DELHI PHARMACEUTICAL SCIENCES & RESEARCH UNIVERSITY

(***Established Under Act*** 07 of 2008, Govt. of ***NCT of Delhi***)

(The First Pharmacy University in India)

PushpVihar Sector-III, M.B. Road, New Delhi-110017

Master of Science (M.Sc.)

Artificial Intelligence and Precision Medicine

Course Outline

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Syllabus

M.Sc.: Artificial Intelligence and Precision Medicine

Semester I

Semester	Paper Code	Subject	Periods			Credit Units	Evaluation scheme		
			L	**T**	**P /S**		**Internal**	**External**	**Total**
I	AIPM 101	Artificial Intelligence and Machine Learning: Foundations and Applications	3	1	-	4	25	75	100
	AIPM 102	Basics of Drug Action	3	1	-	4	25	75	100
	AIPM 103	Introduction to Human Genetics and Genomics	3	1	-	4	25	75	100
	AIPM 104	Bioinformatics and Structural Biology	3	1	-	4	25	75	100
	AIPM 105	Precision Diagnosis for Precision Medicine	3	1	-	4	25	75	100
	AIPM 106P	Practical Laboratory Research Skills-I			8	4	25	75	100
	AIPM 107P	Practical Laboratory Research Skills (AI)-II			4	2	20	30	50
		Total	15	5	6	26	170	480	650

M.Sc.: Artificial Intelligence and Precision Medicine

Semester –II

Semester	Paper Code	Subject	Periods			Credit Units	Evaluation scheme		
			L	T	P/S		Internal	External	Total
II	AIPM 201	Understanding Machine Learning in Health Care	3	1	-	4	25	75	100
	AIPM 202	Medical Genomics: The Genetics and Epigenetics of disease	3	1	-	4	25	75	100
	AIPM 203	Personalised Molecular Medicine	3	1	-	4	25	75	100
	AIPM 204	Drug Design and Discovery	3	1	-	4	25	75	100
	AIPM 205	Analytical Skills in Precision Medicine	3	1	-	4	25	75	100
	AIPM 206P	Practical Laboratory Research Skills-II			8	4	25	75	100
	AIPM 201P	AI and ML Practical			4	2	20	30	50
		Total	15	5	6	26	170	480	650

M.Sc.: Artificial Intelligence and Precision Medicine

Semester –III

Semester	Paper Code	Subject	Periods			Credit Units	Evaluation scheme		
			L	T	P /S		Internal	External	Total
III	AIPM 301	Machine Learning and Deep Learning in Disease	3	1	-	4	25	75	100
	AIPM 302	Proteomics and Metabolomics	3	1	-	4	25	75	100
	AIPM 303	High-Throughput Technologies	3	1	-	4	25	75	100
	AIPM 304	Novel Therapies: From concept to clinical translation	3	1	-	4	25	75	100
	AIPM 305	Clinical Interpretationof Precision Diagnostics and Response Monitoring	3	1	-	4	25	75	100
	AIPM 306	Research Methodology	3	1	-	4	25	75	100
	AIPM 307	Yogic Science	2	-	-	2	10	40	50
	AIPM 307P	Practical Laboratory Research Skills (AI)-III	-	-	4	2	10	40	50
	AIPM 308P	Practical (Research Methods)			4	2	20	30	50
		Total	20	6	8	30	190	560	750

M.Sc.: Artificial Intelligence and Precision Medicine

Semester –IV

Semester	Paper Code	Subject		Periods			Credit Units	Evaluation scheme		
				L	T	P/ S		Internal	External	Total
IV	AIPM 401	Journal Club, Assignment and Presentation		1	1	2	4	40	60	100
	AIPM 402	Research Project	Project Thesis				6		150	150
			Internal Assessment				6	150		150
			Viva-voce				4		100	100
		Total		3	1		20	175	325	500

SEMESTER-I

Subject : AI and Machine Learning: Applications and Foundations
Paper Code : AIPM 101

Course Objectives:

For decades, Pharmaceutical data analytics has been a largely manual and tedious task conducted by the commercial research, health outcomes, R&D and Clinical Study groups at Pharma companies both small and large. With the emergence of machine learning, artificial intelligence and other disruptive innovations, Pharma, like other industries has also started its slow but sure transition to a more agile, data-driven model – one where in-house research is supplemented by intelligence gathered by applying algorithms across terabytes of Physician Rx, Patient Claims and other related datasets. Improvements in budgeting, lower operational costs, and improved overall organizational efficiency can be seen as a positive result of AI data analysis in pharmaceutical industries. This course deals with an introduction to the basic principles, techniques, and applications of Artificial Intelligence and Machine Learning.Coverage includes knowledge of AI and machine learning basics, applications and case studies of AI and ML in pharmacy, Theoretical models, use-cases, fundamental programming application of AI and ML in pharma datasets, statistical and probabilistic analysis. Foundation to the AI and Machine learning will be provided to the students.

Learning Outcomes:

On completion of the course, the student should be able to:

- Explain core elements of AI and ML
- Critically evaluate the Programming and Descriptive Statistics and carry out Statistical Analysis
- Learn basics and applications of AI and ML

Course Contents:

Unit I: AI foundation

Introduction: Introduction to Artificial Intelligence, AI fundamentals, Use-cases and applications of AI, Issues concerning AI in business, ethics and bias, jobs and scope. Brief history of AI and ML in Healthcare and Pharmacy, Machine Learning workflow and terminologies, computational models of intelligence; conceptual frameworks from cognitive and educational psychology, neuroscience, information theory, and linguistics; philosophical foundations of AI. **[15]**

Knowledge Representation and Reasoning: Prepositional logic, first-order logic, ontological engineering, probabilistic reasoning

Time-series analysis: temporal models (probabilistic reasoning over time). Emerging paradigms and concepts in artificial social and emotional intelligence.

Unit II **[10]**

Introduction to Data Manipulation and Data Visualization. Introduction to Data Science, Flow of Data Science, Numpy, Pandas: Data Frames, operations, Pandas built-in data visualization, Matplotlib, Matplotlib visualization

Data pre-processing: Importing libraries, importing dataset, taking care of missing

data, encoding categorical data, split data into train and test set, features scaling
Lab: Data Manipulation using Numpy and Pandas, Data Visualization in different Graphs and basic python based on arrays, list, data management, functions.

Introduction to Machine Learning: Introduction, Types of Machine Learning: Supervised, Unsupervised, Reinforcement learning and Transfer Learning, Applications, Classification vs Prediction Problems, Regression models (Prediction Problem), Mean Square Error, R2 Score, Rule-based machine learning (Association Learning)

Machine Learning and Medical bio-sensors: ML in micro biosensors and devices for electronic data capture (ECG, Actigraphy, Oximetry), data disambiguation techniques, Bayesian ML, SVM-optimal mix, Shallow learning, Ensemble Learning, anomaly detection.

Probabilistic and Statistical analysis

Unit III **[10]**

CART (Classification and Regression Tree): Linear Regression, Multiple linear regression, polynomial regression, Decision trees, Kernel-Ridge Regression, Random-Forest, evaluating regression models performance, Logistic Regression, SVM, KNN(Confusion matrix, accuracy score), Decision trees classification, Random-Forest classification, classification model selection in python, evaluating classification models performance.

Clustering: K-means clustering, Hierarchical clustering

Introduction to R in Healthcare: Basic analysis in R, R programming: understanding common data distribution and types of variables, formulate scientific hypothesis, correlation and dependence. Statistical analysis, Survival analysis, Logical and Logistic regression. Ways to choose predictors in regression model, Run and interpret Kaplan-Meier curves in R
Lab: IRIS Flower Classification using KNN

Lab: R programming for Pharma data analysis, Data classification using Python (Databases: kdb+)

Unit IV **[10]**

Deep Learning: Introduction, Types of Deep Learning, ANN, Neural Networks, DNN, RNN, CNN architectures for medical data manipulations**.**

Challenges in Pharmaceutical industrieswhich AI can solve: Notations, Approaches of AI to be used in solving healthcare data and its applications

Case studies: Disease identification and diagnosis-Google DeepMind Health, Personalized Treatment/Behavioral Modification (Study any one case), COVID – 19 Coronavirus Prediction Outcomes, Forecasting, Analysis & Visualization

Textbooks/ References/Further Reading:

1. Russell, Norvig, Arti_cial Intelligence: A Modern Approach, Third edition, Prentice Hall, 2010
2. Hastie, Tibshirani, Friedman. The elements of statistical learning, Second edition, Springer, 2009
3. Tsang. Foundations of constraint satisfaction, Academic press, 1993.
4. https://tevgeniou.github.io/FoundationsML/index.html

5 Daphne Koller and Friedman. Probabilistic Graphical Models - Principles and Techniques, The MIT Press, 2009
6. Machine Learning with R: Expert techniques for predictive modeling, by Brett Lantz, 3rd Edition
7. Hands-on programming with R: Write your own functions and simulations by Garrett Grolemund, 2014

Subject : Basics of Drug Action
Paper Code : AIPM 102

Course Objectives:
The main purpose of the subject is to understand what drugs do to the living organisms and how their effects can be applied to therapeutics. The subject covers the information about the drugs like, mechanism of action, physiological and biochemical effects (pharmacodynamics) as well as receptors, enzyme kinetics. Study of drug targets such as enzyme inhibition, nucleic acids. Student should have a general idea about drug metabolism.

