

UNIVERSITY OF MUMBAI

No.UG/30 of 2010

CIRCULAR: -

The Directors/Heads of the recognized Science Institutions concerned and the Principals of the affiliated Colleges in Science are hereby informed that the recommendation made by the Faculty of Science at its meeting held on 3rd August, 2009 has been accepted by the Academic Council at its meeting held on 14th July, 2009 an adjunct meeting held on 7th August, 2009 vide item No.4.46 and subsequently approved by the Management Council at its meeting held on 21st August, 2009 vide item No.18 and that, in accordance therewith, the M.Sc. Degree Course in Nutraceuticals has been introduced by the University.

Further that in exercise of the powers conferred upon the Management Council under Section 54(1) and 55(1) of the Maharashtra Universities Act, 1994, it has made **Ordinances 5880 and 5881 and Regulations 8128, 8129, 8130, 8131, 8132, 8133, 8134, 8134-A and 8135** including scheme and syllabus relating to the M.Sc. Degree Course in Nutraceuticals is as per Appendix and that the same has been brought into force with effect from the academic year 2009-2010.

MUMBAI-400 032
16th February, 2010

PRIN. K. VENKATARAMANI
REGISTRAR

To,

The Directors/Heads of the recognized Science Institutions concerned and the Principals of the affiliated Colleges in Science.

A.C./4.46/07.08.2009

M.C./18/21.08.2009

No. UG/30-A of 2010, MUMBAI-400 032

16th February, 2010

Copy forwarded with compliments for information to :

- 1) The Dean, Faculty of Science.
- 2) The Controller of Examinations.
- 3) The Co-ordinator, University Computerization Center.



UNIVERSITY OF MUMBAI



**Ordinances, Regulations
and Syllabus for the
M.Sc. (Degree Course)
In
Nutraceuticals**

(Introduced from the academic year 2009-2010)

Indian Nutraceutical industry

Indian Nutraceutical industry has recently proved its mite both at national and international arena. With the *WTO* regime just rising on the horizon our nutraceuticals are in for a great boom especially in European and American regions. The market for these products is expected to rise in the coming years especially in the area of lifestyle medicines. Traditional systems of medicine in India will be playing a major role in these since Indian systems of medicines have been traditionally emphasizing on constitutional medicines.

Inadequacy of Trained personnel

Major hurdle faced by the R&D centers at various companies is the lack of adequately trained and appropriately oriented personnel. The lacunae become more evident when dealing with newer formulations and naturally derived food supplements.

There is a dire need for standardization techniques based on modern instrumental procedures and principles to ensure consistent quality of the nutraceutical products. A major hurdle in achieving this is the lack of adequate expertise among the manufacturers, the national laboratories and other Testing and research centers.

This lacunae needs to be addressed very diligently and the proposed programme is a step in this direction. Nutraceutical science is an interdisciplinary knowledge area and requires highly skilled personnel with strong background of both instrumental and non-instrumental (bio-assays) techniques. There is no programme available today for such a training to generate such expertise in students. There is a dire need of technical personnel with an overall expertise in human nutrition, various bioanalytical techniques, biological techniques and regulatory requirements to be able to take up R&D in nutraceutical industry.

The proposed programme has been planned to address this need of trained personnel.

Objectives of the Course

1. Develop trained manpower in the field of nutraceutical Sciences with specific emphasis for exploitation of traditional system of medicine as well as the need for changing trends in the nutraceutical Industry.
2. Training in the formulation, processing, manufacture and packaging requirements of nutraceuticals.
3. Amalgamate conventional biological sciences with modern genomic and proteomic technologies of manufacturing and analysis of nutraceuticals.
4. Impart knowledge of specialty nutraceuticals their design requirements.
5. Exposure to National & International regulatory affairs with reference to nutraceuticals

O. 5880 Title The degree shall be titled as "M.Sc. degree course in Nutraceuticals"

O. 5881 Eligibility:

A candidate for being eligible for admission to the M.Sc. Degree course in Nutraceuticals must have passed from any recognized University in India with minimum 50% marks in aggregate for students belonging to general category and 45% marks for students belonging to Reserved category or equivalent grade with any of the following science subjects up to the second year of the B.Sc. course: Chemistry, Botany, Zoology, Microbiology, Life science, Biotechnology, Biochemistry. Alternatively students with degree in Medical sciences or Graduation in food and nutrition sciences or Pharmacy with aggregates marks as mentioned above for B.Sc. degrees are also eligible.

