw reads, adaptor removal using Porechop, Genome assembly workflow using three different assemblers: wtdbg, SMARTdenovo, and Flye, parameters for assembly

**Week 7:**
Day 1: de novo assembly using Supernova, parameters, usage of genomic and transcriptomic reads to increase assembly contiguity
Day 2: Merging assemblies to create hybrid assembly, gap closing of assembly and polishing, fixation of small indels, base errors, and local misassemblies, determining the quality of assembly using N50, BUSCO scores, coverage etc.,
Day 3: Chromosomal level assembly using Hi-C, concept of reference genome, finished genome, draft genome, case studies

**Week 8:**
Day 1: Annotation of repeats in final genome assembly using RepeatMasker, Determining the simple and complex repeat content of a genome
Day 2: de novo transcriptome assembly, Determining the coding gene set using MAKER pipeline
Day 3: Prediction of tRNA, rRNA and miRNA in a genome, Identification of metabolic pathways by KEGG

**Week 9:**
Day 1: Comprehensive functional annotation of predicted genes or protein sequences by homology-based alignment using Blast or Blat, COGs, Gene ontology based annotation, Interproscan, PROSITE, Pfam, prints, patterns, motifs and fingerprints
Day 2: Evolutionary analysis using homologs, paralogs and orthologs, Multiple signs of adaptation, gene family expansion and contraction
Day 3: Taxonomic classification, marker sequences such as 16S rDNA and ITS, taxonomic hierarchy, Phylogeny reconstruction using multiple sequence alignment, Distance based approaches such as Neighbour joining, Character based approaches such as Maximum parsimony, Maximum likelihood, RAxML

**Week 10:**
Day 1: Epigenetics, ChIp-seq, transcriptome and microarrays for regulation of expression
Day 2: Single cell genomics, 10X Chromium linked-reads and Illumina sequencing, single cell gene expression
Day 3: Application of multiomics approaches in human health and diseases such as cancer, diabetes, etc.

**Week 11:**
Day 1: Prokaryotic genome sequencing and assembly approaches, draft and complete genomes, taxonomic identification
Day 2: Gene prediction approaches and common methods, annotation of a bacterial genome, t-RNA, rRNA, operon prediction
Day 3: Phylogenetic, metabolic and comparative analysis

**Week 12:**
Day 1: Microbiome and Metagenome, Human, organismal and environmental microbiomes
Day 2: Sequencing and assembly of metagenomes, gene prediction, annotation, MAGs
Day 3: Taxonomic analysis using amplicon sequence variants, Statistical analysis

**Books and references**
1. Bioinformatics: Sequence and Genome Analysis by David Mount
2. Computational Genome Analysis: An Introduction by Richard C. Deonier, Simon Tavare, Michael S. Waterman, Springer India

## Microbial Biotechnology

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** 10+2 with Biology and Chemistry

**Course layout**

**Week 1:** Introduction and principles of microbial biotechnology, Classification and taxonomy of microbes

**Week 2:** Structure and life cycle of representative groups of bacteria, viruses and eukaryotic microorganisms

**Week 3:** Physiology of microorganisms, adaptation to diverse environmental conditions

**Week 4:** Genome structure, mechanisms of gene expression and regulation

**Week 5:** Control of microorgansisms

**Week 6:** Industrial and pharmaceutical applications of microorganisms

**Week 7:** Microbes in agriculture, biofertilizer, microbial pesticides, integrated pest management

**Week 8:** Environmental biotechnology

**Week 9:** Food production involving microorganisms and their products

**Week 10:** Microbes in medical biotechnology

**Week 11:** Microbes in alternative energy

**Week 12:** Patenting in microbial biotechnology

**Books and references**

1. Lee Y. K., Microbial Biotechnology: Principles and applications. World Scientific Publisher, 2013.

2. Tortora, Funke and Case, Microbiology, An Introduction, 5th Edition. Benjamin/Cummings Publishing Company, Redwood City, CA, 1995.