Learning Outcomes:

On completion of the course, the student should be able to:

- Explain basics of drug action and pharmacology
- Critically evaluate the role of receptors and targets in drug action
- Learn basics of drug likeliness and drug biotransformation

Unit-1 Introduction to Pharmacology:
Basic principles of pharmacology, including receptor mechanisms, drug distribution and metabolism, and pharmacokinetics. [10]

Unit-2 Interactions
Inter- and intramolecular interactions. Weak interactions in drug molecules. Chirality and drug action. Covalent, ion-ion, ion-dipole, Hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, Van der Waals interactions and the associated energies [7]

Unit-3 Receptorology
Drug-receptor interactions, Receptor theories and drug action: Occupancy Theory, Rate Theory, Induced Fit Theory, Macromolecular perturbation theory, Activation-Aggregation theory. Topological and stereochemical consideration. [6]

Unit-4 Enzyme Inhibition
Drug action through enzyme inhibition. Examples based on PDE4, GSK3, etc. Theories of enzyme inhibition and inactivation. Enzyme activation of drugs prodrugs.
[7]

Unit-5 Drug likeness
Drug like molecules and theories associated with the recognition of drug like properties. Physical organic chemistry of Drug metabolism, drug deactivation and elimination. [6]

Unit-6 Drug action after Metabolism: Phase I and Phase II transformations. Concept of hard and soft drugs. Chemistry of ADME and Toxicity properties of drugs.
[9]

Recommended Books

1. The Organic Chemistry of Drug Design and Drug Action by R.B. Silverman
2. C.J. Coulson, Molecular Mechanism of Drug Action by C.J. Coulson
3. A primer of Drug Action by R.M. Julien
4. Drug-Receptor Thermodynamics by R.B. Raffa
5. Principles of Drug Action by W.B. Pratt, P. Taylor
6. Medicinal Chemistry How Drugs Act and Why by A. Gringauz
7. Principles of Molecular recognition by A.D. Buckingham
8. Quantitative molecular pharmacology and Informatics by M. Lutz
9. Physical Biochemistry by K.E.V. Holde
10. Free energy calculations in rational drug design by M. Rami Reddy

Subject: Introduction to Human Genetics and Genomics
Paper Code: AIPM-103

Course Objectives:
This course introduces the structure and variation in human genomics, the fundamental principles of genetics and genomics, and the architecture of the human genome, including the functional units embedded in it. Explore DNA sequence variation, how variation arises and its extent in populations and to design a project to find genetic variants affecting health, disease and responses to drugs and environmental factors.

Learning outcomes

On completion of the course, the student should be able to:

- Explain core elements of genome architecture, including the properties of DNA and chromatin structure.
- Critically evaluate the regulation of gene expression, transcription and translation.
- Interpret variation in genome structure and sequence in the context of physiological function and disease and across human populations.
- Describe the correlation between genotype and phenotype.

Contents

Unit-1
Genome organization in viruses, prokaryotes and eukaryotes: Organization of nuclear and organellar genomes; C-value paradox, Repetitive DNA-satellite DNAs and interspersed repeated DNAs, Transposable elements, LINES, SINES, Alu family and their application in genome mapping. [12]

Unit-2
Concept of gene: Conventional and modern views. Fine structure of gene, split genes, pseudogenes, non-coding genes, overlapping genes and multi-gene families. Importance of genotype to phenotype correlation. [5]

Unit-3
Genome mapping: Physical maps -an overview and approaches, Genome evolution [4]

Unit-4
DNA replication, transcription and translation, cell division (mitosis, meiosis) and recombination.
DNA sequence variation, type and frequency, for example single nucleotide variants (SNVs), small insertions and deletions (indels), copy number variation (CNVs), rearrangements and tandem repeats. [10]

Unit-5

Mutational mechanisms: how different types of DNA variants, including epigenetics and imprinting, affect gene function or expression to cause disease. [7]

Unit-6

Correlation of genotype with phenotype, including penetrance and variation in expression. Concepts of heterogeneity and pleiotropy. Modes of inheritance for clinical manifestation of human variation. [7]

Suggested Reading:

1. Human Molecular Genetics Strachan T. & Read A. Garland Science
2. An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases Pasternak J. Fitzgerald Science Press
3. Thompson and Thompson Genetics in Medicine Robert et al. Saunders
4 Landmarks in Medical Genetics (Ed.) Harper P. S. Oxford University Press
5. Chromosome Banding Sumner A.T. Unwin Hyman
6. Human Genetics: Problems and Approaches Vogel F. and Motulsky A. G. Springer Verlag

Subject : Bioinformatics and Structural Biology
Paper : AIPM 104

Course Objectives:
This course introduces the utilization of bioinformatics in drug design. Determination of computational structure, protein structure and protein structure visualization in drug design to be learnt.

Learning Outcomes
On completion of the course, the student should be able to:

- Explain the relationship between protein sequence and protein structure
- Describe how structure translates into function within different biological fields such as catalysis, transport and regulation
- Estimate the validity of information in macromolecular structure databases, and use computer programs to visualise and analyse macromolecular structures from a functional perspective
- Use bioinformatics tools for sequence alignment, sequence motif identification and prediction of secondary and tertiary structures
- Account for the purpose, theoretical background, and limitations of the above mentioned boinformatics methods and use this knowledge to interpret relevant results.

CONTENTS

Unit-1
Introduction and scope of Bioinformatics. Major Biological Databases and Information Retrieval. Homology Concept and Alignment of pairs of sequence, Global & Local Alignment, Basic Local Alignment Search Tool (BLAST), Other Blast options, PSI-BLAST. Applications of BLAST tool. Multiple sequence alignment and its applications. [12]

Unit-2
Introduction to Computational Gene Prediction and Genome annotation Basic concepts in Computational Phylogenetic Analysis [8]

Unit-3
Principles of Protein Structure and Classification: Properties of amino acids and peptide bonds, Ramachandran plot, Secondary structures, motifs and folds. Secondary structure prediction methods. Tertiary structure Prediction methods (Homology modeling, Fold recognition and ab-initio method). [10]

Unit-4
Protein Structure Visualization; tools and analysis of protein structures. Protein Databank, PDB in detail, 3D visualization softwares, Pathway and molecular interaction databases, Prediction algorithms for pathways and Molecular Interactions, Integrating gene expression data with pathway information.Concepts of B-factor and R-factor. Protein Structural Alignment and Superposition. Protein Fold Classification, CATH,

SCOP and FSSP Databases.
[7]

Unit-5

Biological databases: Nucleotide Sequence Databases, GenBank, DDBJ, EMBL, Sequence Flatfile and submission process, Protein sequence databases, UniProt in detail, Mapping databases, Genomic databases, Data mining. Sequence analysis: Gene Prediction methods and programs, Markov and Hidden Markov models in gene prediction, Promoter analysis, RNA secondary structure thermodynamics, Dynamic programming and genetic algorithms for secondary structure prediction, refining multiple sequence alignment based on RNA secondary structure predictions, Vienna RNAfold, Evolution and origins of sequence polymorphisms, SNP discovery methods and databases, Genotyping, International haplotype map project, 1000 genomes project. [8]

Suggested Readings

1. Claverie, J.M. and Notredame C. 2003 Bioinformatics for Dummies. Wiley Editor.
2. Durbin R., Eddy S., Krogh A. and Mithchison G. 2007 Biological Sequence Analysis, Cambridge University Press.
3. Lesk, A.M. 2005, 2nd edition, Introduction to Bioinformatics. Oxford University Press.
4. Fogel, G.B. and Corne, D.W., 1997 Evolutionary Computation in Bioinformatics.
5. Rastogi et al 2003. Bioinformatics: Concepts, Skills and Applications. CBS
6. Rashidi and Buchler 2000. Bioinformatics Basics. CRC Press
7. Mount, D.W., Bioinformatics 2004. Sequence and Genome Analysis. CSHL Press
8. Wilkins, M.R., Williams, K.L., Appel, R.D., Hochstrasser, D.F. (Editors) 1997 Proteome Research: New Frontiers in Functional Genomics. Springer Verlag Berlin Heidelberg.
9Baxevanis, A.D. and Francis Ouellette, B.F. 2004 Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins. Second Edition, Wiley.
10. Graur, D. and Li, W-H. 2000 Fundamentals of Molecular Evolution. Sinauer Ass., Mass., .USA. 4. Tisdall, D., 2003 Mastering Perl for Bioinformatics. O'Reilly.

Subject : Precision Diagnosis for Precision Medicine

Paper : AIPM 105

Course Objectives

- Provide overview of a mechanistic understanding of the aetiology and pathogenesis of disease with the ability to detect (diagnose in the clinical laboratory) specific causal factors.
- Provide an overview of the different types of molecular biomarkers (macromolecules and/or metabolites) and how they are collected for diagnostics.
- Provide an overview of the technologies available to measure these markers, eg so called next generation sequencing (NGS) technologies as well as techniques used to analyse and interpret large, multidimensional data sets using biomedical informatics and systems biology techniques.
- Highlight how precision molecular diagnostics (also known as companion diagnostics) enables the prediction of efficacies of targeted therapeutics and are mandatory prerequisites for cost-effective and safe use of individual drugs and combination therapies in the clinical care setting.