Selection: Open Entrance test.

Students seeking admission to the M.Sc. Course in Nutraceuticals will first appear for an open Entrance test of one hour duration. The test will be of objective type questions (multiple choices) based on undergraduate syllabus with emphasis on topics from biological sciences and general knowledge.

Students will be selected for admission strictly on basis of merit list derived on the scores at the entrance examination and as per the reservation policy of the University of Mumbai and Government of Maharashtra. Students featuring in the merit list may be called for an interview and counseling session at the respective institution so that they may be acquainted about the teaching –training programme as envisaged in the syllabus.

R.8128 No.of Lectures:

60 lectures / paper; 4 papers in Part I, 4 papers in Part II

R.8129 No.of Practical periods:

4 practical of four periods each per week

Work Load:

- Four periods per week per paper where each period is of ONE hour duration
- Four practical per week. Each practical is of Four periods Where each period is of ONE hour duration.
- One Seminar per Week. Each seminar is of ONE hour Duration for a batch of TEN students.
- Guidance to the students for projects

R.8130 Passing Standard: Minimum 25 % marks in each paper and each Practical and minimum 40 % marks in aggregate in Theory and Practical separately.€€€

R.8131. Duration:

The course shall be a full time course. The course shall be covered in 2 years in 04 semester.

R.8132. Fee Structure

Particulars	Amount per year
Tuition fee	Rs.15,000
Laboratory Fee(wet and Instrument Labs)	Rs.15,000
Project/Product Development	Rs.2,500
On job Training	Rs.1,700
Industrial Visit	Rs.1,000
Library	Rs.2,000
Gymkhana	Rs. 300
Utility	Rs. 100
Extracurricular	Rs. 200
Development Fund	Rs. 1,000
Other fee	Rs. 1,000
Miscellaneous	Rs. 2,191
Internet	Rs. 200
Additional Fee	Rs. 200
PTA/NPC	Rs. 1100
Total Rs.43,491/=	

R.8133. Number of Students :20 per batch

R. 8134. The following will be the **staffing pattern** for the course;

- Instrument technician – 01
- Technical Assistant – 02
- Lecturers – 03 (full time)
01 (part – time)

and remaining workload to be completed using guest faculty.

Core Faculty :

Post-graduate degree with B+ and NET / SET qualified in the subject of Biophysics/ Biochemistry/ Biotechnology /Botany/ Chemistry/ Dietetics/ Life Sciences/ Medicine / Microbiology / Nutrition / Statistics/ Zoology

Visiting Faculty from Industry & Research Institutes

The visiting Faculty will be from a post equivalent to that of Senior Lecturer level with Ph. D and not less than 5 years of research experience or with experience in industry not below Assistant Manager Level.

R.8134-A– Mark-list

- The mark-list of the students must indicate titles of papers in the syllabus

M. Sc Part I

- Four Theory papers : 60 lectures each and seminars / presentations etc.
- Three practical
- Industrial exposure (e.g. Visits)

Distribution of Credits;

M.Sc Part I

Paper	Code	Semester –I				Semester – II			
		Lectures	Credits	Practical	Credits	Lectures	Credits	Practical	Credits
Food Chemistry and Biochemistry	FCB	60	4	60	2	60	4	60	2
Human Nutrition and Physiology, Clinical dietetics	NPC	60	4	60	2	60	4	60	2
Nutraceuticals and Functional Foods	NFC	60	4	60	2	60	4	60	2
Biostatistics, Instrumentation and Biological Evaluation	BIB	60	4	-	-	60	4	-	-
Industrial visits	INV	-	-	60	2	-	-	60	2
Seminar / Assignment	SEM	15	1	-	-	15	1	-	-
TOTAL		255	17	240	8	255	17	240	8
TOTAL CREDITS		25				25			

*Lecture allotment includes periods for seminar & Presentations.

