CHAITANYA BHARATHI INSTITUTE OF TECHNOLOGY(A),HYDERABAD
DEPARTMENT OF BIOTECHNOLOGY
NPTEL/SWAYAM COURSES FOR HONOURS DEGREE IN BIOTECHNOLOGY

Sl. No	Code	Course Name	Duration	Credits	Link
1	H20BT001	Solid and hazardous Waste Management	15 Weeks	4	https://swayam.gov.in/nd2_cec20_ge34/preview
2	H20BT002	Dairy and Food process and products technology	12 Weeks	3	https://swayam.gov.in/nd1_noc20_ag02/preview
3	H20BT003	Thermal Processing of foods	12 Weeks	3	https://swayam.gov.in/nd1_noc20_ag07/preview
4	H20BT004	Food Safety and Quality Control	8 Weeks	2	https://swayam.gov.in/nd2_cec20_ag06/preview
5	H20BT005	Organic farming for Sustainable Agricultural Production	8 Weeks	2	https://swayam.gov.in/nd1_noc20_ag05/preview
6	H20BT006	Introduction To Mechanobiology	8 Weeks	2	https://swayam.gov.in/nd1_noc20_bt27/preview
7	H20BT007	Biomedical Nanotechnology	4 Weeks	1	https://swayam.gov.in/nd1_noc20_bt29/preview
8	H20BT008	Biomicrofluidics	4 Weeks	1	https://swayam.gov.in/nd1_noc20_bt22/preview
9	H20BT009	Fundamentals of Micro And Nanofabrication	12 Weeks	3	https://swayam.gov.in/nd1_noc20_bt37/preview
10	H20BT010	Industrial pharmacy I	12 Weeks	3	https://swayam.gov.in/nd2_cec20_lb05/preview
11	H20BT011	Mechanical Unit Operations	12 Weeks	3	https://swayam.gov.in/nd1_noc20_ch27/preview
12	H20BT012	Nanotechnology In Agriculture	8 Weeks	2	https://swayam.gov.in/nd1_noc20_bt41/preview
13	H20BT013	Introduction to Biomaterials (being offered as professional elective in regular curriculum)	8 Weeks	2	https://nptel.ac.in/content/syllabus_pdf/113104009.pdf
14	H20BT014	Wildlife Conservation	8 Weeks	2	https://swayam.gov.in/nd1_noc20_bt39/preview
15	H20BT015	Computational systems Biology	12 Weeks	3	https://nptel.ac.in/content/syllabus_pdf/102106068.pdf

16	H20BT016	Drug Delivery: Principles And Engineering	12 Weeks	3	https://swayam.gov.in/nd1_noc20_bt24/preview
17	H20BT017	Introduction To Proteogenomics	12 Weeks	3	https://swayam.gov.in/nd1_noc20_bt19/preview
18	H20BT018	Patent Law for Engineers and Scientists	12 Weeks	3	https://swayam.gov.in/nd1_noc20_hs55/preview
19	H20BT019	Computer Aided Drug Design	8 Weeks	2	https://swayam.gov.in/nd1_noc20_bt23/preview
20	H20BT020	Introduction To Proteomics (being offered as professional elective in regular curriculum)	8 Weeks	2	https://swayam.gov.in/nd1_noc20_bt20/preview
21	H20BT021	Introduction to cell culture Technology	8 Weeks	2	https://nptel.ac.in/courses/102/104/102104059/
22	H21BT022	Maternal Infant Young Child Nutrition	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt01/preview
23	H21BT023	Optical Spectroscopy and Microscopy: Fundamentals of optical measurements and instrumentation	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt05/preview
24	H21BT024	Human Molecular Genetics	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc22_bt07/preview
25	H21BT025	Demystifying The Brain	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc22_bt14/preview
26	H21BT026	Medical Biomaterials	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_bt15/preview
27	H21BT027	Forests And Their Management	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt24/preview
28	H21BT028	Bioelectrochemistry	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc22_bt26/preview
29	H21BT029	Plant Developmental Biology	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc22_bt27/preview
30	H21BT030	Conservation Economics	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt31/preview
31	H21BT031	Soft Nano Technology	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_ch11/preview
32	H21BT032	Understanding Design	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc22_de01/preview

33	H21BT033	Design, Technology and Innovation	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_de05/preview
34	H21BT034	Emotional Intelligence	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_hs11/preview
35	H21BT035	Exploring Survey Data on Health Care	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_hs40/preview
36	H21BT036	Material and Energy Balances	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt04/preview
37	H21BT037	Bioreactor Design and Analysis	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_bt19/preview
38	H21BT038	Waste to Energy Conversion	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_ch05/preview
39	H21BT039	Physico-chemical processes for wastewater treatment	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ch25/preview
40	H21BT040	Renewable Energy Engineering: Solar, Wind and Biomass Energy Systems	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ch27/preview
41	H21BT041	Biomass Conversion and Biorefinery	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ch28/preview
42	H21BT042	Environmental Quality Monitoring & Analysis	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ch33/preview
43	H21BT043	Bio photonics	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ee59/preview
44	H21BT044	Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_ge06/preview
45	H21BT045	Interactomics: Basics & Applications	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt11/preview
46	H21BT046	Data Analysis for Biologists	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_bt20/preview
47	H21BT047	Structural Biology	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc22_bt28/preview
48	H21BT048	Biointerface Engineering	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc22_bt21/preview
49	H21BT049	Introduction to Dynamical Models in Biology	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc 21_bt42/preview

50	H21BT050	Conservation Geography	12 Weeks	2	https://onlinecourses.nptel.ac.in/noc21_bt44/preview
51	H21BT051	Wildlife Ecology	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc 21_bt45/preview
52	H21BT052	Organic Chemistry in Biology and Drug Development	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc 21_cy30/preview
53	H21BT053	Legal and Regulatory Issues in Biotechnology	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc 21_lw04/preview
54	H21BT054	Nanomaterials and their Properties	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc21_mm38/preview
55	H21BT055	Ecology and Environment	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc 21_ge16/preview
56	H21BT056	Bioreactors	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc21_bt28/preview
57	H21BT057	Transport Phenomena in Biological Systems	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc 21_bt40/preview
58	H21BT058	Technologies For Clean And Renewable Energy Production	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc 21_ch42/preview
59	H21BT059	Principles and Practices of Process Equipment and Plant Design	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc 21_ch52/preview
60	H21BT060	Introduction to Biomedical Imaging Systems	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc 21_bt50/preview
61	H21BT061	Biomechanics of Joints and Orthopaedic Implants	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc 21_me130/preview
62	H21BT062	Neuroscience of Human Movements	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc21_ge17/preview
63	H21BT063	Current regulatory requirements for conducting clinical trials in India for investigational new drugs/new drug (Version 3.0)	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc 21_ge25/preview
64	H21BT064	Functional Genomics	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc21_bt39/preview
65	H21BT065	Aspects of Biochemical Engineering	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc21_bt17/preview
66	H21BT066	RNA Biology	12 Weeks	3	https://nptel.ac.in/courses/102106097