Learning Outcomes

On completion of the course, the student should be able to:

- Have acquired an overview of modern molecular biomarkers (macromolecules and metabolites), how they are discovered and validated.
- Understand the technologies available to measure these biomarkers such as Next Generation Sequencing (NGS) including some of the analysis methodology needed for analysis of such datasets.
- Understand how precision technologies such as companion diagnostics can enable the prediction of efficacy of targeted therapeutics and aid in the estimation of their efficacy.

Syllabus:

Unit-1
Molecular Diagnostics
Historical Overview of Diagnostics; Central Dogma of Biology and Genomics; Technology Fundamentals (Sample preparation, Gel electrophoresis, DNA probes); Key Genomic Technologies (PCR, Microarray); In-Situ Hybridisation; DNA sequencing; Case studies in genomics and assay trouble-shooting; Proteomics. [8]

Unit-2
Mechanistic Understanding of Aetiology
A mechanistic understanding of the aetiology and pathogenesis of disease. The ability to detect (diagnose in the clinical laboratory) specific causal factors. The ability to

specifically treat the underlying cause(s)
[8]

Unit-3
Molecular Biomarkers
Different types of molecular biomarkers (macromolecules and/or metabolites) and how they are collected for diagnostics. Technologies available to measure these markers, eg so called next generation sequencing (NGS) technologies as well as techniques used to analyse and interpret large, multidimensional data sets using biomedical informatics and systems biology techniques. [9]

Unit-4
Precision Molecular Diagnostics
Precision molecular diagnostics (also known as companion diagnostics) The prediction of efficacies of targeted therapeutics and are mandatory prerequisites for cost effective and safe use of individual drugs and combination therapies in the clinical care setting. [10]

Unit-5
Role of AI in the future of precision diagnosis
Case Studies: Cognitive Systems in health care – Cognitive Assistant for visually impaired – AI for cancer detection, Predictive Analytics - Text Analytics – Image Analytics -Speech Analytics – IBM Watson
[10]

Suggested Reading:

Lela Buckingham: 2012, Molecular Diagnostics: Fundamentals, Methods and Clinical Applications, 2, 978-0-8036-26

AIPM 106P: Practical Laboratory Research Skills-I (04 Credits)

Course Contents

A number of practical experiments based on the theory to be designed and conducted by the concerned teacher.

AIPM 101P: Practical Laboratory Artificial Intelligence-II (02 Credits)

Course Contents

Lab: Apply ML models in predicting outcome on Pharmacy dataset downloaded from Open-Source platforms (Kaggle.com, MNIST data, IRIS data), Rare disease Patient finder using claims dataset(APLD (Anonymised Patient-Level Data) and Truven Marketscan), finding Physician Trends for Commercial Market Research, Risk-Based monitoring in clinical trials, Physician Matching, Market mix modeling, Clinical studies

SEMESTER-II

Subject : Understanding Machine Learning in Healthcare
Paper Code : AIPM 201

Course Objectives:

Data is transforming the health care industry relative to improving quality of care and reducing costs-key objectives for most organizations. Employers are desperately searching for professionals who have the ability to extract, analyze, and interpret data from patient health records, insurance claims, financial records, etc. and more to tell a compelling and actionable story using health care data. The course begins with a study of key components of the Machine Learning and its implications in Healthcare.

Learning Outcomes:

On completion of the course, the student should be able to:

- Comprehend various Machine Learning aspects and their role in Healthcare.
- Identify current forces disrupting today's health care industry.
- Summarize data collection, processing, and analysis best practices

Course Contents:

Unit I: INTRODUCTION AND APPLICATIONS

Introduction: Machine Learning, Data Science, Learning, Role of ML in Healthcare, Applications in Healthcare, Prediction, Diagnosis, Potential in Healthcare, Understanding a learning problem, Common Libraries for Machine Learning, Framing, Data preparation, Training model, Future Scope in healthcare . **[15]**

Applications: Disease Prognosis and Management, Disease Detection, Clinical decision support systems, Healthcare information management, Analytics in Healthcare, Intelligent Healthcare, Medical Information System, Identifying Diseases, Medical Imaging Diagnosis, Personalized Medicine, Better Radiotherapy, Smart Health Records, Drug Discovery and Manufacturing, Clinical Trial and Research, Machine Learning-based Behavioral Modification

Unit II APPLICATIONS OF MACHINE LEARNING IN HEALTHCARE [15]

ML in business and administration of health care: Blockchain in health care, Health information and records, Population health, Healthcare analytics, Precision health, Preventive medicine/healthcare.

ML applications in diagnostic technologies: Major diagnostic technologies - Diagnostic imaging, Laboratory testing, Genetic testing, etc., Electrodiagnosis; Telemedicine; Concurrent medical conditions ("Comorbidity"), Expert Systems; Chatbots.

ML applications in medical therapies: Medical care (primary, secondary, tertiary, quaternary care); Pharmaceutical and biopharmaceutical care; Hospital care; Nursing care; Home health care, nursing home, and hospice care; Concurrent medical conditions ("Comorbidity", aka "Multimorbidity"); Precision medicine; Medical/surgical Robotics; Stem cells and regenerative medicine; Genetics and

genomics therapies.

The Pandemic 2020: ML for clinical considerations for coronavirus infections, Epidemiology and public health considerations,

Unit III MACHINE DRIVEN ANALYTICS **[10]**

Predictive Analytics and Machine Learning in Medicine: Introduction, Prediction Research in Medicine, Building a Prediction Model, Selecting and Training Prediction Models, Reporting, Implementing and Evaluating Predictive Models.

Unit IV CASE STUDIES **[5]**

Use Cases:

Case Study 1: AI for Imaging of Diabetic Foot Concerns and Prioritization of Referral for Improvements in Morbidity and Mortality

Case Study 2: Outcomes of a DigitallyDelivered, Low-Carbohydrate, Type 2 DiabetesSelf-Management Program: 1-Year Results of aSingle-Arm Longitudinal Study

Case Study 3: Delivering a Scalable and EngagingDigital Therapy for Epilepsy

Case Study 4: Improving Learning Outcomesfor Junior Doctors Through the Novel Useof Augmented and Virtual Reality

Case Study 5: Do Wearable Apps Have Any Effecton Health Outcomes? A Real-World ServiceEvaluation of the Impact on Activity

Case Study 6: Big Data, Big Impact, Big Ethics:Diagnosing Disease Risk from Patient Data

Case Study 7: Assessment of a Predictive AI Modelfor Personalised Care and Evaluation of Accuracy

Case Study 8: Can Voice-Activated AssistantsSupport Adults to Remain Autonomous,a Real-World Service Evaluation of the Impact of a Voice-Activated Smart Speaker Applicationon Weight and Activity

Textbooks/ References/Further Reading:

1 Arjun Panesar, Machine Learning andAI for HealthcareBig Data for Improved Health Outcomes, APress, Second Edition, 2021

2 Ankur Saxena, Shivani Chandra.Artificial Intelligence and Machine Learning in Healthcare, First edition, Springer, 2021

3 Pradeep N, Sandeep Kautish, Sheng-Lung Peng. Demystifying Big Data,Machine Learning, andDeep Learning forHealthcare Analytics, Elsevier Academic Press, 2021

4 Fatos Xhafa, Sudipta Roy, Lalit Mohan Goyal, Mamta Mittal, Advanced PrognosticPredictive Modellingin Healthcare Data Analytics, Springer, Lecture Notes 2021.

5 Rashmi Agrawal, Jyotir Moy Chatterjee, Abhishek Kumar, Pramod Singh Rathore, Dac-Nhuong Le; Machine Learningfor Healthcare: Handling and Managing Data, First Edition, CRC Press, 2021

6. Vishal Jain, Jyotir Moy Chatterjee; Machine Learningwith Health Care PerspectiveMachine Learning and Healthcare, Springer 2020

Subject : Medical Genomics: The Genetics and Epigenetics of disease (Theory)
Paper Code : AIPM 202

Course Objectives

This course is an introduction to the genetic basis of various diseases, epigenetic processes and epigenetic basis of human disease. The course will take a mechanistic view of the epigenetic modifications, including transcription factors, DNA methylation, histone modifications, non-coding RNAs as well as how they regulate chromatin status and gene transcription. This course provides a strong foundation for the students from various basic branches other than biological sciences along with the biological science students.