*Units equally distributed between two terms.

M. Sc Part II

- Four Theory papers :

60 lectures for each paper per semester and seminar/presentations etc.

- Three practical

- Industrial training / Project

Paper	Code	Semester – IX				Semester – X			
		Lectures	Credits	Practical	Credits	Lectures	Credits	Practical	Credits
Microbiology, Quality and process control	MQP	60	4	60	2	60	4	60	2
Development and marketing of Nutraceutical products: Product Development, Packaging & Safety Evaluation	DMN	60	4	60	2	60	4	60	2
Molecular Biology and Biotechnology for Nutraceuticals and Functional Foods	MBB	60	4	60	2	60	4	60	2
Quality Assurance, Regulatory Affairs and Intellectual Property Rights	QAR	60	4	-	-	60	4	-	-
Industrial Training	INT	-	-	60	2#	-	-	60	2#
Seminar/Field visits	SFV	-	-	-	-	30	2	-	-
TOTAL		240	16	240	8	270	18	240	8
TOTAL CREDITS		24				26			

*Lecture allotment includes periods for seminar & Presentations.

*Units equally distributed between two terms.

Note: Industrial Training will be for 8-12 weeks and may be spread out in Semester III and IV for a total of 4 credits.

Evaluation:

- Theory Examination of all four papers for each year.
- Practical Examination.
- Successful completion of Industrial Visits (Practical III).
- Successful completion AND submission of report of project (Practical VIII).
- All rules and pattern as per University of Mumbai for M.Sc courses.

Theory Examination Question Paper Pattern:

- Each Theory paper will be of 75 marks
- Each Theory paper will be of 3 hr. duration.
- Each Theory paper will have eight questions in all divided in two sections.
- Students will attempt any five questions with at least two questions from each section.

Paper	Maximum Marks	Duration	Minimum for Passing	Remarks
I	75	3 Hr	20	
II	75	3 Hr	20	
III	75	3 Hr	20	
IV	75	3 Hr	20	
Aggregate	300	---	120	
V	75	3 Hr	20	
VI	75	3 Hr	20	
VII	75	3 Hr	20	
VIII	75	3 Hr	20	
Aggregate	300	---	120	

Practical Examination: Suggested Pattern:

- Each Practical paper will be of 50 marks (i.e. 200 marks in all)
- Each Practical paper will be of 6 hr duration on separate days, i.e. Four days in all
- For each Practical there will be 2 experiments with marks suitably assigned for Viva and Journal.
- For Practical III in Part I the marks will be allotted to the reports on the industrial visits and a presentation by the student on the visit.
- For Practical VIII in Part II the marks will be allotted to the report on the Project carried out by the student and the report submitted on the Project. Student will be asked to make a power point presentation and rating of the performance will be based on certain evaluation criteria.

R. 8135 SCHEME OF EXAMINATION

1. Each course will have:
Term work / internal assessment and external / University. Written examination of three hours and Practical examination wherever applicable of six hours duration. All examinations will be held at the end of each semester and will be conducted by the University as per the existing norms.
2. The student has to obtain 25 percent in each head of passing and 40 percent in aggregate.
3. To pass, a student shall have to get minimum aggregate 40% marks (Grade P and above on grade point scale) in each course.
4. Student failing in semester-end exam may be allowed to appear for the supplementary semester-end exam. The semester end examination will be conducted within one month after declaration of the result. The student will be finally declared as failed if he/she does not pass in all credits within a total period of two years. After that, such students will have to seek fresh admission as per the admission rules prevailing at that time.
5. If a student misses an internal assessment examination he/she will have a second chance with permission of the Institutional committee. Such a second chance shall not be the right of the students; it will be the discretion of the committee concerned to give or not to give second chance to a student to a student to appear for internal assessment.
6. A student cannot register for the next semester, if she/he fails to complete 50% credits of the total credits in each subject including Foundation course, Environmental Science and Applied components expected to be ordinarily completed in previous semester.
7. In subjects where project work is part of the credits, the project work will consist of not more than 02 credits for B.Sc. per semester and 06 credits for MSc per semester.
8. For internal (Continuous) assessment. A teacher may select a variety of procedures for examination such as:
 - i. Mid Term Test ;
 - ii. Short Quizzes / Viva / Presentations;
 - iii. Assignments / Seminars / Laboratory Journal Work ;
 - iv. Extension/Field/experimental Work;
 - v. Research Project by individual students or group of students; or
 - vi. An open Book Test / Review of Research Papers (with the concerned teacher deciding what books / scientific publications / research papers / Chapters from Reference books are to be allowed for this purpose.)