67	H21BT067	Biomechanics	12 Weeks	3	https://nptel.ac.in/courses/102106098
68	H21BT068	Enzyme Sciences and Technology	12 Weeks	3	https://nptel.ac.in/courses/102103097
69	H21BT069	Metabolic Engineering	8 Weeks	2	https://nptel.ac.in/courses/102105086
70	H21BT070	Introduction to Professional Scientific Communication	4 Weeks	1	https://nptel.ac.in/courses/102104061
71	H21BT071	Bioengineering: An Interface with Biology and Medicine	8 Weeks	2	https://nptel.ac.in/courses/102101068
72	H24BT072	Environmental Biotechnology (being offered as Elective in our R20 curriculum)	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt60/preview
73	H24BT073	Industrial Biotechnology (being offered as Elective in our R20 curriculum)	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt61/preview
74	H24BT074	Introduction To Biostatistics	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc23_bt58/preview
75	H24BT075	Medical Image Analysis	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt40/preview
76	H24BT076	Introduction To Developmental Biology (being offered as Elective in our R20 curriculum)	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt43/preview
77	H24BT077	Tissue Engineering (being offered as Elective in our R20 curriculum)	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc23_bt46/preview
78	H24BT078	Organ Printing	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc23_bt49/preview
79	H24BT079	Genome Editing And Engineering	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt51/preview
80	H24BT080	Next Generation Sequencing Technologies : Data Analysis And Applications	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt34/preview
81	H24BT081	Computational Neuroscience	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc23_bt64/preview
82	H24BT082	Neurobiology	4 weeks	1	https://onlinecourses.nptel.ac.in/noc23_bt65/preview

83	H24BT083	Neural Science for Engineers	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_ee01/preview
84	H24BT084	Classics in Neuroscience	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc24_bt38/preview
85	H24BT085	Human Behaviour	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc24_hs35/preview
86	H24BT086	Microsensors, Implantable Devices and Rodent Surgeries for Biomedical Applications	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_bt37/preview
87	H24BT087	Education for Sustainable Development	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_hs04/preview
88	H24BT088	Advances in Omics	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc24_bt42/preview
89	H24BT089	Statistics for Biomedical Engineers	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_bt70/preview
90	H24BT090	Design for Biosecurity	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_bt77/preview
91	H24BT091	Advanced Fluorescence Microscopy and Image Processing	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc25_bt01/preview
92	H24BT092	Computational Genomics	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc25_bt13/preview
93	H24BT093	Microbial Biotechnology	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc25_bt33/preview
94	H24BT094	Optical Spectroscopy and Microscopy : Fundamentals of Optical Measurements and Instrumentation	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc25_bt37/preview
95	H24BT095	Biological Data Analysis and Visualization with R	8 Weeks	2	https://onlinecourses.nptel.ac.in/noc25_bt43/preview
96	H24BT096	Experimental Nanobiotechnology	4 Weeks	1	https://onlinecourses.nptel.ac.in/noc25_bt44/preview
97	H24BT097	Algorithms in Computational Biology and Sequence Analysis	12 Weeks	3	https://nptel.ac.in/courses/106108571
98	H24BT098	Biophotonics	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_ge11/preview

99	H24BT099	Comprehensive Molecular Diagnostics and Advanced Gene Expression Analysis	12 Weeks	3	https://onlinecourses.nptel.ac.in/noc24_ge36/preview
100	H24BT100	Cellular Biophysics: A Framework For Quantitative Biology	8 weeks	2	https://onlinecourses.nptel.ac.in/noc22_bt32/preview
101	H25BT101	Engineering Aspects of Biofuels and Biomass Conversion Technologies	12	3	https://onlinecourses.nptel.ac.in/noc25_ch92/preview
102	H25BT102	Biomedical Instrumentation	12	3	https://onlinecourses.nptel.ac.in/noc25_bt49/preview
103	H25BT103	Drug delivery principles and engineering	12	3	https://onlinecourses.nptel.ac.in/noc25_bt55/preview
104	H25BT104	Regeneration Biology	12	3	Regeneration Biology - Course
105	H25BT105	Artificial Intelligence in Drug Discovery and Development	12	3	https://onlinecourses.nptel.ac.in/noc25_ch96/preview
106	H25BT106	Fundamentals of Cryo-Electron Microscopy (Cryo-EM) and 3D Image Processing in Structural Biology	12	3	https://onlinecourses.nptel.ac.in/noc25_bt47/preview
107	H25BT107	An Introduction to Evolutionary Biology	12	3	https://onlinecourses.nptel.ac.in/noc25_bt87/preview
108	H25BT108	Cell Signaling	8	2	https://onlinecourses.nptel.ac.in/noc25_bt88/preview

Solid and hazardous Waste Management

Duration: 15 weeks
Credits: 4

Course layout

Week 01
01. Waste- Types and classification
02. Waste sources and generation rates
03. Traditional methods of waste collection and disposal

Week 02
04. Factors influencing waste generation and health hazards
05. Waste composition
06. Waste collection - I

Week 03
07. Waste collection - II
08. Characterization of wastes

Week 04
09. Waste processing : Size and volume reduction
10. Waste minimization, waste hierarchy and waste audit

Week 05
11. Recycling of solid wastes
12. Hazardous waste- Definition, sources, classification, collection and segregation
13. Hazardous waste characterization, treatment and disposal

Week 06
14. Radioactive waste-I
15. Radioactive waste-II

Week 07
16. e waste
17. Plastic waste

Week 08
18. Biomedical waste- I
19. Biomedical waste-II
20. Biomedical waste management rules, 2016

Week 09
21. Composting
22. Vermicomposting
23. Biogas production from solid waste

Week 10
24. Thermal treatment of solid waste – Incineration
25. Thermal treatment of solid waste – Pyrolysis and gasification

Week 11
26. Solid waste disposal – Sanitary landfilling- I
27. Solid waste disposal – Sanitary landfilling- II

Week 12
28. Landfill leachate and gas management
29. Landfill bioreactors
30. Fly ash- Generation and management
31. Fly ash management
32. Noti/Solid waste management rules, 2016
33. Hazardous and other waste (management and transboundary movement) amendment rules, 2016
34. Plastic waste management rules, 2016

Week 14
35. e waste management rules, 2016
36. Basel Convention on the control of transboundary movement of hazardous waste and their disposal
37. Mechanical biological treatment of solid wastes

Week 15
38. Solid waste management in rural areas
39. Swachh Bharat Abhiyan
40. Recent advances in solid waste management

Dairy and Food process and products technology

Duration: 12 weeks
Credits: 3

Course layout

Week 1 : Basic principles and methods of food processing and preservation. EmergingTechnologies in food processing. Food additives and preservatives.

Week 2 : Food lawsand standards. Effect of processing on acceptability and nutritive value offood.

Week 3 : Physico-chemical properties and structure of milk and milk constituents.

Week 4 : Chemical and microbial spoilage of milk and milk products; Fluid milkProcessing, packaging and distribution.

Week 5 : Common dairy processes – creamseparation (standardization),pasteurization, sterilization andHomogenization.

Week 6 : Process technology for manufacture of evaporated milk, condensedmilk, dried milk, malted milk, infant and baby foods, ice-cream, cheese, butter,fermented milk and indigenous dairy products.

Week 7 : Methods and procedures forsampling and testing of milk and milk products. Laws and standards for milk andmilk products.

Week 8 : Technological processes for industrially manufactured foods of commercial importance, from plant and animal origin.

Week 9 : Cereals, vegetables,fruits, meats, poultry and egg products; Bakery, pasta and confectionaryproducts, ready to eat foods, fermented foods, alcoholic and non- alcoholicBeverages, tea, coffee and cocoa, fabricated foods.