Learning Outcomes

Upon completion of this course, the student should be able to understand:

- Genetic variation and its effect on human health
- Epigenetic processes and their role in various diseases
- Various methods to identify genetic variation or epigenetic modifications
- Diagnose the genetic cause of the disease
- Animal models available for genetic disorders and methods to develop the animal models
- Drug and genetic interaction through pharmacogenomics and hence the effective treatment

Syllabus:

Unit I [**12**]

Genetic Variation and Epigenetic Regulation in Human Health and disease/ disorders:

Chromosomal disorders: Principle of chromosomal abnormalities, Structural and numerical; Autosomal/sex or chromosomal/sex reversal; Mechanisms – mitotic/meiotic non-disjunction/ chromosomal rearrangements; Some examples (Syndromes/Cancer/Infertility); Common single gene disorder: Inborn errors of metabolism, Haemoglobinopathies and hematological disorders: thalassemia, hemophilia, sickle cell disease; Multifactorial disorders; Introduction; Etiology - genetic and non-genetic determinants; Methods of study (Epidemiological, Twin/ adoption and Family studies);; Epigenetics and disease susceptibility: Mechanisms (Imprinting/methylation; Chromatin dynamics and remodeling; microRNA); Current understanding in neuronal development-function, Cancer; Examples- Mitochondrial myopathies, Cancer.

Unit II [**10**]

Genetic and epigenetic mapping and analysis:

Single gene disorders- conventional and contemporary methods: Pedigree analysis, Linkage mapping, Positional/structural and functional cloning; Multifactorial disorders: Familial forms- Linkage analysis, Candidate gene identification; Genetic polymorphism and disease susceptibility; Sporadic cases- Association studies- markers from candidate gene/pathways; whole genome association (Single nucleotide polymorphism- SNPs, Copy number variations- CNVs); Novel molecular methods in epigenetic regulations:; Histone modifications methods; DNA methylation methods; Assessment of non-coding RNA as an epigenetic modulator; Epigenetic methods for evaluating chromatin higher order; Bioinformatics and Statistical methods.

Unit III [7]

Functional genomics and animal models in human disease:

Functional genomics: An overview and major advancements in genomic approaches; epigenetics and metagenomics; forward versus reverse genetics; Genome editing; gene expression analyses and applications; Methods for DNA/RNA sequencing, sequence analysis and their applications; Comparative Genomics; Animal model system in human diseases: methods for generation of transgenic animals/ knock-in, knockout models (microinjection, ES cell transformation); ENU mutagenesis; RNAi approach; Some examples.

Unit IV [**8**]

Pharmacogenetics:

History, Early evidence; Clinical determinants; Molecular insights (genes involved in pharmacokinetics and pharmacodynamics of drugs); Applications in pre-prescription testing.

Current trends in medical genomics:

Cytogenetics/ Molecular Cytogenetics/ Biochemical/ Molecular methods; Screening for mutation/ chromosomal anomaly - Adult/Prenatal/Newborn screening; Pre-implantation screening (Assisted reproductive technology- *in vitro* fertilization and Embryo transfer); Forensic testing - DNA fingerprinting, paternity testing, individual identification.

Unit V [7]

Treatment and management of genetic disorders:

Methods of therapy - Drug (recombinant proteins); Diet; Gene (Viral vectors, delivery methods, efficacy); Gene editing-CRISPR technology; Dosage compensation, Genomic imprinting, Stem cell therapy and gene editing; Some examples (Thalassemia, Phenylketonuria, Cystic fibrosis, Duchenne muscular dystrophy (DMD), etc.).

Genetic counseling:

Principles of genetic counseling; Causes and factors for seeking counseling; Risks and benefits; Dysmorphology; Ethical and legal issues in genetic counseling; Informed consent; Right of choice; Dilemmas faced by counselors; Case studies.

References

1. Strachan T. & Read A., 2018, Human Molecular Genetics, 5th Ed., CRC Press.
2. Pasternak J.J., 2005, An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases, 2nd Ed., Wiley.
3. Nussbaum R., McInnes R. and Willard H., 2015, Thompson and Thompson Genetics in Medicine, 5th Ed., Elsevier.
4. Harper P.S., 2004, Landmarks in Medical Genetics, 1st Ed., Oxford University Press.
5. Speicher M., Antonarakis S.E., Motulsky A.G., 2016, Vogel and Motulsky's Human Genetics: Problems and Approaches, 5th Ed., Springer.
6. Allis C.D., Caparros M., Jenuwein T., Reinberg D., 2015, Epigenetics, 2nd Ed., Cold Spring Harbor Laboratory Press.
7. Behrend C., Hagh J.K., Mehdipour P. and Schwanitz G., 2017, Human Chromosome Atlas: Introduction to diagnostics of structural aberrations, 1st Ed., Springer.
8. Paro R., Grossniklaus U., Santoro R., Wutz A., 2021, Introduction to Epigenetics (Learning Materials in Biosciences), Springer.

Subject : Personalized Molecular Medicine (Theory)
Paper Code : AIPM 203

Course Objectives:

This course will provide an in-depth analysis of molecular medicine and advances in the field taught through a combination of didactic methods and the use of case studies. Topics will include basic principles of molecular medicine, discoveries in cellular and molecular biology, disease mechanisms and development, clinical research, biomedical ethics, and personalized medicine. Lecture instruction may include understanding: how genes are used for personalized medicine, how current devices and therapeutics are used for the detection and treatment of cancer, how cell-based therapeutics are used to eradicate disease, and how molecular medicine impacts global health.

Learning outcomes

On completion of the course, the student should be able to:

- Understand and explain the organizational requirements for the translation of biomedical therapeutics from bench to bedside.
- Debate the impact translational research has had on human health and disease.
- Articulate the significance and potential of molecular medical advances in biomedical research.
- Debate ethical issues, analyze key moral concepts and principles, and discuss them productively with others.
- Make responsible decisions about social issues that relate to translational medicine such as availability and cost of therapies, use of human subjects in research, race and ethnicity in clinical trials.
- Identify and utilize well established and reputable sites for scientific research.

Contents

Unit I: INTRODUCTION TO MOLECULAR MEDICINE - 16 Hrs

Using WGS/WES: NGS Raw data FASTA Sequence alignment, Genome assemblies of NCBI and UCSC, Variants calling, .VCF files, .VCF annotations, Pipelines for disease specific and traits specific mutation identification, mutation annotation (wANNOVAR, SG-ADVISER and

others), gene enrichment analysis, disease gene and candidate gene identification strategies, gene-protein and protein-protein network construction, gene-based drug selection (PharmGKB, DrugBank, DGIdb, Druggable Human Proteome), Building pathways using genes bearing mutations, strategies for identifying both known and novel genes for diseases, strategies for identifying both known and novel mutations/polymorphisms in genes, disease risk and protection assessment.

Nutrigenomics: Identifying good and poor metabolizers, Interpretation, Statistics and Data Quality Assurance in Genome Analysis

Unit II: PERSONALIZED MOLECULAR MEDICINE MAPPING - 8 Hrs

Personalized Genomic Medicine map Drug toxicity estimation, drug response efficacy, and drug dosing recommendations. Personalized Genomic Medicine map creation, clinical development of drugs and biologics, drug repositioning, personalized report preparation, strategies for deciding treatment options, counseling patient and family members, ethics and conversing with clinicians and healthcare personnel.

Unit III: MOLECULAR DIAGNOSTICS OF DISEASES - 14 Hrs

Clinical & molecular diagnostics using microarray, microarray based gene expression in cancer cells for personalized treatment, identifying molecular targets for cancer, tumor profiling for targeting cancer treatment and the use of blood-based gene expression profiles in cancer prognosis.

Next Generation Sequencing: Handling Big Data, The use of next-generation sequencing for solving diagnostic dilemmas, Methods used in patient populations to uncover associations between genome variation and common diseases, Predictive tests for common, complex diseases.

Unit IV: DRUG DEVELOPMENT - 6 Hrs

Pharmacogenomic testing for drug selection, dosing and predicting adverse effects of commonly prescribed drugs, drug-drug interactions. In silico protein modelling, drug target prediction, 3D drug molecule structure and drug-protein docking

Unit V: MINDING THE BUSINESS OF GENOMICS - 6 Hrs

The Commercialization of Genetic Testing, Obstacles in Establishing Genetic Testing as Consumer Product,Connecting Consumer Needs with Genetic Testing through Marketing,Challenges to Marketing Genetic Testing,Stimulating Market Growth for Genetic Testing,Integrating Genetic Testing with Clinical Practice. Opportunities and Challenges in the Genomic Era.

Suggested Reading:

1. Human Molecular Genetics Strachan T. & Read A. Garland Science
2. An introduction to Human Molecular Genetics: Mechanism of Inherited Diseases Pasternak J. Fitzgerald Science Press
3. Thompson and Thompson Genetics in Medicine Robert et al. Saunders
4 Landmarks in Medical Genetics (Ed.) Harper P. S. Oxford University Press
5. Chromosome Banding Sumner A.T. Unwin Hyman
6. Human Genetics: Problems and Approaches Vogel F. and Motulsky A. G. Springer Verlag

Subject : Drug Design and Discovery (Theory)
Paper Code : AIPM 204

Course Objectives

Drug discovery is a costly and time-consuming process that takes 10 to 15 years and costs more than $1.3 billion. Several drug candidates fail in the late stages of development due to a lack of ability to demonstrate safety and pharmacokinetics in clinical trials. Computer-assisted drug design can minimize the rate of failure in drug discovery and development by speeding up the process, reducing surprises, and predicting drug-like features of molecules. From target identification to drug design and optimization, this course will take you through the whole drug design process. Throughout the course of the study, you will learn the fundamentals of drug design, utilizing rational approaches such as structure-based drug design, Ligand-based drug design, and drug-like property prediction.