9. The system of evaluation will be as follows; Each term work module mentioned above will be evaluated in terms of marks first and then to letters grades as shown in the following table.

Marks Out Of 100	Grade	Grade Point
Greater than or equal to 90	O	10
Greater than or equal to 80 but less than 90	A	09
Greater than or equal to 70 but less than 80	B	08
Greater than or equal to 60 but less than 70	C	07
Greater than or equal to 55 but less than 60	D	06
Greater than or equal to 50 but less than 55	E	05
Greater than or equal to 40	P	04
Less than 40	F	0

10. Grade Point Average (GPA) = Total of product of grade points earned and credits hrs for each course divided by total credit hours.

$$GPA = \frac{\sum G_k * C_k}{\sum C_k}$$
11. 'B' Grade is equivalent to at least 55% of the marks as per circular No.UGC-1298/[4619] UNI-4 dated December 11, 1999.
12. The formula for GPA will be based on Weighted Average. The final GPA will not be printed unless a student passes courses equivalent to minimum 72 credits for B.Sc. and 122 credits for M.Sc.
13. A seen point grade system [guided by the Government of Maharashtra Resolution No. NGV-1298/[4619] UNI.4 dt. December 11, 1999] will be followed. The corresponding grade table is detailed in 09 above.
14. If the GPA is higher than the indicated upper limit in the three decimal digit then the student be awarded higher final grade (e.g. a student getting GPA of 3.491 be awarded 'B')
15. GPA calculation will be done by the Institute. The existing VCD guidelines will be followed for verification and revaluation. The evaluation result will be adopted if there is a change of at least 10% GPA marks and in the grade of the course.
16. For grade improvement minimum 24 credits (two papers) should be taken by the student for grade improvement. Grade improvement programme will be implemented at the end of the first semester after declaration of the final result. A student can opt for the grade improvement programme only after the declaration of final semester examination.

M.Sc Nutraceuticals: In A Nutshell

Course: Two years degree course
Base given: Four papers per year, each paper comprising of 120 lectures and 75 Marks, Practical of 200 marks per year including industrial visits in first year and submission of Research project in second year.

M.Sc. PART I

Paper No.	Title
I	Food Chemistry and Biochemistry
II	Human Nutrition and Physiology, Clinical dietetics
III	Nutraceuticals and Functional Foods
IV	Biostatistics, Instrumentation and Biological Evaluation

Practical: Four including Industrial Visits Totaling to 200 marks (Industrial visits of 50 marks, and Three laboratory courses of 50 marks each).

M.Sc. PART II

Paper No.	Title
V	Microbiology, Quality and process control
VI	Development and marketing of Nutraceutical products: Product Development, Packaging & Safety Evaluation
VII	Molecular Biology and Biotechnology for Nutraceuticals and Functional Foods
VIII	Quality Assurance, Regulatory Affairs and Intellectual Property Rights

Practical: Four including Industrial Training totaling to 200 marks (Industrial Training for 50 marks and Three laboratory courses of 50 marks each).