Week 10 : Packaging materials;Characteristics, properties and their design. Packaging requirement forDifferent processed and unprocessed foods.

Week 11 : Working Principles of various typeof fillers : form-fill- seal machine.

Week 12 : Gas packaging and modified atmospherePackage design. Shelf life prediction of foods in packages. Quality control inFood packaging. Product safety and packaging regulations.

Books and references

Nil

Thermal Processing of foods

Duration: 12 weeks
Credits: 3

Course layout

Week 1 :Food microbiology: microbial growth and concerns in various foods, Blanching, Pasteurization, Ultra-pasteurization, Hot fill and UHT

Week 2 :Thermal processing equipment, Milk pasteurization, Canning operations

Week 3 :Temperature distribution and heat penetration, Kinetics of reactions, F value and process requirements

Week 4 :Quality considerations and process optimization, Shelf life studies, Validation of heat processes

Week 5 :Fundamentals of aseptic processing, Aseptic equipment design, Aseptic process design

Week 6 :Microwave and radio frequency heating, Ohmic heating, Overview of non-thermal processing technologies

Week 7 :Advanced separation processes, High pressure, dialysis, ultrafiltration and reverse osmosis, Nanofiltration, electro dialysis and membrane separation

Week 8 :Various types of heat exchangers for food process engineering, Various types of driers for food process engineering

Week 9 : Importance and applications of extrusion technology in food processing, Changes of properties and functional components of extruded foods

Week 10: Food biosensors, Types of functional foods: Probiotics and nutraceuticals

Week 11: Packaging considerations: Barrier and mechanical properties of different food packaging materials, Biocomposite/bionanocomposite materials for food packaging applications

Week 12: Sanitary components and requirements, Regulatory considerations

Books and references

1. Chan, E. C. S., Pelczar, M. J., Jr. Krieg N. R. 2010. Microbiology. 5th edition. Tata McGraw Hill, Delhi.
2. Banwart, G.J. 1989. Basic Food Microbiology. 2nd edition. Chapman & Hall, New York.
3. Meyer, L.H. 2004. Food Chemistry. 1st edition. CBS Publishers & Distributors, Delhi.
4. McCabe, W. L., Smith J., Harriot P. 2014. Unit Operations of Chemical Engineering. 7th edition. McGraw - Hill, International.
5. Nelson, P.E. (Editor). 2010. Principles of Aseptic Processing and Packaging. 3rd edition. Purdue university press.
6. Sun, D. (Editor). 2005. Emerging Technologies for Food Processing. Elsevier Academic Press.
7. Metaxas, A.C., Meridith, R.J. 1993. Industrial Microwave Heating. Peter Pergrinus Ltd., London.
8. Soroka, W. 1999. Fundamentals of Packaging Technology. Institute of Packaging Professionals.
9. Curtis, P.A. 2005. Guide to food laws regulations. Blackwell Publishing.

Food Safety and Quality Control

Duration: 12 weeks
Credits: 3

Course layout

Week 1 | Assignments (No. & Type)*

1. Food supplementation, substitution, fortification and enrichment
2. Importance of the costing of the Product
3. Quality control and Internal control in Food Industry
4. Sensory evaluation of food samples and container evolution

Week 2 | Assignments (No. & Type)*

1. Food Analysis
2. Waste control and sanitation Government regulations for quality standards
3. Food Standards
4. Primary Sources of Microorganisms in Food

Week 3 | Assignments (No. & Type)*

1. Fundamentals of control of microorganisms in foods
2. Food borne infections
3. Transmission of food borne infections
4. Microbes used in food biotechnology

Week 4 | Assignments (No. & Type)*

1. Importance of sanitation and hygiene in food
2. Bacteriological analysis of food
3. Bacteriological analysis of water and milk
4. Morphological identification of molds and yeasts in foods

Week 5 | Assignments (No. & Type)*

1. Sampling to study the source of transmission of microorganisms in foods
2. Laws governing food service establishments
3. Laws concerning hygiene and safety
4. Hygiene, sanitation and safety of quantity food production

Week 6 | Assignments (No. & Type)*

1. Determinants of Health
2. Role of agricultural production in food availability and consumption
3. Post harvest handling, Marketing and Distribution of Foods
4. Food Adulteration

Week 7 Assignments (No. & Type)*

1. Water pollution and its effects on food quality
2. Industrial effluents and their impact on food quality, Pesticide residues in foods
3. Food cost control in catering business
4. Recording and Reporting control charts Production control

Week 8 Assignments (No. & Type)*

1. Menu planning, purchasing and storage of food for quantity food production
2. Acquisition of resources and organization

Books and references

♣ Bhatti,S1995.Vame, Fruit and vegetable processing. CBS Publishers, Distributors, NewDelhi.

♣ Coles, R., McDowell, D., Kirwan, M .J. 2003. Food Packaging Technology. Blackwell Publishing Co.

♣ Dauthy, M. E. 1995. Fruits and Vegetables Processing- FAO Bulletin 119. International Book Distributing Co., Lucknow.

♣ Devendra, K. B. and Priyanka, T. 2006. An Introduction to Food Science and technology and Quality Management. Kalyani Publishers 81-272-2521-5.

♣ FAO - Training Manual No.17/2. 2007. Prevention of post-harvest food losses: Fruits, Vegetables and Root crops. Daya Publishing House, Delhi.

♣ Fellows, P. J. 1998. Food Processing Technology – principles and Practices. Ellis Horwood.

♣ Girdhari Lal, G.S. Siddappa and G.L. Tandon. 1959. Preservation of Fruits and Vegetables. ICAR, New Delhi.

♣ Girdharilal, Siddappa,G. S.andTandon, G. L.1998. Preservation of fruits and vegetables. ICAR, NewDelhi.

♣ Gordon L. Robertson. 2014. Food Packaging: Principles and Practice, 3rd Ed. CRC Press, Boca Raton, FL, USA.

♣ Gosby, N.T. 2001. Food Packaging Materials. Applied Science Publication

♣ James G. Brennan. 2006. Food Processing Handbook. Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany.

♣ John, P.J. 2008. A Handbook on Food Packaging Narendra Publishing House,

♣ Kalia, M. and Sood, S. 2010. Food Preservation and Processing. Revised Edition, Kalyani Publishers, New Delhi.

♣ KaysandStanely,J.1998. Postharvest physiology of perishable plant products. CBS Publishers, Distributors, New Delhi

♣ Mahadevia, M., Gowramma, R.V. 2007. Food Packaging Materials. Tata McGraw Hill

♣ Manoranjan, K. and Sangita, S. 1996. Food Preservation and Processing. Kalyani Publishers 978-81-272-4262-6.

♣ Monoranjam, K. and Sangita, S. 2008. Food Preservation and Processing. Kalyani Publishers 978-81-272-4262-6.

♣ P. Fellows. 2000. Food Processing Technology: Principles and Practice, 2nd Ed. CRC Press, Boca Raton, FL, USA.

♣ Robertson, G. L. 2001. Food Packaging and Shelf life: A Practical Guide. Narendra Publishing House.

♣ Robertson, G. L. 2005. Food Packaging: Principles and Practice. Second Edition. Taylor and Francis Pub.

♣ S. Rajarathnam and R.S. Ramteke, 2011.Advances in preservation and processing technologies of fruits and vegetables.