3. Board RG, Jones D, Skinner FA, Identification methods in applied and Environmental Microbiology, 1st Ed. Blackwell Science, 1992.

4. Funke, Study Guide for Microbiology, 5th Ed. Benjamin/Cummings Publishing Company, Redwood City, CA, 1995.

**Optical Spectroscopy and Microscopy: Fundamentals of Optical Measurements and Instrumentation**

**Course Duration: 12 weeks**

**Credits: 3**

**Course layout**

**Week 1**: Essential Quantum Mechanics: Uncertainity Principle, Probabilistic nature of measurement, postulates of qmech, Stern Gerlach equivalent in light, Photon picture (PMT response), Linear Vector Space.

**Week 2:** Time dependent perturbation theory, Fermi Golden Rule, Transition probability in light matter interaction, Beer Lambert relation, Einestin's phenomenolgical treatment, A and B coefficients, Spontaneous emission, Origins of fluorescence

**Week 3:** Nature of Fluorescence, Emisson spectrum, Absorption spectrum, Anisotropy, Life time, FRET

**Week 4:** Second quantaisation, creation and anhilation operators, Fock states, light matter interaction in Feynman digrams

**Week 5:** Spontaneous emission orgin, Stimulated Emission origin dependence through Fock states

**Week 6:** Laser emission, two state, three state and four state laser systems

**Week 7**: Real world lasers, Charecteristics of laser emission, thershold behavior, Laser gain equation, CW operation, Pulsed lasers, Qswitching, mode locking, Saturable absorber

**Week 8:** Laser induced fluorescence, optical components (lenses, mirrors, gratings, prisms) and their working principles, Interference filters, dichroic filters, efficiency calculations for SNR improvement, aligning an optical equipment.

**Week 9:** Intro to optical hardware, common opto-mechanical assemblies, setting up a simple laser based spectrometer using gratings in lab, calibration and acqusition of fluorescein spectra.

**Week 10:** Principles of photo detection, QE, Dynamic range shot noise, photodetectors – PMTs, photodiodes, photo resistors, understanding common metrics and specs. Detection electronics – preamps, A2Ds

**Week 11:** Area detectors, CCDs, emCCDs, sCMOS, comparison, read noise, speed and other sensor charecteristics. Theory of Image formations – widefiled microscopy, bright field, phase contrast, DIC and fluorescence microscopy

**Week 12:** Scanning system: Principles of scanning system, Gaussian light progation and focussing, optical resolution, deinition in xy and z. Measurement and charecetrisation in lab. Scanning as time averaged focus, optical hinges, imaging of hinges, Confocal microscope

**Books and references:**

1. Optical Spectroscopy (Demtroder), Quantum Electronics – Yariv, Building Scientific Apparatus – WJ Moore

**Pharmacognosy & Metabolic Engineering**

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES:** Knowledge of basic biology and chemistry at 10+2 level. Appropriate basic background knowledge will be imparted while introducing each thematic topic.

**Course layout**

**Week 1:**
Medicinal and aromatic plants.
Origin and Evolution of plant specialized metabolism.
Eliciting specialized metabolism in plant cell and organ culture.

**Week 2:**
Different strategies of metabolic engineering. Genetic transformation for manipulation of plant specialized metabolism.

**Week 3:**
Introduction to alkaloids.
Engineering tropane alkaloid pathways in plants.

**Week 4:**
Engineering morphine and purine alkaloid pathways.

**Week 5:**
Biosynthesis and genetic manipulation of indole alkaloid pathways. Metabolic reprogramming for non-natural indole alkaloids in plants.

**Week 6:**
Discovery of new alkaloid pathways in plants (strychnine and colchicine).
Terpenoid metabolism and pathway manipulation.

**Week 7:**
Genetic manipulation of carotenoid pathway. Emission biology of terpenoid floral volatiles.

**Week 8:**
Biotechnological intervention for production of complex terpenes viz. hyperforin and taxol.

**Week 9:**
Biochemistry of phenylpropanoid/benzenoid metabolism. Pathway manipulation for reduction of lignin content and composition.