SYLLABUS FOR M. Sc. NUTRACEUTICALS
DISTRIBUTION OF TOPICS
M. Sc. PART I

PAPER I - Biochemistry and Food Chemistry

UNIT I – FIRST SEMESTER	UNIT II – SECOND SEMESTER
1.1 Carbohydrates, and Bioenergetics	1.2 Enzymes, Vitamins, Minerals, Flavors
1.3 Proteins, Lipids	1.4 Food preservation- principles and Techniques
1.5 Nucleic Acids	1.6 Membrane Biochemistry, Endocrinology, Biochemistry of tissues

PAPER II – Human Nutrition, Physiology and Clinical dietetics

UNIT 2 – FIRST SEMESTER	UNIT 2 – SECOND SEMESTER
2.1 Metabolism of Carbohydrates , Lipids, Vitamins and Minerals	2.2 Human physiology– Skeletal System
2.3 Amino acid and Protein Metabolisms	2.4 Human physiology– Excretory System
2.5 Disease and Nutrition	2.6 Nutritional Requirements & Special Dietary Needs

PAPER III Nutraceuticals and Functional Foods

UNITS 3 – FIRST SEMESTER	UNIT 3 – SECOND SEMESTER
3.1 Introduction to Nutraceuticals as Science	3.2 Functional Foods – I
3.3 Properties, structure and functions of various Nutraceuticals	3.4 Functional Foods – II
3.5 Food as remedies, Anti-nutritional Factors present in Foods	3.6 Nutritional Genomics

PAPER IV Biostatistics, Instrumentation and Biological Evaluation

UNIT 4 – FIRST SEMESTER	UNIT 4 – SECOND SEMESTER
4.1 Biostatistics – I	4.2 Biological testing, organoleptic responses and bioassays
4.3 Biostatistics – II	4.4 Preclinical testing and clinical trials
4.5 Introduction to Instrumentation Techniques	4.6 Advanced Instrumentation Techniques

M. Sc. PART II

PAPER V - Microbiology, Quality and Process Control for nutraceuticals

UNIT 5 – THIRD SEMESTER		UNIT 5 – FOURTH SEMESTER	
5.1	Basic Microbiology including Fermentation Technology	5.2	Biological controls and Monitoring of food quality
5.3	Products of microbial fermentations and downstream processing	5.4	Nutraceutical Industry and Market Information
5.5	Unit operations in manufacturing-I	5.6	Unit Operations in Manufacturing-II

PAPER VI: Development and marketing of Nutraceutical products: Product Development, Packaging , label claims, consumer acceptance, future prospects

UNIT 6 – THIRD SEMESTER		UNIT 6 – FOURTH SEMESTER	
6.1	Nutraceuticals and the Future of Medical Science and Consumers' views on nutraceuticals	6.2	New technologies in development of Nutraceuticals and functional foods and Chemoprevention and Nutraceuticals
6.3	Packaging strategies for nutraceutical products	6.4.	The food industry's role in promoting functional foods
6.5	Labeling and claims for Nutraceuticals products	6.6	The role of marketing Communication in the introduction of functional foods to the Consumer

PAPER VII – Molecular Biology and Biotechnology for Nutraceuticals and Functional Foods

UNIT 7 – THIRD SEMESTER		UNIT 7 – FOURTH SEMESTER	
7.1	Genetic engineering, Library construction & screenings	7.2	Plant Biotechnology & Plants as factories
7.3	Animal Biotechnology	7.4	Metabolic engineering & industrial products
7.5	Development of Novel Food and Food Ingredients	7.6	Bioinformatics

PAPER VIII : Quality Control & Assurance, Regulatory Affairs and Intellectual Property Rights

UNIT 8 – THIRD SEMESTER		UNIT 8 – FOURTH SEMESTER	
8.1	Quality Control & Quality Assurance	8.2	Medicinal Plants: Ethnomedicine In India
8.3	Intellectual Property Rights (IPR)-1	8.4	Chemi-informatics and Pharma-informatics
8.5	Intellectual Property Rights (IPR)-2	8.6	Regulatory Affairs & Regulatory certifications

M.Sc. Nutraceuticals: SYLLABUS IN DETAIL

PAPER I

Biochemistry and Food Chemistry

1.1: Carbohydrates and Bioenergetics (20 L)

- **Bioenergetics** :Enthalpy, Entropy, Free energy, laws of thermodynamics as applied to biochemical systems, energy rich compounds (ATP, PEP), role of high energy phosphates in bioenergetics and energy capture, coupled reactions, Biological oxidation reduction, redox potentials, mechanism of oxidative phosphorylation
- **Carbohydrates** :Structure, Function, Classification, Characteristic Reactions, physical and Chemical properties, Derivatives, Glycogen metabolism, its breakdown and synthesis, glycogen storage diseases, Glycolysis, gluconeogenesis, synthesis of oligosaccharides and Glycoproteins