♣ Salunkhe, D.K., Bolin, H. R. and Reddy, N. R. 1991. Storage, Processing and Nutritional Quality of Fruits and Vegetables. 2nd Edition. Vol. II. CRC Press 0849356245

♣ Siddappaa, G. S., Girdhari Lal and Tandon, G.L. 1998. Preservation of Fruits and Vegetables. ICAR, New Delhi

♣ Sivasankar, B. 2002. Food Processing and Preservation. PHI Learning Pvt. Ltd. Delhi

♣ Srilakshmi. 2010. Food Science. New age International 978-81-224-2724-0.

♣ Srivastava, R. P. & Sanjeev Kumar. 2002. Fruits and vegetable Preservation – Principles and Practice. International Book Distributing Co., Lucknow.

♣ Swaminathan, M. 1988. Hand book of Food Science & Experimental Foods. Bappco publishers, Bangalore

♣ U.D. Chavan and J.V. Patil. 2013. Industrial Processing of fruits and vegetables. Astral International Pvt Ltd. New Delhi.

Vijay, K. 2001. Text Book of Food Sciences and Technology. ICAR, New Delhi.

Organic farming for Sustainable Agricultural Production

Duration: 8 weeks
Credits: 2

Course layout

Week 1 : Organic Farming: Concepts and principles of organic farming

Week 2 : Key indicators of sustainable agriculture, organic farming and climate change

Week 3 : Input management; compost production, vermicomposting, Compost quality, Compost utilization and marketing

Week 4 : Organic crop management: field crops, horticulture and plantation crops

Week 5 : Plant protection measures, biopesticides, natural predators, cultural practice

Week 6 : Rotation design for organic system, Transition to organic agriculture, farming system

Week 7 : Quality analysis of organic foods, Antioxidants and their natural source, organic food and human health

Week 8 : Standards of organic food and marketing

Books and references

Nil

Introduction to Mechanobiology

Duration: 8 weeks
Credits: 2

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).

Biomedical Nanotechnology

Duration: 4 weeks
Credits: 1

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).

Biomicrofluidics

Duration: 4 weeks
Credits: 1

Course layout

Week 1 : **I**ntroduction to Biomicrofluidics
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 Electrokinetics

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

Fundamentals of Micro and Nanofabrication

Duration: 12 weeks
Credits: 3

Course layout

Week 1: Introduction to micro-fabrication
Week 2: Substrate
Week 3: Cleaning
Week 4: Additive processing: Doping
Week 5: Additive processing: Native Films
Week 6: Additive processing: CVD
Week 7: Additive processing: PVD
Week 8: Lithography 1
Week 9: Lithography 2
Week 10: Subtractive Process: Wet Etching
Week 11: Subtractive Process: Dry Etching
Week 12: CMP and Packaging

Books and references:

1. The Science and Engineering of Microelectronic Fabrication by Stephen A. Campbell

2. VLSI Fabrication Principles: Silicon and Gallium Arsenide by Sorab K. Gandhi

3. Introduction to Microelectronic Fabrication by Richard C. Jaeger

4. Materials Science of Thin Films by Milton Ohring

5. Fundamentals of Microfabrication and Nanotechnology, by Marc J. Madou

6. Fundamental Principles of Optical Lithography by Chris Mack

7. Electronic Materials by Prof. Dr. Helmut Föll

Industrial pharmacy I

Duration: 12 weeks
Credits: 3

Course layout

WEEK: 12
MODULES 40

Week 1 Preformulation I

Preformulation I: Physical form (crystal & amorphous),
Preformulation I: polymorphism, particle size, shape
Preformulation I:, solubility profile (pKa, pH)
Preformulation I: Partition coefficient, flow properties

Week 2 Preformulation II

Preformulation II: Hydrolysis, oxidation, reduction
Preformulation II: Racemisation,
Preformulation II: Dissolution, permeability & BCS classification
Preformulation II: Polymerization

Week 3 Tablets

Tablets: Introduction, classification of tablets. Formulation/preparing of tablets, granulation methods.
Tablets: Compression and processing problems. Equipment and tablet tooling, Tablet defects.
Tablets: Tablet coating: Types, coating materials, formulation of coating composition, Methods of coating, equipment's employed and defects in coating
Tablets: QC of tablets: apparatus, methods, graphical presentations, official and unofficial tests.

Week 4 Liquid Orals

Liquid orals: Formulation and manufacturing of solution, syrups and elixirs, Filling and packaging
Liquid orals: Emulsions: I
Liquid orals: Emulsion II
Liquid orals: Suspensions: Formulation, evaluation

Week 5 Parenterals I

Parenterals I: Introduction, Preformulation of parenterals
Parenterals I: Formulation of Parenterals

Week 6 Parenterals I

Parenterals I: Types of Parenteral preparation
Parenterals I: Lay out and Production facilities

Week 7 Parenterals II

Parenterals II: Pyrogens and pyrogenisity
Parenterals II: Quality control of parenterals

Week 8 Capsules

Capsules: Introduction, Advantages, Disadvantages, Capsule Production, hard Gelatin capsules
Capsules: Methods of filling capsules, Soft Gelatin Capsules
Capsules: Formulation Consideration, Production of soft gelatin capsules, Non-gelatin soft capsules
Capsules: Evaluation of commercial capsules

Week 9 Pellets and Ophthalmic Preparations

Pellets: Introduction, formulation, pelletization process, equipment needed
Ophthalmic Preparations: Introduction, absorption through eye, formulation considerations
Ophthalmic Preparations: formulation of eye drops, lotion, ointments
Ophthalmic Preparations: Methods of preparation; labeling, containers Evaluation

Week 10 Pharmaceutical Aerosols

Pharmaceutical Aerosols: Definitions, Advantages, Limitation, Uses
Pharmaceutical Aerosols: Components of aerosols
Pharmaceutical Aerosols: Components and systems of aerosols
Pharmaceutical Aerosols: inhalers and Evaluation of Aerosols

Week 11 Cosmetics

Cosmetics: Introduction, absorption through skin, types of cosmetic preparations, Formulation of tooth pastes
Cosmetics: Formulation of lipsticks, shampoos, hair dyes
Cosmetics: Formulation of cold cream and vanishing cream, sunscreens

Week 12 Packaging Materials Science

Packaging Materials Science: Materials used for packaging of pharmaceutical products,
Packaging Materials Science: Factors influencing choice of containers Legal and official requirements, Stability aspects,
Packaging Materials Science: Quality control tests of packaging materials

Books and references:

- IP/USP/BP
- Semalty et al. Essentials of Pharmaceutical Technology, II edn 2018, reprint 2019, Pharma med Press, Hyderabad
- Niazi SK, Handbook of Preformulation, Informa Health Care, 2007
- Aulton ME (ED), Pharmaceutics: The science of Dosage form design, II edn, Churchill Livingstone, London, 2002.
- Banker GS & Rhodes T, Modern Pharmaceutics, CRC Press.
- Lachman L/Lieberman HA, Kanig JL, The Theory And Practice Of Industrial Pharmacy,4E (2013).
- Qiu Y, Chang Y and Zhang GZ (Exe. Eds), Developing solid oral dosage forms: Pharmaceutical theory and practice, Elsevier, 2009.
- Gibson M. (Ed), Pharmaceutical preformulation and formulation: a practical guide from candidate drug selection to commercial dosage form, II edn, Informa Healthcare.
- Qiu Y, Chang Y and Zhang GZ (Exe. Eds), Developing solid oral dosage forms: Pharmaceutical theory and practice, Elsevier, 2009
- Dressman JB, Karmer J, Pharmaceutical Dissolution Testing, 2005, Taylor & Francis, NY.
- Ansel's Pharmaceutical Dosage Forms and Drug Delivery Systems. Philadelphia: Lipincott Williams and Wilkins.
- Augsburger LL, Hoag SW (Eds), Pharmaceutical Dosage Forms: Tablets, Volume 1, III Edn, Informa healthcare, 2008