Learning Outcomes

On completion of this course students should:

- Describe and justify the importance of rational drug design methods over irrational approaches.
- Be able to describe various methods of drug design.
- Be able to discuss the challenges of using various computer-assisted drug design methods
- Gained a basic knowledge of applying computational methods in drug design and discovery.

Syllabus:

Unit I [**10**]

Introduction to drug design and discovery

Stages of Drug discovery and development, Drug Discovery approaches – Drug discovery by Rational Drug design, Random Screening, Serendipity, Clinical observations, etc. with examples. Case studies of successful drug discovery using rational drug design methods - HMG CoA reductase inhibitor-Statins, H-2 Histamine antagonist – Cimetidine, HIV protease inhibitors, Choline esterase inhibitors.

Fundamentals of Computational drug design

Introduction to molecular mechanics and quantum mechanics, Energy Minimization methods and Conformational Analysis

Applications of Computational methods in drug discovery.

Unit II [**8**]

Target Identification and Validation

Target identification methods, Criteria of target validation, Study of targets using RCSB protein data bank, Concept of Homology modeling for construction of a model for target protein

Lead generation and databases

1D, 2D, and 3D chemical structures and software to draw it – Chemdraw, MarvinSketch, ACD/ ChemSketch, etc., Converting 2D to 3D chemical structures – Open Babel, Small molecule structure databases – ZINC, Drug bank, Coconut, ChEMBL, Pubchem, etc.

Structure-based drug design (SBDD)

Concept of SBDD, Methods of SBDD – Docking, Fragment-based drug design, Denovo drug design, etc., Ligand receptor interaction, Binding energy scores. (Dock score)

Unit III [**10**]

Molecular Docking

Concept and application of molecular docking, Steps in molecular docking – Protein preparation, Ligand preparation, Active site identification, Grid generation, Selection of parameters for docking, interpretation of docking results. Software used for molecular docking studies

Molecular Dynamic Simulation

Introduction to molecular dynamics. Importance of molecular modeling in drug design. Software used for molecular dynamics studies.

Unit IV [**10**]

Quantitative Structure Activity Relationship (QSAR)

SAR versus QSAR, History, and development of QSAR, Types of physicochemical parameters, experimental and theoretical approaches for the determination of physicochemical parameters such as Partition coefficient, lipophilic effects, logP, and logD, the effect of ionization on logP, calculation of logP and logD, Steric effects- the Taft equation Hammet's substituent constant and Tafts steric constant. Hansch analysis, Free Wilson analysis, 3D-QSAR approaches like COMFA and COMSIA. Software used for 3D QSAR Studies.

Pharmacophore Mapping

Pharmacophore concept, Introduction to Pharmacophore mapping, Steps in Pharmacophore mapping studies, Applications of Pharmacophore modeling studies. Software used for Pharmacophore mapping.

Unit V [7]

Virtual screening (VS)

Concept of virtual screening. Virtual screening Vs High throughput screening. Different methods of virtual screening e.g. Docking-based VS, 3D QSAR, Pharmacophore-based VS.

Drug like Properties (DLP)

Concept of Drug like Properties, Importance of DLP in drug discovery projects, Prediction of Absorption, Distribution, Metabolism, Elimination and Toxicity (ADMET) of the molecule, Lead Optimization, Software for prediction of DLP.

Cheminformatics, Bioinformatics, and Artificial Intelligence

Introduction to Cheminformatics, Bioinformatics, and Artificial Intelligence and their applications in drug discovery and development.

References

1. Stroud R.M. and Moore J.F., 2008, Computational and structural approaches to drug discovery, Vol. 8, RSC Press.
2. Martin Y.C., 2010, Quantitative Drug Design: A Critical Introduction, 2nd Ed., CRC Press.
3. Smith J.H. and Williams H., 2006, Principles of Drug Design and Action, 4th Ed., CRC Press.
4. Abraham D.J., 2003, Burger's Medicinal Chemistry and Drug Discovery, 6th Ed., Vol. 1, John Wiley & Sons: New York.
5. Burger's Medicinal Chemistry, Drug Discovery and Development, 8th Ed., Vol. 1, 2021, John Wiley & Sons: New York.
6. Patrick G.L., 2013, An Introduction to Medicinal Chemistry, 5th Ed., Oxford University Press.
7. Beale J.M. and Block J.H., 2011, Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, 12th Ed., Lippincott Williams & Wilkins.
8. Kerns, E.H.; Di, L., 2008, Drug-Like Properties: Concepts, Structure Design, and Methods: from ADME to Toxicity Optimization, 1st Ed., Academic Press, Oxford.
9. Leach A. R., 2001, Molecular Modelling – Principles and Applications, 2nd Ed., Prentice-Hall.
10. Strømgaard K., Krogsgaard-Larsen P. & Madsen U, 2016, Textbook of Drug Design and Discovery, 5th Ed., CRC Press.
11. Baron R., 2012, Computer-Aided Drug Design, Humana Press.
12. Kubinyi H., 1994, 3D QSAR in Drug Design: Theory, Methods, and Applications, Vol. 1, Springer.
13. Schlick T., 2010, Molecular Modeling and Simulation -An Interdisciplinary Guide, 2nd Ed., Springer.
14. Artificial Intelligence in Drug Discovery. United Kingdom: Royal Society of Chemistry, 2020.

Subject : Analytical Skills in Precision Medicine
Paper Code : AIPM 205

Objective

To understand the basic and advanced molecular techniques used for detection and diagnosis of genetic and infectious diseases.

Course Outcome

- Students will be familiar with advanced techniques currently used in the biomedical field for the diagnosis of diseases.
- It will also provide expert training in informatics-based approaches and biomedical technologies enabling to design, perform and derive new knowledge from personalised medicine.

Unit I: INTRODUCTION TO MOLECULAR BASIS OF DIAGNOSIS - 12 Hrs

The Polymerase Chain Reaction.Bioinformatics: Computer Based Approaches to Genetic Analysis .Molecular Diagnostic Technologies: PCR-Based Methods for Mutation Detection, Alternative Methods for Amplified Nucleic Acid Testing, Electrophoretic Methods for Mutation Detection and DNA Sequencing, Single-Nucleotide Polymorphisms:Testing DNA Variation for Disease Association, Microarray Approaches to Gene Expression Analysis, Methods for Analysis of DNA Methylation.

Unit II: CLINICAL DIAGNOSTIC TECHNOLOGIES – 8Hrs

Flow Cytometry, Medical Cytogenetics, Fluorescence In Situ Hybridization, Immunohishemistry, Laser Capture Microdissection (FFPE). Quality Assurance in the Molecular Diagnostics Laboratory, Framework for Quality Assurance in Molecular Diagnostics, Verification of Molecular Assays, Standards and Standardization of Molecular Diagnostics.

Unit III: LABORATORY-DEVELOPED TESTS IN MOLECULAR DIAGNOSTICS, APPLICATIONS OF MOLECULAR DIAGNOSTICS FOR GENETIC DISEASES – 12 Hrs

An Overview of Molecular Genetics, Genetic Basis of Neurologic and Neuromuscular Diseases, Molecular Mechanisms of Endocrine Disorders, Molecular Pathogenesis of Cardiovascular

Disease, Molecular Diagnostics in Coagulation, Cystic Fibrosis, Prenatal Genotyping for Identification of Fetuses at Risk for Immune Cytopenic Disorders, Personalized Medicine, Applications of Molecular Diagnostics for Human Cancers ,Molecular Pathogenesis of Human Cancer, Application of Molecular Diagnostics to Hereditary Nonpolyposis Colorectal Cancer, Molecular Genetic Applications to the Diagnosis of Lymphoma ,Molecular Genetic Abnormalities in Acute and Chronic Leukemias, Applications of Molecular Diagnostics for Infectious Diseases:Molecular Testing for Chlamydia trachomatis and Neisseria gonorrhoeae, Human Papillomavirus,

UNIT IV: DIAGNOSTIC METHODS OF INFECTIOUS DISEASES (VIRAL, BACTERIAL AND FUNGAL) – 6 HRS

Viral diseases RNA and DNA viruses- Pox virus, herpes virus, retrovirus, hepatitis, adenovirus, Bacterial diseases- Gram positive and negative bacteria causing human infections, Staphylococcal infections, Streptococcal infections, Vibrio cholera infections, Klebsiella infections, Salmonella infections, Shigella infections, Neisseria infections, Fungal diseases-cutaneous, sub-cutaneous and systemic infections. Histoplasma infections, Candida infections, Cryptococcus infections. Advantages and disadvantages of DNAbased diagnostic methods, Confocal Microscopy

Unit V: APPLICATIONS OF MOLECULAR DIAGNOSTICS FOR IDENTITY-BASED TESTING – 8 Hrs

HLA Typing Using Molecular Methods , Molecular Analysis for Forensic Casework and Parentage Testing , Molecular Assessment of Bone Marrow Transplant Engraftment , The Use of DNA-Based Identity Testing for Specimen Identification .Issues for the Clinical Molecular Pathology Laboratory:Genetic Counseling Considerations in Molecular Diagnosis , Ethical, Social, and Legal Issues Related to Molecular Genetic Testing

Reference Text Books

1. Buckingham and Flaw's, "Molecular Diagnostics: Fundamentals, Methods and Clinical Applications", F.A. Davis Company; First edition , 2007.