1.2: Enzymes, Vitamins, Minerals, Flavors (20)

Enzymes :Characteristics of Enzymes as biological catalysts , classification, nomenclature, cofactors, mechanism of action, inhibitions- Competitive and non-competitive, definition of unit of enzyme activity, regulation of enzyme activity, Isoenzymes, immobilized enzymes abzymes, synzymes,

- **Vitamins**: Structure of water and fat soluble vitamins, plant animal sources, vitamins as coenzymes, deficiency of vitamins.
- **Flavours** : Natural and synthetic flavors, food colors, types properties, regulatory aspects, safety issues

1.3: Proteins and Lipids (20 L)

- **Proteins**: Essential and nonessential amino acids, peptide bond, structure, function, classification, denaturation of proteins, Metabolic breakdown and synthesis of amino acids, amino acids as synthetic precursors, heme biosynthesis, active amines, glutathione, Distribution of proteins, amount and type of proteins in food groups, protein concentrates, hydrolysates, textured vegetable proteins, proteins of egg, fish, milk, soya, Storage proteins of cereals and legumes, anti-freeze proteins, stress proteins.
- **Lipids** : Classification, saturated and unsaturated, essential fatty acids, structure and function of acylglycerols, phospholipids, sphingolipids, glycolipids, steroids, Characterization of fats- saponification, iodine, acid, peroxide values, Fatty acid oxidation, biosynthesis of fatty acids, cholesterol, metabolism of prostaglandins, thromboxanes, leukotrienes, lipoproteins

1.4: Food preservation- principles and Techniques (20 L)

- **Water**: Functions of water in body and its regulation. Solution interactions, water in food, water activity; Osmolarity, Relation between viscosity and temperature; Acid, base and pH.
- **Food stability**: freezing, lyophilization, air drying and shelf life. Gels and emulsions

- **Contamination and microbial spoilage** of various food products: Milk and milk products; eggs and poultry, fish, breads and cereals, meat, canned foods, vegetables and fruits. Food borne infections and intoxications. Methods of food preservation.
- **Radiation and Food Preservation:** Role of radiation in food preservation. Principles underlying destruction of micro-organisms by irradiation. Effect of irradiation on food constituents. Legal status of food irradiation.

1.5: Nucleic Acids (20 L)

- Structure of nucleotides, DNA, forms of DNA, replication, transcription and translation, gene regulation in prokaryotes and eukaryotes
- Biosynthesis and degradation of purines and pyrimidines, salvage pathway,
- Methods of studying Nucleic acids: Isolation of DNA & RNA, **PCR:** methodology and application in diagnosis and genome mapping. Nucleic acid hybridization, Nucleic acid sequencing, site directed mutagenesis, Northern, Southern. Western and dot blots.
- Molecular Markers: RFLP, RAPD, AFLP, STS, SCAR, CAPS, SSCP microsatellites & QTL mapping. Application of molecular markers.

1.6 Membrane Biochemistry, Endocrinology, Biochemistry of tissues (20 L)

- **Membrane Biochemistry:** Structure, supramolecular architecture, transport of substances through membranes- passive, active, facilitated, Molecular mechanism of signal transduction- gated ion channels, G protein coupled receptors and second messengers, cell- cell interaction.
- **Endocrinology:** Characteristics, classification of hormones and hormone receptors, location of glands, Mechanism of hormone action, second messengers, Biosynthesis, transport and metabolic effects of hormones.
- **Biochemistry of tissues:** Biochemistry of muscle, bone and nerve, collagen metabolism

• Suggested Reference Books:

1. Stryer E.A., Biochemistry, Moscow, Mir Publications, 1989.
2. Zubay, Geoffrey L., Biochemistry, 4th Ed, Dudagye, IAWCB Wm. C. Brown Publishers, 1988, London.
3. Murray Robert, Harper's Biochemistry, 24th Ed, Prentice Hall International UK Ltd, 1990.
4. Greenberg David M., Metabolic Pathways, Vol 3, 3rd Ed, Academic Press Pvt Ltd, New York.
5. Todd and others, Clinical Diagnosis and Management, 17th Ed, W.B.Saunders, Philadelphia.