**Week 10:**
Biochemistry and cell biology of anthocyanin formation in flowers.
Manipulation of anthocyanin pathways and creation of blue rose.

**Week 11:**
Biochemistry of tea polyphenols. Biosynthesis of phenolic alcohols and esters.
Pathway manipulation for production of phenolic esters.

**Week 12:**

Metabolic engineering for vanillin biosynthesis. Genetic engineering of shikonin pathway. Molecular pharming for human somatotropin production in transplastomic plants.

**Books and references:**


1. Trease & Evans', Pharmacognosy
2. Buchanan et al. Biochemistry & Molecular Biology of Plants
3. Walton & Brown, Chemicals from Plants
4. Bosher & Tobins, Plant Biochemistry

## Biological Data Analysis and Visualization with R

**Course Duration: 8 weeks**

**Credits: 2**

**PREREQUISITES:** Should be at least at the UG level with knowledge of probability and statistics

**Course layout**

**Week 1:** Introduction and set up for biological data analysis with R

**Week 2:** Basic statistical analysis and data visualization techniques

**Week 3:** Bioconductor packages

**Week 4:** Gene expression analysis and co-expression network

**Week 5:** Analysis of ChIP-seq data in R

**Week 6:** Regression models on biological data

**Week 7:** Dimensionality reduction techniques

**Week 8:** Decision trees and Random Forest

**Books and references:**


1. Introduction to Bioinformatics with R: A Practical Guide for Biologists (Chapman & Hall/CRC Computational Biology Series)

2. R Programming for Bioinformatics (Chapman & Hall/CRC Computer Science & Data Analysis) \

3. A Little Book of R for Bioinformatics 2.0 (brouwern.github.io)

## Experimental Nanobiotechnology

**Course Duration: 4 weeks**

**Credits: 1**

**PREREQUISITES:** Basic knowledge in biology / nanotechnology Or Desirable: NPTEL course on Biomedical nanotechnology

**Course layout**

**Week 1**: Physical method of nanoparticle synthesis: Ball milling, Chemical synthesis of nanoparticles: Gold Nanoparticles, Hydrothermal synthesis of Carbon Dots, Polymeric nanoparticle synthesis (Albumin & PLGA Nanoparticles), Hydrogel fabrication

**Week 2:** Nanoparticle characterization techniques: UV-Vis Spectroscopy, DLS- Hydrodynamic Size & Zeta potential, Fourier transform infrared spectroscopy, Fluorescence Spectroscopy, Electron microscopic analysis

**Week 3:** Biomedical applications: Nanobiosensor, Fabrication of nanofibers using electrospinning, Hemocompatibility test, 3D Bioprinting, In vitro 3D cell culture.

**Week 4:** Nanotoxicology: Antibacterial properties of nanomaterials, In vitro cytotoxicity analysis, Apoptotic studies, In vivo toxicity studies using zebrafish embryo and hydra.

**Books and references**

1.McNeil, S.E., (2011) Characterization of Nanoparticles Intended for Drug Delivery", Humana press

2.Xian, W. (2009). A laboratory course in biomaterials. CRC Press.

3.Micou, Melissa Kurtis, and Dawn Kilkenny. A Laboratory Course in Tissue Engineering. CRC Press, 2016.

4.Bisen, P.S., (2014) "Laboratory Protocols in Applied Life Sciences" , Taylor & Francis Group, LLC

5.Holtzhauer, M., (2006) "Basic Methods for the Biochemical Lab", Springer-Verlag Berlin Heidelberg

## Algorithms in Computational Biology and Sequence Analysis

**Course Duration: 12 weeks**

**Credits: 3**

**PRE-REQUISITES :** Elementary knowledge of discrete mathematics, basic algorithms and data structures is required. Programming proficiency with either C or C++ or Java or Python is required. Knowledge of basic algorithms for sorting, searching, hashing, graph traversal algorithms will be required.