2. Molecular Diagnostics: For the Clinical Laboratorian / Edition 2 William B. Coleman (Editor), Gregory J. Tsongalis (Editor) Publisher: Springer-Verlag New York, LLC.

Subject : Practical Laboratory Research Skills-II(Practical)
Paper Code : AIPM 206P

Bioinformatics Practical

1. **Molecular Modelling Practical**

This practical will teach how to use molecular visualization software to explore the structure and properties of small, drug-like molecules, including conformational models and superimpositions.

2. **Molecular Modelling Practical: Visualization**

Students will use the same molecular visualization software to examine protein structures, protein/ligand interactions, and DNA/ligand interactions pertinent to structure-based drug design.

Subject : AI and ML (Practical)
Paper Code : AIPM 201P

Implementation of AI techniques and Machine Learning Models in different Healthcare Use Cases and relevant Case studies.

Semester 3

Subject : Machine Learning and Deep Learning in Disease
Paper Code : AIPM 301

Course Objectives:
With the advance of science and modern technology, several branches of science, programming, and new algorithmic developments have been designed and developed for various applications and uses. Deep learning is one such newly formed branch of science. It is instead a blend of science, mathematics, statistics, and algorithms Along with programming and coding elements. Deep learning is a subfield or part of machine learning. It consists of algorithms that are replications or inspirations of the human brain, designed to imitate the structure and work of the human mind, and are called an artificial neural network. Deep learning has a varied range of applications, which has led to a rise in its popularity and its usage in various industries. It is used by several organizations from different sectors or industries. Some fields of application of deep learning are : Image and fingerprint recognition functions, Open source platforms with customer recommendations, Medical research tool, Business trends and outcomes, Banking apps

Learning Outcomes:
On completion of the course, the student should be able to:

- Comprehend various Deep Learning Models.
- Identify Deep Learning dimensions in health care industry.
- Understand Deep Learning applications in Disease

Course Contents:

Unit I: INTRODUCTION
Introduction: Deep Learning in Data Science, Role of Deep Learning in Healthcare, Mathematical Foundations, Dimensionality Reduction Methods, Deep Learning Concepts, CNN, RNN, Boltzmann Machine, ANN, Time Series Modelling, DNN. **[12]**

Unit II DEEP LEARNING MODELS **[12]**
Deep Neural Network with Data, DNN for Time Series Forecasting, Attribute Additions in Models, RNN for back-propagation with time, Elman NN, Jordan NN, NARX Network, LSTM-RNN

Unit III DEEP LEARNING APPLICATIONS **[10]**
DNN for Covid-19 estimations, Landmark Detection, Image Classification using DNN, Pandemic Management, Text mining and NLP for Health informatics, Disease Detection, Privacy preserving Techniques and Framework.

Unit IV DEEP LEARNING IN DISEASE DETECTION **[10]**
Facial Emotion Detection, Alzheimer's Detection, Glaucoma Detection, Chronic Kidney Disease Prediction, Cancer prevention, Modelling for Nipah Virus, Brain Tumor Detection, Biomedical Signal Analysis, Neuro-Degenerative disease detection, Clinical Decision Support Systems, ECG image classification, Heart Disease prediction, Mental Health Analysis, Liver Disease Prediction, Utilysing IoT and Biofeedback Measures,

Suggested Reading:

1. Deep Learning: Methods and Applications. Foundations andTrendsby Li Deng and Dong Yu. 2014, Now Publishers
2. Deep Learning Made Easy with R: A Gentle Introduction for Data Science by Dr. N.D. Lewis. 2016, CreateSpace
3. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville. 2016, MIT Press
4. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms. 2017, O'Reilly Media

Subject : Proteomics and Metabolomics
Paper Code : AIPM 302

Course Objectives:
Proteomics and metabolomics play significant role in precision medicine. In the last one decade, the role and importance of metabolite in biomarker discovery is increasing and therefore, to provide the advance knowledge to the prospective students is a contemporary need in the curriculum for better understanding about the application of AI.

Learning Outcomes:

Upon completion of the course, the student should be able to understand:

- Introduction of proteomics and metabolomics in biomedicine and biology.
- To understand the tool and techniques for proteomics and metabolomics study.
- Learn about basic application of proteomics and metabolomics in biomedicine and biology research.
- Able to carry out basic experimental design for a given biological and biomedical problem
- Able to carry out raw data analysis on collected measurement raw data such as conversion to standardized format, quality control and identification of metabolite and proteins.

Course Contents:

Unit I: INTRODUCTION TO PROTEOMICS AND METABOLOMICS

Introduction to proteomics and metabolomics, Source of biological samples for proteomics and metabolomics study, Types of Metabolites and their role in human physiology, Hierarchical organization of protein structure – Primary, Secondary, Tertiary and Quaternary structure, Pacing of protein structure, Ramachandran Map, Protein folding, Peptide Sequencing, Protein expression, Concept of Phenomics, Metabolites and metabolite profiling, targeted and untargeted metabolomics, General workflow including quenching and sample preparation **[10]**

Unit II: ANALYTICAL TECHNIQUES OF PROTEOMICS AND METABOLOMICS **[15]**

Analytical techniques use in metabolomics profiling (NMR, HPLC-MS, UHPLC-MS, CE-MS, GC-MS), Proteomics technologies: Identification and analysis of protein by 1D and 2D-Gel electrophoresis, isoelectric focusing, 2D gel spot picking and visualization, Western Blotting, Protein Microarray, Mass Spectrometry (LC-MS, LC-MS-MS, GC-MS), ERLIC Chromatography technique, HILIC Chromatography technique, Mass Spectrum (base peak, molecular ion, fragment ion), Hard and Soft Ionization, Types of mass analyzers and their significance, Chromatographic techniques of protein purification

Unit III: APPROACH OF PROTEOMICS AND METABOLOMICS TECHNIQUES IN DISEASE BIOLOGY **[10]**

Clinical proteomics and metabolomics, Targeted and Nontargeted LC-MS Approach for metabolomic study, Protein-Protein Interaction, ELISA, Immunoprecipitation, Yeast two hybrid system (Y2HS), Tryptic digestion, Top down and bottom up proteomics, Analytical study of protein modification, Single Reaction Monitoring (SRM)

Unit IV: ROLE OF PROTEOMICS AND METABOLOMICS IN DISEASE BIOLOGY **[5]**

Role and scope of proteomics and metabolomics in disease biology, Metabolomics in precision medicine, Proteomic and Metabolomic biomarker discovery with case study

Unit V: PROTEOMICS AND METABOLOMICS DATA SET ANALYSIS **[5]**

Software tools available for metabolomic analysis, Raw file formats of proteomics and metabolomics and their analysis, PDB data base, HMDB (Human Metabolome Data Base), MASCOT, Proteome Discoverer, Pin Point Software, Statistical methods (PCA, PLS, PLS-DA) in metabolomics

Textbooks/ References/Further Reading:

1 Fan, Lane, Higashi. The Handbook of Metabolomics, Springer, 2012.
2 Datta, Mertens. Statistical Analysis of Proteomics, Metabolomics and Lipidomics data using Mass Spectrometry, Springer, 2017.
3 Holmes, Lindon, Nicholson. The handbook of metabonomics and metabolomics. Elsevier, 2007.
4 Mishra, Blobel. Introduction to Proteomics, Principles and Applications, Wiley, 2010.
5 Nelson, Cox. Lehninger Principle of Biochemistry, 8th Edition, 2021.

Journals

1 Proteomics
2 Journal of Proteomics
3 Metabolomics

Other Electronic Resources

1 NPTEL
2 SWAYAM

Subject : High-Throughput Technologies

Paper Code : AIPM 303

Course Objectives:

The course deal with Rapid technological advances have made high-throughput technologies available for the study of biological systems, laying the foundation for the development of the "-omics" era. This offers the ability to carry out high-throughput studies characterized by big data production. Indeed, the completion of the first human genome sequence and the availability of high-scale technological tools have made it possible to study genomics, transcriptomics, epigenomics, and other -omic sciences at a previously unthinkable level. The integration of these disciplines is further increasing our understanding of the molecular bases of human diseases. This module aims to offer a comprehensive overview of the fundamentals of omic sciences and the potential of the datasets emerging from these technologies to diagnose, monitor, target including drug discovery for common diseases.

Learning outcomes

On completion of the course, the student should be able to:

- High-throughput technologies are those that allow the generation of large-scale data related to omic analysis (such as genomics, transcriptomics, proteomics, phenomics, and metabolomics).
- Explains the newly available technologies such as High-throughput sequencing (HTS),High-throughput screening (HTS) High-Throughput Imaging, High-throughput protein sequencing

Unit I: High-throughput sequencing : 12 Hrs

Regulation of Gene Expression, Chromatin Immunoprecipitation Sequencing (ChIP-seq); Methylation Sequencing (Methyl-seq); Transcriptome Sequencing (RNA-seq); Ribosomal Sequencing (Ribo-seq); The Future of Sequencing Technology; Fluorescent Probes, Comparative Transcriptomics Analysis, Recent Advances in Nutrigenetics and Nutrigenomics, Experimental methods to study protein–nucleic acid interactions, High-throughput protein sequencing.