Mechanical Unit Operations

Duration: 12 weeks
Credits: 3

Course layout

Week 1: Introduction of Particulate Sizes and Shapes

Week 2: Screening

Week 3: Size Reduction

Week 4: Storage and Conveying of Bulk Solids

Week 5: Size Enlargement

Week 6: Flow past Bluff Bodies

Week 7: Flow Through Packed and Fluidized Beds

Week 8: Filtration

Week 9: Cross Flow Filtration and Membrane Separations

Week 10: Gravity Sedimentation Processes

Week 11: Centrifugal Separations

Week 12: Floatation

Books and references:

1. E. Ortega-Rivas, Unit Operations of Particulate Solids: Theory and Practice, CRC Press, FL, 2012.
2. W.L. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw Hill, 2005.
3. J.F. Richardson, J.J. Harker, Coulson and Richardson's Chemical Engineering, 2nd Volume, 5th Edition, Butterworth-Heinemann, 2003.

Nanotechnology in Agriculture

Course Duration: 8 weeks

Credits: 2

Course layout

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

Introduction to Biomaterials (being offered as professional elective in regular curriculum)

Course Duration: 8 weeks

Credits: 2

Course layout

Week 1:
Introduction to Biomaterials Background history, Properties (Mechanical and Physico-Chemical)

Week 2:
Mechanical properties resorb ability, biodegradation Resorbability, biodegradation Biofilm

Week 3:
Biofilm (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 (metals – properties

Week 6:
Metals - properties (metals Polymers-types, classifications, applications Polymers Polymers

Week 7:
Blends/composites Biopolymers Hydrogels Preparation of different morphologies with experiments) Surface modifications with experiments)

Week8:
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.

References:

1. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratner, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004.
2. Comprehensive structural integrity, Vol.9: Bioengineering Editors: Mithe, Ritchie and Karihalo, Elsevier Academic Press, 2003.

Additional Reading:

1. Biomaterials Science and Biocompatability, Fredrick H. Silver and David L. Christiansen, Piscataway, Springer, New Jersey.
2. Biological Performance of Materials: Fundamentals of Biocompatibility, Janathan Black, Marcel Dekker, Inc., New York and Basel, 1981.
3. Basic Cell Culture: A Practical Approach, Edited by J.M. Davis, IRL Press, Oxford University Pres, New York, 1994.

Wildlife Conservation

Course Duration: 8 weeks

Credits: 2

Course layout

Week 1: Introduction, Importance, Threats

Week 2: Monitoring wild animals

Week 3: Monitoring & managing habitats

Week 4: Management of wildlife diseases

Week 5: Capturing and restraining wild animals

Week 6: Conservation genetics

Week 7: Ex-situ conservation

Week 8: Management of changes

Books and references

1. Pullin, A.S., Conservation Biology. 2002: Cambridge University Press.

2. Van Dyke, F., Conservation Biology: Foundations, Concepts, Applications. 2008: Springer Netherlands.

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

Computational Systems Biology

Course Duration: 12 weeks

Credits: 3

Course layout

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

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.

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

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.

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.

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

Introduction to cell culture Technology

Duration: 8 weeks
Credits: 2

Course layout

Week 1:
Introduction & biology of cultured cells

Week 2:
Equipments, aseptic techniques, safety protocols

Week 3:
Culture vessels & media development

Week 4:
Serum-free medium development & sterilization

Week 5:
Primary culture, secondary culture, cloning & selection

Week 6:
Cell separation, characterization, differentiation & transformation

Week 7:
Contamination, cryo-preservation & cyto-toxicity

Week 8:
Organo-typic culture & specialized cell culture techniques

BOOKS AND REFERENCES: NIL

Maternal Infant Young Child Nutrition

Course Duration: 12 Weeks
Credits: 3

Course layout

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

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

Human Molecular Genetics

Course Duration: 4 Weeks

Credits: 1

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Bioelectrochemistry

Course Duration: 4 weeks

Credits: 1

Course layout

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

Course layout

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.
1. 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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

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

Introduction to Environmental Engineering and Science – Fundamental and Sustainability Concepts

Course Duration: 12 weeks

Credits: 3

Course layout

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

Interactomics: Basics & Applications

Course Duration: 12 weeks
Credits: 3

Course layout

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

Course layout

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/

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

Course layout

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

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.

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:

2. 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.

3. 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.

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.

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.

Aspects of Biochemical Engineering

Course Duration: 12 weeks

Credits: 3

PRE-REQUISITES: Mathematics in 10+2

Course layout

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

RNA Biology

Course Duration: 12 weeks

Credits: 3

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

Course layout

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

Course layout

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

Course layout

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

Course layout

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

Introduction to Professional Scientific Communication

Course Duration: 4 weeks

Credits: 1

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

Course layout

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

Course layout

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

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, 6th 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.

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

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

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

Engineering Aspects of Biofuels and Biomass Conversion Technologies

Course Duration: 12 weeks

Credits: 3

Course layout

Week 1:

- Introduction to biofuels and biomass conversion technologies
- Problems arising due to waste biomass and agro residues
- Need for biorenewable energy and biofuels
- Economic and innovation opportunities
- Government policies and sustainable development goals
- Waste to Wealth

Week 2:

- Different types of biomasses and their categorization
- Biomass worldwide production and in India
- History of biofuels and biomass conversion technologies
- Different generations of biofuels
- Introduction to high-temperature conversion technologies
- Brief on thermochemical conversion of biomasses

Week 3:

- Briquetting of biomass: Different processes and equipment
- Development of block flow diagram for briquetting of biomass
- Process flow diagram development for briquetting plant
- Fume exhaust system, pressing systems for briquetting
- Biomass pelletizers
- The difference between briquets and pellets and their burning

Week 4:

- Gasifier stove: Household and commercial
- Types of commercial gasifier stove
- Components and accessories of commercial gasifier stove
- Types of household gasifier stove
- Operation of household gasifier stove
- Factors affecting gasifier stove

Week 5:

- Large-scale industrial gasifiers and theory
- Process flow diagram development for gasification plant
- Gasifier operating and design parameters
- Gasifier classification and design, Commercial Gasifiers
- Rule of thumb for gasifier selection
- Detailed parameters for gasifier selection

Week 6:

- Pyrolysis of biomass
- Types of pyrolysis processes
- Bio-oil, syngas, and bio-coal production
- Process flow diagram development for different pyrolyzers
- Bio-oil upgradation

Week 7:

- Introduction to low-temperature conversion technologies
- High-value chemical production from biomass
- Catalytic processes for biomass conversion
- Fuel additives, artificial sweeteners, and biopolymers production
- Green gasoline, green diesel, and sustainable aviation fuel additives production

Week 8:

- Biochemical conversion of biomass
- High-value chemical production via biochemical route
- Basics of 1G and 1.5G ethanol production & economics
- Process flow diagram development for bioethanol production
- Development of auxiliary units for separation and purification of ethanol
- By-products utilization