**COURSE PLAN :**

**Week 1:** Introduction

**Week 2:** Strings and exact matching

**Week 3:** Pairwise Sequence Alignment

**Week 4:** Heuristic Sequence Alignment

**Week 5:** Genome reconstruction using graph algorithms

**Week 6:** Evolutionary tree construction

**Week 7:** Sequence models and classification

**Week 8:** Pangenome graphs

**Week 9:** Discussion of research papers

**Week 10:** Discussion of research papers (Contd.)

**Week 11:** Discussion of research papers (Contd.)

**Week 12:** Discussion of research papers (Contd.)

## Biophotonics

**Course Duration: 12 weeks**

**Credits: 3**

**PREREQUISITES :** None but basic knowledge of optical physics will be useful

**Course layout**

**Week 1 :** Introduction of Biophotonics

**Week 2 :** Fundamentals of Light and Matter

**Week 3 :** Basics of Biology

**Week 4 :** Basics of light-matter interactions in molecules, cells and tissues

**Week 5 :** LASERs for Biophotonics

**Week 6 :** Bioimaging: Principles and Applications

**Week 7 :** Optical Biosensors

**Week 8 :** Light Activated Therapy: Photo Thermal and Photo Dynamic Therapy

**Week 9 :** Tissue Engineering with Light

**Week 10 :** Optical Tweezers, Scissors and Traps

**Week 11 :** Nanotechnology for Biophotonics: Nano Bio Photonics

**Week 12 :** Optogenetics & Neurophotonics

**Books and references:**


1. Introduction to Biophotonics, Paras N. Prasad (2003)
2. Biophotonics: Concepts to Applications, Gerd Keiser (2016)
3. Physical Biology of the Cell, Rob Phillips (2012)
4. Fundamentals of Biomedical Optics, Caroline Boudoux (2017)

## Comprehensive Molecular Diagnostics and Advanced Gene Expression Analysis

**Course Duration: 12 weeks**

**Credits: 3**

**Course layout**

**Week 1:** Basic Concepts including Central Dogma in Molecular Biology Definition and Scope of Molecular Diagnostics and Historical Developments Importance and advantages of molecular diagnostics over traditional methods, Nucleic Acid Structure and Function, DNA Replication and Repair, RNA Transcription and Processing, Protein Synthesis from mRNA-Translation

**Week 2:** Tools of Molecular diagnostics and Gene expression Analysis (I) PCR (Polymerase Chain Reaction) Fundamentals, RT PCR and qPCR, Modifications of PCR-Hot start, Touch down, nested PCR, Multiplex, Modifications of PCR 2-Long-range PCR,Single-cell PCR,Fast-cycling PCR, Methylation-specific PCR (MSP), Digital Droplet PCR-modern implications, PCR-based mutation analysis

**Week 3:** Tools of Molecular diagnostics and Gene expression Analysis (II) Principles (Sanger sequencing, Overview of NGS Technologies and Platform, Application of NGS in Molecular Diagnostics, Clinical Interpretation of NGS Data, Whole genome vs Whole exome sequencing, Targeted gene panels, NGS library preparations)

**Week 4:** Tools of Molecular diagnostics and Gene expression Analysis (III) DNA Microarray, FISH (Fluorescence in situ Hybridization), Serial analysis of gene expression, RNA sequencing, Tiling array, DNA protein interaction-chromatin immune precipitation.

**Week 5:** Techniques of Gene Manipulation: RNA interference and detection methods, Recombinant DNA Technology, CrispR-CAS9 technology, Epigenetics and diseases, DNA methylation analysis.

**Week 6:** Proteomics: Clinical Applications Overview of proteomics techniques and workflows, Protein separation techniques-brief discussion of gel electrophoresis and
chromatography, mass spectrometry, label-free and isotope labelling methods, role of metabolomics in laboratory diagnosis.