6. Swaminathar Ganesh and Co. Essentials of Food and Nutrition, 2nd Ed, 1985,
7. Gopalan C., et al, Dietary Allowances for Indians, NIH, Hyderabad.
8. Anita F.P., Clinical Dietetics and Nutrition, 4th Ed, 1997, Oxford Univ Press.
9. Lehninger Albert, 2001, Principles of Biochemistry, Kalyani Publishers, New Delhi.
10. Devlin, T.M., 1997, 4th Ed, Text Book of Biochemistry with Clinical Correlation, Wiley Liss Inc.
11. Voet and Voet, Fundamentals in Biochemistry

PAPER II

Human Physiology and Nutrition

2.1 Energy Requirement, Proximate composition and Metabolism of Carbohydrates, Lipids, Vitamins and Minerals (20 L)

- **bioenergetics:** Enthalpy, Entorpy, Free energy, laws of thermodynamics as applied to biochemical systems, Energy rich compounds (ATP, PEP), role of high energy phosphates in bioenergetics and energy capture, coupled reactions, biological oxidation reduction, Redox potentials, mechanism of oxidative phosphorylation
- Proximate composition of foods: Analysis of food items for calorific value, protein, carbohydrates, vitamins, minerals, finer contents, etc.

Metabolism of Carbohydrates & Lipids, Vitamins and Minerals

- **Carbohydrate & Lipid Metabolism:** Food Sources, Digestion and Absorption, Alcoholic Fermentation, Formation of Lactate in Muscles, Hexose Monophosphate Shunt and its significance, Regulation of carbohydrate metabolism, Glycemic index, Lipid Metabolism: Functions and diet sources of fats. Digestion and absorption of lipids, ketone body formation and their utilization, Role of cholesterol and lipoproteins.

- **Vitamins and Minerals:** Functions of fat and water soluble vitamins and their deficiency, Vitamin like substances: Choline, Carnitine etc., Minerals: Dietary sources, metabolism, Nutritional significance, functions and deficiency of minerals and trace elements.

2.2 Amino acid and Protein metabolisms (20 L):

Functions of proteins. Metabolism and synthesis of amino acids and proteins, Urea cycle, Food Proteins and their quality, Essential amino acids, Protein energy malnutrition, Methods of evaluating protein quality.

2.3. Human physiology– Skeletal system (20 L):

Functions of skeletal system. Digestive system: different parts, secretory & digestive functions of salivary glands, stomach, pancreas, liver & intestine. Circulatory system: structure and function of heart. Composition & function of blood, coagulation of blood, Rh factor & Blood Groups, hypertension. Respiratory system: Respiratory organs, gaseous exchange, laryngitis, pharyngitis, & asthma (in brief). Reproductive system in male & female and related disorders; sex hormones.

2.4 Human physiology– Excretory System(20 L):

Function of kidney, urine formation, haematuria and uremia. Nervous System: Function of various parts of Brain: spinal cord, hypothalamus, cerebrospinal fluid, cerebral cortex; reflex action and coma. Physiology of vision, taste & smell. Endocrine glands: Functions and disorders of thyroid, parathyroid, adrenal and pituitary glands.

2.5 Nutritional Requirements & Special Dietary Needs (20 L)

Nutritional Requirements:

Recommended dietary allowances for different sections of population, Balanced Diet, Alterations in carbohydrates, protein and fat metabolism in certain conditions and nutrition needs, Factors affecting BMR and energy requirements for different activities, Role of different nutrients in health and disease, Bioavailability, Nutrient Interactions, Energy Balance and Weight Control. Nutritional requirements for different types of physical activities and sports, Special needs before and after certain intensive and prolonged sports (Pre-game and Post-game meals).