Week 9:

- Biogas production from biomass
- Aerobic and anaerobic digestion
- Block flow diagram and process of anaerobic digestion
- Digesters and factors affecting its performance
- Standard testing in a biogas plant

Week 10:

- Equipment of biogas plant
- Operation and maintenance of the biogas plant
- Control philosophy and safety aspects of biogas plant
- Biogas enrichment and handling system
- CO_2 capture and conversion

Week 11:

- Algal biomass
- Types, sources, and generation
- Algal biomass conversion technologies
- Fuel production from algal biomass
- Chemicals production from algal biomass

Week 12:

- Non-edible oil: availability and opportunities
- Non-edible oil to fuel
- Non-edible oil to sustainable aviation fuel
- Non-edible oil to bio-lubricants and polymer precursor
- Used and discarded cooking oil to fuels and chemicals

Books and references

1. Wertz, J-L. and Béduéand, O. (2013). Lignocellulosic Biorefineries, EPFL and CRC Press
2. Bhaskar, T., Pandey, A., Venkata Mohan, S., Lee, D.-J., Khanal, S. K. (2018). Waste Biorefinery: Potential and Perspectives, Elsevier

K.K. Pant, Sanjay Gupta, Ejaz Ahmad "Catalysis for Clean Energy and Environmental Sustainability Volume-I, Biomass Conversion and Biorefinery" Springer Nature https://doi.org/10.1007/978-3-030-65017-9

Biomedical Instrumentation

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: Basic Electrical Engg, Basic principles of sensing, measurement and transduction

INDUSTRY SUPPORT: Medical Devices and MedTech industry

COURSE LAYOUT

Week 1:
INTRODUCTION TO MEASUREMENTS & SIGNAL PROCESSING
Introduction to measurements – Sensors & Transducers, Generalized measurement system- Characteristics of Measurement system, Overview of amplifiers - Gain, bandwidth, input impedance, output impedance. Overview of signal processing - Filtering techniques (low-pass, high-pass,
band-pass, notch filters), Noise sources, and reduction techniques.

Week 2:
BASIC SENSOR TYPES AND MOTION MEASUREMENT
Overview of Basic sensor types and their principles- Resistive: Strain gauges, thermistors, Capacitive: Pressure & displacement sensors, Inductive: LVDT, eddy current sensors, Piezoelectric: Force & vibration sensors, Hall Effect: Magnetic field sensors. Measurement of Linear and Rotational movements

Week 3:
PHYSIOLOGICAL MEASUREMENTS PART 1: FORCE, AND TEMPERATURE
Measurement of Force & Torque -Load cells, strain gauge based sensors - Applications in prosthetics and rehabilitation. Measurement of Body Temperature - Contact-based sensors: Thermocouples, thermistors - Infrared temperature sensors.

Week 4:
PHYSIOLOGICAL MEASUREMENTS PART 2: PRESSURE, FLOW AND VOLUME
Measurement of Pressure - Piezoelectric, capacitive, and strain gauge pressure sensors- Blood pressure measurement techniques (sphygmomanometer, catheter-based). Measurement of Flow & Volume in Arteries, Veins & Tissues - Electromagnetic, ultrasonic, and thermal flow meters - Plethysmography and cardiac output measurement.

Week 5:
MEASUREMENT OF BIOPOTENTIAL AND ELECTRODES
Measurement of Biopotential – Origin of Biopotential – Overview of Biopotential electrodes- Electrode – Electrolyte interface, Electrode-skin interface, types of biopotential electrodes and Recording issues – Motion artifacts and Impedance mismatching.

Week 6: BIOPOTENTIAL MEASUREMENT TECHNIQUES PART I
ECG (Electrocardiogram) Measurement - Einthoven's triangle, standard 12-lead system, Electrode placement and lead configurations. EEG (Electroencephalography) Measurement - 10-20 electrode system, unipolar & bipolar configurations, Brain wave classification (delta, theta, alpha, beta).EMG (Electromyography) Measurement - Signal acquisition and muscle activity analysis.

Week 7: BIOPOTENTIAL MEASUREMENT TECHNIQUES PART II

ERG (Electroretinogram) & EOG (Electrooculography) - Eye movement and retinal potential monitoring – unipolar and bipolar mode. GSR (Galvanic Skin Response) & PCG (Phonocardiogram).

Week 8: BIO-AMPLIFIERS AND BIOSIGNAL CONDITIONING

Bio-amplifiers - Need for Bio-Amplifiers, Types of Bio- Amplifiers: Single-ended bio-amplifier, Differential bio amplifier, Right-leg driven ECG amplifier, Filtering & Interference Reduction: Band-pass, notch, and adaptive filtering, Power-line interference reduction techniques, Isolation Techniques: Optical isolation, transformer-based isolation, Amplifier Types:: Isolated DC amplifiers, AC carrier amplifiers, chopper amplifiers

Week 9:

MEDICAL EQUIPMENT AND INSTRUMENTATION PART I

Blood Pressure Measurement (Sphygmomanometer) – Direct and Indirect Methods. Ventilators - Pressure vs. volume controlled ventilators, Sensors in ventilators (flow, pressure, oxygen sensors). Pacemakers - External and implantable pacemakers.

Week 10: MEDICAL EQUIPMENT AND INSTRUMENTATION PART II

Defibrillators- Monophasic & biphasic defibrillators. Pulse Oximeters - Principle of SpO_2 measurement. Hemodialysis Machines- Dialysis process and monitoring parameters.

Week 11: LASER APPLICATION IN BIOMEDICAL ENGINEERING

LASER- Principle of LASER operation and its characteristics. Types of LASERs – Pulsed Ruby LASER, Nd-YAG LASER – Helium-Neon LASER– CO_2 LASER – Semiconductor Laser and their biomedical application. Overview of LASER safety standards – Biological effects, LASER Hazard classification and safety measures

Week 12: ELECTRICAL ISOLATION AND SAFETY STANDARDS

Optical & Electrical Isolation Techniques, Leakage Currents in Medical Devices, Grounding & Protection Mechanisms, Standards for Biomedical Equipment Safety : IEC 60601 (Medical Electrical Equipment Standard), FDA Regulations for Medical Devices, Electromagnetic Interference (EMI) & Electromagnetic Compatibility (EMC)

Books and References

- [1] John G. Webster, "Medical Instrumentation Application and Design", John Wiley and sons, New York, 2004
- [2] Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 2003.
- [3] Tatsuo Togawa, "Biomedical Sensors and Instruments", CRC Press, Germany, 2011.
- [4] John G. Webster, " The Physiological Measurement Handbook", CRC Press – Taylor and Francis Group, Newyork, 2015

Drug Delivery Principles and Engineering

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: A course in biochemistry, molecular biology, anatomy is recommended

INDUSTRY SUPPORT: All pharmaceuticals, hospitals and biotechnology industries

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

Regeneration Biology

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: Basic knowledge in cell and organismal biology

INDUSTRY SUPPORT: Biotechnology and pharma companies could learn from the contents of the course to gain insights on tissue regeneration

Course Layout

Week 1:

1. Basics of regeneration: basics and types

2. Regeneration, Wound healing and Scar formation in different regenerative capacity

3. Regeneration: in normal life and implications

4. Tissue regeneration: mammalian context

5. Liver regeneration: Signaling events

Week 2:

6. Liver regeneration: mechanistic insights

7. Regeneration: lessons from animal model Hydra

8. Mechanisms of regeneration in Hydra

9. Asexual Reproduction- Fragmentation. Morphallaxis, Epimorphosis, lessons from Hydra

10. Mechanisms of regeneration in Planaria

Week 3:

11. Planaria regeneration-polarity and gradient in regeneration

12. Planaria regeneration: Neoblasts and organ formation

13. Planaria regeneration: Species type and enviornment

14. Position control genes and regeneration

15. Progenitor targeting and ectopic organs

Week 4:

16. Tissue dedifferentiation, cellular reprograming into blastema Cellular types in regeneration. Neural crest cells in vertebrates

17. Totipotency, pluripotency, multipotency and unipotency, in regeneration context

18. Adult stem cells: Natural and induced and their roles in regeneration-zebrafish

19. Common cellular events during regeneration, embryonic development, and cancer

20. Epithelial to mesenchymal transition (EMT) and mesenchymal to epithelial transition (MET) in regeneration

Week 5:

21. Organ regeneration: Basics with examples

22. Zebrafish fin regeneration-in a brief

23. Zebrafish heart regeneration-in a brief

24. Zebrafish retina regeneration-in a brief

25. Spinal cord and brain regeneration-Conclusive mechanisms of regeneration

Week 6:

26. Cellular, Molecular and Genetic factors involved in retina regeneration

27. Detailed mechanisms of fin regeneration

28. Retina regeneration-importance of Shh signaling Roles of epigenetic factors and their involvement in regeneration

29. Importance of regeneration associated gene induction events-Transcription activators and repressors

30. Roles of different cellular signaling in regeneration: Examples- Wnt signaling

Week 7:

31. Different cellular signaling during regeneration-Overview

32. Different cellular signaling during regeneration. Examples- Jak-STAT and Fgf signaling

33. Different cellular signaling during regeneration -Egf, and Hippo signaling

34. Roles of Delta-Notch signaling during regeneration

35. Tgf-beta signaling during regeneration

Week 8:

36. Organ regeneration: An overview

37. Accessory limb model of regeneration: lessons from Axolotl and newt

38. Nerve-dependent regeneration-Axolotl and Newt

39. Roles of Histone deacetylases in regeneration of vertebrates like fishes and amphibians

40. Dynamics of immune system in organ regeneration regeneration

Week 9:

41. Extracellular matrix and its roles in tissue regeneration

42. Induced pluripotency and roles if iPFs during tissue Hox genes and homeotic transformation

43. Animal cloning: implications in regeneration

44. Embryonic stem cells, cord blood stem cells and adult stem cells

45. Ethics of stem cell research in regeneration studies, regenerative medicine and biotechnology

Week 10:

46. Tissue engineering and-Why and how?

47. History of tissue engineering

48. Different steps in tissue engineering

49. Different aspects of organ culture

50. Major challenges in tissue engineering in practice

Week 11:

51. Tissue 3D printing and organ culture

52. Importance of scaffolds in tissue engineering

53. Stem cells for tissue engineering-Use of CRISPR-Cas9 for genome targeting

54. Types of adult stem cells and trans-differentiation for tissue engineering

55. Influence of niches and scaffolds on stem cells: An organ culture perspective

56. The basics of regeneration put into practice *in vitro.*

Week 12:

57. Adhesion, migration and aggregation of stem cells

58. Artificial, liver, kidney and urinary bladder for transplantation in patients

59. Limbal stem cells and artificial cornea

60. Xenotransplantation vs organ culture in practice

61. Future implications of regeneration in mammals

62. Future implications of Organ culture in patient care

Books and References

1. Principles of Regenerative Biology. By Bruce M. Carlson
2. Regenerative medicine and stem cell biology. Edited by Nagwa El-Badri
3. Extracellular Matrix for Tissue Engineering and Biomaterials. Edited by Anna C. Berardi

Artificial Intelligence in Drug Discovery and Development

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: The participants should have basic knowledge of biology, chemistry, and pharmacology. The keen interest in the domain of drug discovery and a basic introduction to Python programming language is desirable.

INDUSTRY SUPPORT: Pharmaceutical industry such as TCS Life Science, Dr.Reddy's Laboratories, Reliance Life Science, Suven Life Sciences Ltd

Course Layout

Week 1: Basics of drug discovery pipeline
1. Drug discovery and development
2. Overview of drug discovery workflows
3. Drug design strategies
4. Conventional methods for drug discovery
5. Riddles in drug discovery

Week 2: Introduction to AI in drug discovery and development
1. History and evolution of AI in drug discovery
2. Overview of AI technologies
3. Key applications of AI across the pipeline
4. Available AI tools and platforms
5. Advantages of AI integration in drug discovery

Week 3: Fundamentals of AI and ML techniques
1. Introduction to machine learning concepts
2. Overview of neural networks
3. Feature engineering and data preprocessing
4. Evaluation metrics for AI models
5. Introduction to Python libraries for AI in drug discovery

Week 4: AI in target identification, prediction and validation
1. Introduction to biological targets
2. Basics of target identification and validation
3. Omics data integration for target discovery
4. Binding site and protein structure prediction with AI
5. Hands-on tutorial: Protein structure prediction

Week 5: AI in high throughput virtual screening and lead identification
1. Introduction and approaches to virtual screening
2. AI tools for virtual screening
3. AI assisted molecular docking
4. Workflow of high-throughput virtual screening
5. Hands-on tutorial: AI-assisted molecular docking

Week 6: AI in lead optimization and drug-target interaction
1. Basics of lead optimization
2. AI for drug-target interaction studies
3. QSAR modelling
4. Molecular dynamics simulations
5. Hands-on tutorial: Molecular dynamics trajectory analysis

Week 7: ADMET predictive modelling in drug discovery
1. Introduction to ADMET Properties
2. Importance in lead optimization
3. Conventional methods for ADMET prediction
4. Open available resources for ADMET prediction
5. Hands-on tutorial: AI-enabled ADMET prediction

Week 8: AI in clinical phase
1. Overview of clinical trials
2. Patient recruitment, stratification, and retention
3. Clinical trial protocol design and optimization
4. Predicting outcomes of clinical trials with AI
5. Data collection and monitoring for regulatory submissions

Week 9: De Novo Drug Design using Generative AI
1. Introduction to Generative AI in drug design
2. Deep Generative Models for drug design (GAN, GNN, RNN, VAE etc.)
3. Benchmarking Generative Models for drug design
4. Molecule optimization with Generative AI
5. Hands-on tutorial: AI-powered de novo drug design

Week 10: Advanced concepts: Precision medicine, Network pharmacology and Drug repurposing
1. AI in genomics for personalized treatments
2. AI in real-time monitoring and feedback
3. Overview and data sources for AI in drug repurposing
4. Integrating multi-target drug discovery
5. Network pharmacology with AI

Week 11: Case studies, challenges, future directions, and resources
1. Public AI resources for drug discovery
2. Examples of notable successful case studies
3. Challenges in modern drug discovery realm
4. Regulatory considerations for AI implementation in drug development
5. Future outlook: Explainable artificial intelligence, (XAI) and other emerging technologies in drug discovery

Week 12: Hands-on sessions (Implementing an advanced workflow for molecular structure representation, property prediction, and ultra-large virtual screening)

1. Molecular structure representation

2. ML-assisted solubility prediction

3. AI-assisted bioactivity prediction

4. Pharmacophore- based ultra-large virtual screening

5. Similarity based virtual screening

Books and References

1. Ramsundar, B., Eastman, P., Walters, P., & Pande, V. (2019). Deep learning for the life sciences: applying deep learning to genomics, microscopy, drug discovery, and more. " O'Reilly Media, Inc.".
2. Brown, N. (Ed.). (2020). Artificial intelligence in drug discovery. Royal Society of Chemistry.