**Week 7:** Proteomics: Advanced topics in Clinical Proteomics High throughput proteomics like-Shotgun and data independent acquisition (DIA), Single cell proteomics and spatial profiling, methods to detect post translational modification and protein-protein interaction, proteomic data analysis and bioinformatic tools, Luminex multiplex assays and its application in biomarker analysis.

**Week 8:** Molecular Diagnostics in Infectious Diseases Syndromic Panels and Multiplex Assay, Molecular identification of Microorganism- covering bacterial, viral, fungal and parasitic diseases, antimicrobial resistance testing, POC Molecular diagnostics for infectious diseases, Molecular diagnostics in Hospital acquired infections.

**Week 9:** Molecular Diagnostics in Cancer Management Cancer markers, Liquid biopsies in cancer detection, circulating Tumour DNA (ctDNA) analysis, Monitoring treatment response with molecular diagnostics, Molecular diagnostics in targeted therapy, Digital PCR, Molecular diagnostics quality control

**Week 10:** Molecular Diagnostics in Genetic and Inherited Disorders Genetic testing and inherited diseases, Non-Invasive Prenatal testing (NIPT) and reproductive genetics, Molecular diagnostics in rare genetic disorders, Pharmacogenomics and Personalized Medicine, genetic counselling and patient education.

**Week 11:** Molecular Diagnostics in Medicine Molecular diagnostics in Metabolic disease, Molecular diagnostics in Neurodegenerative disease, Molecular diagnostics in Respiratory, Molecular diagnostics in Gastrointestinal disorders, Molecular diagnostics in Endocrine disorders, Molecular diagnostics in Autoimmune disorders, Molecular diagnostics in Cardiovascular diseases, Molecular diagnostics in Transplantation diseases

**Week 12:** Molecular Diagnostics: Quality control and Ethical Concerns in and Futuristic Trends Quality control in molecular diagnostics , Ethical Concerns in Molecular Diagnostics,Microfluidics and Lab-on-chip in molecular diagnostics, AI and ML in molecular diagnostics, Nanotechnology based molecular diagnostics, Single cell Analysis, Integration of Multi-omics Data.

**Books and references:**

1. Molecular Cloning: A Laboratory Manual by David W. Russell and Joseph Sambrook

2. "Molecular Diagnostics: Fundamentals, Methods, & Clinical Applications" by Lela Buckingham and Maribeth L. Flaws

3."PCR (The Basics)" by Michael L. Mader

4. "Real-Time PCR: Advanced Technologies and Applications" by Nick A. Saunders and Martin A. Lee

5. "Next-Generation Sequencing: Translation to Clinical Diagnostics" by Alireza Heravi-Moussavi

6. "Genetic Testing and Molecular Biomarkers" by George P. Patrinos and William B. Coleman

7. "Essentials of Genomic and Personalized Medicine" by Geoffrey S. Ginsburg and Huntington F. Willard

8. "Bioinformatics for Beginners: Genes, Genomes, Molecular Evolution, Databases and Analytical Tools" by Supratim Choudhuri

9. "Genomic Medicine: Principles and Practice" by Dhavendra Kumar

10. "Pharmacogenomics: Challenges and Opportunities in Therapeutic Implementation" by Urs A. Meyer and FolefacAminkeng

11. "Cancer Genomics: From Bench to Personalized Medicine" by Graham Dellaire and Jason N. Berman

12. "Introduction to Genetic Analysis" by Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley

13. "Medical Genetics: A Core Text with Integrated Cases" by Lynn B. Jorde, John C. Carey, Michael J. Bamshad

14. "Molecular Diagnostics: Techniques and Applications for the Clinical Laboratory" by Wayne W. Grody and Robert M. Nakamura

15. "Molecular Pathology in Clinical Practice" by Debra G.B. Leonard

16. "Diagnostic Molecular Pathology: A Guide to Applied Molecular Testing" by William B. Coleman and Gregory J. Tsongalis