Unit II: High-Throughput Imaging for the Discovery of Cellular Mechanisms of Disease: 12 Hrs

Fluorescence microscopy; High-content imaging; High-throughput imaging; Automated microscopy for high-content RNAi screening; Microscopy-based high-content screening;

quantitative analysis of two-dimensional fluorescence microscopy images for cell-based screening; High-throughput RNAi screening; Phenotypic profiling of the human genome by time-lapse microscopy reveals cell division genes Identification of gene positioning factors using high-throughput imaging mapping.

Unit III: High Throughput Analysis: 10 Hrs

Biomedical sampling - Automation and high throughput; Analysis of Glycans - Polysaccharide Functional Properties; In Vitro Characterization of Cell–Biomaterials Interactions; Microsensors - development of innovative therapeutic nanostructures

Unit VI: High-Throughput Screening in Drug Discovery: 12 Hrs

Drug Discovery Technologies; Streamlining the Purification Process; HPLC-MS;High-throughput NMR-based screening; Virtual high throughput screening (vHTS)

Suggested Reading:

1. Next Generation Sequencing & Applications, by Preethi Kartan (Editor).
2. Next-Generation Sequencing in Medicine (Perspectives CSHL) 1st Edition, by W. Richard McCombie (Editor), Elaine R. Mardis (Editor), James A. Knowles (Editor), John D. McPherson (Editor).
3. High-Throughput Screening in Drug Discovery Jörg Hüser (Editor), Raimund Mannhold (Series Editor), Hugo Kubinyi (Series Editor), Gerd Folkers (Series Editor)
4. High Throughput Screening Methods and Protocols, Editors: William P. Janzen
5. A Practical Guide to Assay Development and High-Throughput Screening in Drug Discovery By Taosheng Chen

Subject : Novel Therapies: From Concept to Clinical Translation
Paper Code : AIPM 304

Objective

To provide awareness in next-generation therapies, training in translational research and rapidly-developing topics in advanced therapeutic medicines.

Course Outcome

- Students will be able to understand translational research illustrating all steps required to progress novel therapies from bench-to-clinic.
- It will also provide expert training in gene and nucleic acid-based therapies; new horizons in pharmacology; regenerative medicine to the students who will be equipped to significantly contribute to these rapidly expanding fields.
- It will prepare the student for careers in industry and higher study in this area of novel therapies.

UNIT I: **INTRODUCTION TO NOVEL THERAPIES** - 12 Hrs

Introduction of classical therapy, Overview of novel therapy, Introduction to genetic engineering, Recombinant DNA technology, Site-directed mutagenesis, Gene transfection techniques, Application of Genetic Engineering, Application of novel therapies, Protein engineering, Basic concepts of Immunology and Immunotechnology, Replacement therapies and apllications.

UNIT II: **GENE OR RNA-BASED NOVEL THERAPIES** - 10 Hrs

Overview of Gene therapy, Types, DNA-based gene therapy, DNA vaccine, Non-coding RNA based gene therapy, RNA interference, Antisense oligomer (ASO), siRNA, miRNA, anti-miRNA, shRNA, Aptamer-RNA, mRNA-based therapeutics (RNA vaccine), RNA activation and saRNA-based approaches, Gene editing technologies, CRISPR-Cas technology, CRISPR-Cas9, sgRNA, Viral and non-viral delivery, Application in various diseases, Their stability and limitations.

UNIT III: **PEPTIDE/ PROTEIN-BASED NOVEL THERAPIES** - 8 Hrs

Overview of peptide therapy, Traditional peptide technologies, Peptidomimetics, Rational design of peptide therapeutics, Emerging peptide areas and technologies, Discovery of novel peptides,

Therapeutic peptides and toxicity, Stability of peptides and formulations, Peptide based vaccines, Peptide inhibitors/ regulators for various diseases

UNIT IV: **CELL- BASED NOVEL THERAPIES** - 9 Hrs

History of cell therapies, Types, Methods of cell therapeutic manufacturing, Acquisition and isolation of cells, Activation and genetic modification of cells, Harvest, formulation, and administration of cells, Analytics for cell therapy manufacturing, Stem cells and cell signaling, Stem cell therapy, Probiotic based therapy, Chimeric antigen receptor (CAR) T-cell therapies

UNIT V: **CLINICAL TRASNLATION OF NOVEL THERAPIES** - 6 Hrs

Scale-up technology, Manufacturing and formulations, Hybridoma technology, Monoclonal antibody production, Clinical evidences of novel therapeutics, FDA approved gene/ RNA/ protein/ cell therapies, Industrialization of novel therapies, Analytics of novel therapy, Standardization and regulation of novel therapies, Clinical trial basics and for novel therapies

TEXTBOOKS/ REFERENCES/FURTHER READING:

1. RNAi: A Guide to Gene Silencing Ed.: Gregory J. Hannon, Cold Spring Harbor Laboratory, 2003
2. CRISPR/Cas Genome Editing: Strategies And Potential For Crop Improvement, Ed.: Anjanabha Bhattacharya, Vilas Parkhi, Bharat Char, Springer Cham, Switzerland AG, 2020
3. Gene Therapy, Mauro Giacca, Springer Milano, Verlag Milan, 2010
4. Cell And Gene Therapies, Miguel Perales and Syed A Abutalib and Catherine Bollard, Springer Cham, Switzerland AG, 2018
5. Chimeric Antigen Receptor T-Cell Therapies for Cancer: A Practical Guide, Daniel W. Lee, Nirali N. Shah, Elsevier, 2019
6. Biotechnology: Applying the Genetic Revolution, David P. Clark, Nanette J. Pazdernik, 2008
7. Trends in Biotechnology, 2021
8. Frontiers in Bioengineering Biotechnology, 2020
9. Nature Reviews Drug Discovery, 2014
10. Cell Death Dis, 2022

Subject : Clinical Interpretation of Precision Diagnostics and Response Monitoring
Paper Code : AIPM 305

Course Objectives:
It is an emerging approach which takes into account variability in the biology, environment, and lifestyle for each individual person to help guide disease diagnosis and treatment. In particular, genetic and genomic data allow us to go beyond conventional histo-pathological assessment, and classify diseases into distinct sub-entities that guide our choice of the right treatment to the right patient at the right time.

In order to make clinical interpretations a reality, the clinical development of diagnostics and therapeutics need to go hand in hand. Future leaders, whether in research or in the clinic, will need a broad understanding of the field and an ability to work with a range of stakeholders.

Learning Outcomes:
On completion of the course, the student should be able to:

- Provide with technical knowledge and an in-depth scientific background in genetics, bio-informatics and statistics;
- Introduce to clinical interpretation, and experimental approaches for validation;
- Foster research skills, in particular critical appraisal and discussion of research findings.

Course Contents:

Unit I: INTRODUCTION
Introduction: Historical Background, Contemporary Approaches, Non-Clinical Comparisons, Justifying Interpretations, The Methodology of Clinical Interpretations: Problems and Progress **[10]**

Unit II **[15]**
Interpreting blood gas results on venous, capillary, and umbilical cord blood; Calcium physiology and clinical evaluation; Magnesium physiology and clinical evaluation; Phosphate physiology and clinical evaluation; Osmolality, sodium, potassium, chloride, and bicarbonate; Lactate physiology and diagnostic evaluation;

Unit III **[15]**
Collection and handling of samples: effects on blood gases, Na, K, ionized Ca, Mg, lactate, and phosphate analyses; Quality control in blood gas and critical care testing; Models for point-of-care testing of critical care analytes;

Unit IV **[5]**
Electrophysiologic Investigation: Technical and General Aspects, Sinus Node Function, Atrioventricular Conduction

Suggested Reading:

1. Josephsons's Clinical Cardiac Electrophysiology: Technique and Interpretations by Mark E Josephson, 5th Edition. 2008, Lippincott Williams & Wilkins

2. Depth - Psychological Understanding: The Methodologic Grounding of Clinical Interpretations by Philip F. D. Rubovits - Seitz. 1994, The Analytic Press.

3. Blood Gases and critical care testing: Physiological, Clinical interpretations, and laboratory applications by John G. Toffaletti and Craig R. Rackley. Third Edition, 2022, Academic Press

Subject : Research Methodology
Paper Code : AIPM 306

Course Objectives:

This course is about demystifying research and research methods. It will outline the fundamentals of doing research, aimed primarily, but not exclusively, at the postgraduate level. The course will complement the research aptitude of students by developing the understanding of research approaches and skills, and importantly an ability to deploy them in studies along with professional skills.

The focus will be placed on qualitative and quantitative research methodologies, sampling approaches, and primary and secondary data collection. There will be an exploration of the sampling design process and different sampling approaches, including probability and non-probability sampling as well as sample size issues. It will further look at the nature and scope of primary and secondary data, and the importance of measurement. Moreover, it will discuss the role of the Internet in market research as well as scaling techniques.