Fundamentals of Cryo-Electron Microscopy (Cryo-EM) and 3D Image Processing in Structural Biology

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: Students with a basic understanding of science—particularly in biology, physics, or chemistry—are eligible to enroll in this course.

Course layout

Week 1: Objectives and basic working principles of different types of microscopes, including all the light microscope. Different types of electron microscopies, like SEM, TEM, STEM, HT-TEM and their applications.

Week 2: Basic introduction of electron microscopy physics like electron gun (sources), electromagnetic lenses system.

Week 3: Various types of aberrations of lenses (Spherical aberration, Chromatic aberration, Astigmatism, Coma), resolution limit of the microscope, magnification, and diffraction by electron microscope.

Week 4: Microscope basic vacuum system, and camera (CCD & Direct electron detectors). Principles of image formation, Ray diagram to understand the image formation, Fourier analysis.

Week 5: Contrast Transfer Function and point spread function, electron scattering, phase contrast, electron–specimen interactions, electron diffraction.

Week 6: Study the various advanced sample preparation techniques for TEM. Negative staining TEM analysis of soluble protein, membrane protein, DNA-protein complex, RNA-protein complex, lipid-protein complex, liposome sample preparation and imaging and image analysis. Identify good and bad negative staining images.

Week 7: Cryo-EM sample preparation (grid preparation) using Vitrobot, VitroJet, Chameleon and other techniques; We will learn sample preparation and imaging of soluble protein, membrane protein, DNA-protein, lipidprotein. Sample loading and automatic data collection and data analysis.

Week 8: Sample preparation using ultramicrotomes & cryo-ultramicrotomes-- tissue sample, whole cells, polymer, and nanoparticles.Learn the methodology to transfer the thin sections to transfer to grids and visualize and analyze samples using TEM and cryo-EM.

Week 9: Data collection using cryo-EM. Study ray diagram to understand focus overfocus under focus image collection, importance of defocused data collection/image collection (for 3D reconstruction and only for imaging), electron dose rate, identify good and bad image, understand Signal/Noise ratio.

Week 10: Theoretical, computational and practical aspects of various advanced 3D image processing techniques for all kinds of EM data. Basic understanding of Cross-Correlation and Convolution. Describe whole pipeline of 3D reconstruction and importance of 2D classification, 3D classifications.

Week 11: Basic principle behind 3D reconstruction and reference-free 2D classification, 3D classifications. Resolution and FSC calculation.

Week 12: Cryo-EM map interpretation and data analysis, FSC calculation, validation, molecular rigid-body docking and basic of model building.

Books and References

1. John J. Bozzola and Lonnie D. Russell (1992). Electron Microscopy (Jones & Bartlett Publishers).
2. Ray F. Egerton (2005). Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM (Springer).
3. Elaine Evelyn Hunter and Malcolm Silver (1993). Practical Electron Microscopy: A Beginner's Illustrated Guide (Cambridge University).
4. Ludwig Reimer and Helmut Kohl (2008). Transmission Electron Microscopy: Physics of Image Formation (Springer).
5. John Kuo (2007). Electron Microscopy: Methods and Protocols (Methods in Molecular Biology) (Humana).
6. Earl J. Kirkland (2014). Advanced Computing in Electron Microscopy (Springer).
7. Gabor T. Herman and Joachim Frank (2014). Computational Methods for Three-Dimensional Microscopy Reconstruction (Birkhäuser Basel).
8. Joachim Frank (2006). Electron Tomography, (New York, Springer).
9. Joachim Frank (2006). Three-Dimensional Electron Microscopy of Macromolecular Assemblies (New York, Oxford U. Press).
10. Joachim Frank (1996). Three-dimensional Electron Microscopy of Macromolecular Assemblies (San Diego, Academic Press).

An Introduction to Evolutionary Biology

Course Duration: 12 weeks

Credits: 3

PREREQUISITES: Students should have a basic (Class XII level) understanding of concepts in Biology. No other course is required as a prerequisite.

Course layout

Week 1: Overview of evolution, History of evolutionary thought, Extended Evolutionary Synthesis.

Week 2: Evidence for evolution. Microevolution (selective breeding, direct observation, vestigial organs). Macroevolution (fossil records, transitional forms, evolutionary homology, molecular homology).

Week 3: Mechanism of evolution: Variation. Kinds of variation important for evolution. Randomness of mutations. Non-genetic inheritances and their importance.

Week 4: Mechanism of evolution: Selection (process, pre-requisites, consequences). Examples of selection under laboratory and natural systems.

Week 5: Mechanisms of evolution: Genetic Drift and Inbreeding. Founder effect, bottleneck effect, neutral evolution.

Week 6: Aging: Why do we age? Molecular theories of aging. Evolutionary theories of aging. Antagonistic pleiotropy and Mutation accumulation.

Week 7: Sex and sexual selection: Sexual selection and its various types (male-male competition, female choice), evolution of sex ratios. Why sex?

Week 8: Cooperation and conflict: Evolution of altruism, Kin selection, Intra- and inter-locus conflicts, Parent-offspring conflicts, Eusociality.

Week 9: Macroevolution: Different species concepts, Speciation, Various mechanisms of reproductive isolation, adaptive radiation, introduction to phylogenetic trees.

Week 10: Genome Evolution and Evolutionary Developmental Biology: Birth and death of genes, chromosome evolution, Phenotypic plasticity, canalization and genetic assimilation, constraints on adaptive evolution.

Week 11: Origin of life and human evolution: Various theories about origin of life, closest relatives of humans, other hominin groups, cultural evolution, human evolution in modern times.

Week 12: Evolution and the society: Evolutionary medicine, Evolution of antibiotic resistance, evolutionary psychology.

Books and References

No single book can be prescribed for the entire course. However, the following books will cover a lot of the material:

1. Futuyma, D. and Kirkpatrick, M. (2022). Evolution. Oxford University Press.
2. Freeman, S., & Herron, J. C. (2021). Evolutionary Analysis. Pearson Prentice Hall.

Cell Signaling

Course Duration: 8 weeks

Credits: 3

PREREQUISITES: A course in Cell Biology and Molecular Biology

INDUSTRY SUPPORT: Anti-cancer and physiology related drug developing industry, Biosimilars

Course Layout

Week 1: Cell signaling, components and types of signaling

Week 2: Types of ligand, regulation of ligand, receptor binding proteins, G-proteins and signaling

Week 3: Kinases, Types of receptors, Mechanoreceptors, Structure and Function, Receptor activation, modes of intracellular signaling

Week 4: Signaling in Microbial world, Two-component signaling,

Week 5: Receptors Serine-threonine kinase, diversity in receptor activation

Week 6: Discovery of Tyrosine kinases, Receptor tyrosine kinase (RTK) signaling ,diversity in RTKs

Week 7: Growth factor signaling, cancer and diseases due to RTK malfunction,

Week 8: G-protein coupled receptor (GPCRs), G-proteins type, regulation of GPCR signaling

Books and References

Molecular Biology of Cell by Bruce Alberts Published research and review articles