Learning Outcomes:

On completion of the course, the student should be able to:

- Provide with research knowledge and an in-depth scientific background in different research methodologies;
- Introduce to different sampling approaches for validation;
- State of Art research skills, in particular Primary and secondary data collection approaches

UNIT 1

Introduction to Research, Characteristics and types of Research, Review of Literature in Research, Research Problem, Steps of Research, Language of Research, Types of Research papers, formats, presentation styles, and ways of publications.

UNIT 2

Language of Research, Research Design, Measurements and Measurement Scales, Sampling, Descriptive Statistics, Measures of Associations.

UNIT 3

Statement of Theory or Hypothesis, Specifications of Mathematical models and Metric Models, Obtaining Data, Estimation of Metric Model, Hypothesis Testing, Forecasting or Prediction, Use of the Model for Control or Policy purposes.

UNIT 4

Application of Information and Communication Technology (ICT) in Research, Role and Characteristics of ICT, Online Resources gathering, Tools, Internet, Emailing, Uses of internet in research work.

Suggested Reading:

1. Essentials of Research Designand Methodology by Geoffrey Marczyk, David DeMatteo, David Festinger. 2005, John Wiley & Sons.
2. Research Methodology: Methods and Techniques by C R Kothari.02004, New Age International

Yogic Science
Paper Code -AIPM307

Contacts: 2L **Credits: 2**

Course Overview:

The course imparts overview of history, tradition and branches of Yoga. Students are also oriented about different types of Yoga Asanas, their importance, methods, rules, regulations and limitations.

Course Objectives: The objectives of this course are:

- To understand the basic concepts and types of Yoga
- To apply the principles of Yoga to live healthy and active lifestyle
- Promote the awareness of health through yoga
- Explain Health plans and recipes in different lifestyle diseases

Course Outcomes: On completion of this course, the students will be able to:

CO1: Explain the various definitions of Yoga, history of Yoga and branches of Yoga.
CO2: Describe kinds of Yogasanas, its importance, methods, rules, regulations and limitations.
CO3: Demonstrate knowledge of pranayamas, pranaand lifestyle, breathing and lifespan.

Course Content:

Unit 1: Introduction to yoga

- Yoga – an exact science and practical system of self -culture
  History & Tradition of Yoga – Yoga sutra of Pantanjali, Yoga as explained in Bhagvad Gita, Yoga in daily life, Yoga – one of the Six Darshans (Philosophy), UN resolution and International Yoga Day
- Introduction of Hatha Yoga, Raja Yoga & Kundalini Yoga
- Eight limbs of Yoga as per Yogasutra of Patanjali – Discipline/self restraint (Yama),Observance (Niyama), Posture (Asana), Restraint of breath/exercises of life force (Pranayama), Abstraction of senses/Introversion-of attention (Pratyahara), Concentration (Dharna), Meditation(Dhyana) and Super conscious state/illumination (Samadhi)
- Aphorism from Yoga Sutra: ll.29, ll.30, 11.32, ll.46, ll.49, ll.54, lll.1, lll.2, lll.3 & lll.4 defining above terms
- Introduction of Mudras, Bandhas and Shat karmas

Unit 2: Kundalini Yoga

- Seven Chakras – Muladhara (att he anus), Svadhisthana, (at the root of organ of generation), Manipura (at the navel), Anahata (in the heart), Visudda (at the neck), Ajna (in the space between two eyebrows) &Sahasrara (at the crown of head)
- Nadis – Ida, Pingala, Shushumna
- Awakening of Kundalini by Pranayama, Asanas & Mudras by Hathayogis and through Concentration by Rajayogins

Unit 3: Raja Yoga

- Purification and Control of mind
- Concentration : Power of concentration, Aids to Concentration, Objects for Concentration, Benefits of Concentration
- Meditation : Concrete and Abstract, Types of Meditation viz Gross (Sthoola), Subtle (Sookshma), More Subtle (Sookshanmatrara) and Most subtle (Sookshamatama), Objects of meditation, Obstacles in meditation

Unit 4: Anatomy & Physiology Of Yoga

- Effect of Yoga on skeleton & Muscular system
- Effect of yoga on physiology

Unit 5: Nutrition In Yoga

- Diet according to season (Ritucharya)
- Health plans and recipes in some lifestyle diseases

Text and References:

1. Asana Pranayama Mudra Bandha by Swami SatyanandaSaraswati. Publisher: Yoga Publication Trust, Munger, Bihar, India
2. Yoga on Hypertension by Swami Shankardevanand.
   Publisher: Yoga Publication Trust, Munger, Bihar, India.
3. Essence of Yoga by Swami SivanandaSaraswati.
   Publisher: The Divine Life Society, Uttarakhand, India
4. Yoga Sutras of Patanjali by Swami Venkateshananda
   Publisher: MotilalBanarsidassPublishers Private Limited, New Delhi, India
5. Hatha Yoga by Swami Sivananda.
   Publisher: The Divine Life Society, Uttarakhand, India
6. GherandaSamhita by Swami NiranjanandaSaraswati.
   Publisher: Yoga Publication Trust, Munger, Bihar, India
7. Essence of Pranayama by Dr Shrikrishna.
   Publisher: Kaivalyadhama, Pune, India.
8. Dhyana Yoga by Swami SivanandaSaraswati Publisher: The Divine Life Society, Uttarakhand, India

Yogic Science Practical
Paper Code- AIPM307P

Contacts:4P **Credits: 2**

Course Overview:

The course imparts overview of history, tradition and branches of Yoga. Students are also oriented about different types of Yoga Asanas, their importance, methods, rules, regulations and limitations.

Course Objectives: The objectives of this course are:

- To understand the basic concepts and types of Yoga
- To apply the principles of Yoga to live healthy and active lifestyle
- Promote the awareness of health through yoga
- Explain Health plans and recipes in different lifestyle diseases

Course Outcomes: On completion of this course, the students will be able to:

CO1: Learn the procedures of Pranayama and be able to execute these.
CO2: Introduce a regular and rigorous practice of yoga for lifestyle management.
CO3: Learn the procedures of different Yogasanas, Shatkarmas and be able to execute these and guide others in practice.

Course Content:
Unit 1: Asana
HATH YOGA

Unit 1:Asana

- SukshmaVyayam (Joints Movement)

Backward Bending Asanas

- Sarpasana (snake pose)
- Bhujangasana (cobra pose)
- ArdhaShalabhasana (half locust pose)
- Shalabhasana (locust pose)
- Dhanurasana (bow pose)
- Kandharasana (shoulder pose)

Forward Bending Asanas

- Paschimottanasana (back stretching pose)
- JanuSirshasana (head to knee pose)
- PadaHastasana (forward bending pose)

Meditation Asanas

- Sukhasana (easy pose)
- Padmasana (lotus pose)

Vajrasana Group of Asanas

- Vajrasana (thunderbolt pose)
- Padadhirasana (breath balancing pose)
- ShashankBhujangasana (striking cobra pose)
- Ustrasana (camel pose)

Digestive/Abdominal Asanas

- Pawanmuktasana
- Uttanpadasana (raised legs pose)
- Nukasana (boat pose)

Standing Asanas

- AkarnaDhanurasana (bow and arrow pose)
- Tadasana (palm tree pose)
- TiryakaTadasana (swaying palm tree pose)
- Kati Chakrasana (waist rotating pose)
- Dwikonasana (double angle pose)
- Trikonasana (triangle pose)

Spinal Twisting Asanas

- BhuNamanasana (spinal twist prostration pose)
- ShavaUdarakarshanasana (universal spinal twist)
- ArdhaMatsyendrasana (half spinal twist)

Balancing Asanas

- EkPadaPranamasana (one-legged prayer pose)
- Natarajasana (Lord Shiva's pose)

Relaxation Asanas

- Shavasana (corpse pose)

Advanced Asanas

- Chakrasana (wheel pose)
- Brahmacharyasana (celibate's pose)

Unit 2: Pranayama

- Narishodhan(psychic network purification)
- Ujjayi (psychic breath)

- Kapalbhati (frontal brain cleansing breath)
- Bhastrika(bellows breath)
- Bharamri(humming bee breath)
- Surya Bhedi(vitality stimulating breath)
- Chandra Bhedi
- Sheetali (cooling breath)

Unit 3: Bandh

- JalandharaBandh(throat lock)
- UddiyanBandh (abdominal contraction)
- Moola Bandh (perineum contraction)
- MahaBandh (great lock)

Unit 4: Mudra

- Giyan Mudra (chin mudra)
- Hridaya Mudra (heart gesture)
- Bhoochri Mudra (gazing into nothing)
- Yoga Mudra (Attitude of psychic union)
- Shambhavi Mudra (eyebrow centre gazing)

Unit 5: Shat-karma

- Kapalbhati
- Neti, Jala (nasal cleaning with water)
- Agnisara (activating the digestive fire)

Subject : Practical (Research Methods)
Paper Code : AIPM 308P

As per above mentioned syllabus including (Wet Laboratory Experiments and In – Silico practicals)