Special Dietary Needs: Nutritional requirements of vulnerable sections such as infants, pregnant and lactating women, elderly and the dietary management. Malnutrition: Occurrence, manifestation, prevention and therapeutic measures including fortification. Formulation of Diet and Foods for Specific Needs.

2.6. Disease and Nutrition (20 L):

Role of diet in hypertension, heart diseases and their prevention, Nutrition in certain conditions like peptic ulcers, diarrhoea, hepatitis. Malabsorption syndrome including intolerances and allergies. Functions of dietary fibre, soluble and insoluble in control of certain disease conditions like diabetes, cancer, heart diseases etc. Effect of drugs on ingestion, digestive absorption & metabolism of nutrients, Effect of food nutrients & nutritional status in drug dosage & efficacy.

Suggested Reference Books:

1. Krause's Food, Nutrition and Diet Therapy, 10th Edition by Mahan, L.K. & Ecott-Stump, S. (2000), W.B. Saunders Ltd.

2. Nutrition - Concepts & Controversies, 8th Edition, bySizer, F. & Whitney, E. (2000): Wadsworth Thomson Learning.
3. Understanding Nutrition, 8th Edition, by Whitney, E.N. & Rolfes, S.R.. (1999): Wadsworth, An International Thomson Publishing Co.
4. Nutrition in Exercise and Sports, 3rd Edition by Ira Wolinsky (Ed) (1998): CRC Press.
5. Modern Nutrition in Health & Disease, 9th Edition by Shils, M.E., Olson, J.A., Shike, N. and Ross, A.C. (Ed) (1999):, Williams & Wilkins.
6. Human Nutrition and dietetics by Davidson, S. Passmore, R. Brock. J.F. and Turswell A.S.
7. Modern Nutrition in health and disease by Goodheart R., S. Shills.
8. Nelson and Cox, 2000, Lehninger's Principles of Biochemistry, Worth Publishers.
9. Nutrition in Health and Disease 17th Edition; Anderson, Dibble, Turkki, Mitchell, Rynbergen J.B. Lippincott Company, 1982
10. Nutrition Principles and Application in Health Promotion Second Edition; C.J.W, Sutor, M.F. Crowley J.B. Lippincott Co., Philadelphia, 1984
11. Nutritional Evaluation of Food Processing Third Edition; E. Karmas and R.S. Harris AVI Boon, New York, 1988
12. Nutrition and Aging; M.L. Hutchinson, H.N. Munro Academic Press, Inc., 1986
13. Nutritional Quality Index of Foods; R.G. Hansen, B.W. Wyse, A.W. Sorenson AVI Publishing Co., Inc., 1979.

PAPER III

Nutraceuticals and Functional Foods

3.1 Introduction to Nutraceuticals as Science (20 L)

Historical perspective, classification, scope & future prospects. Applied aspects of the Nutraceutical Science. Sources of Nutraceuticals. Relation of Nutraceutical Science with other Sciences: Medicine, Human physiology, genetics, food technology, chemistry and nutrition.

3.2 Functional Foods – I (20 L)

Functional Foods-1: Definition, Relation of functional foods & Nutraceutical (FFN) to foods & drugs. Applications of herbs to functional foods. Concept of free radicals and antioxidants; Nutritive and Non-nutritive food components with potential health effects. Effect of processing on Nutrients.

Soy proteins and soy isoflavones in human health; Role of nuts in cardiovascular disease prevention. Functional foods from wheat and rice and their health effects. Role of Dietary fibers in disease prevention.

3.3 Properties, structure and functions of various Nutraceuticals (20 L): Glucosamine, Octacosanol, Lycopene, Carnitine, Melatonin and Ornithine alpha ketoglutarate. Use of proanthocyanidins, grape products, flaxseed oil as Nutraceuticals.

3.4 Functional Foods – II (20 L):

Sources and role of Isoprenoids, Isoflavones, Flavonoids, carotenoids, Tocotrienols, polyunsaturated fatty acids, sphingolipids, lecithin, choline. terpenoids. Vegetables, Cereals, milk and dairy products as Functional foods. Health effects of common beans, *Capsicum annum*, mustards, Ginseng, garlic, grape, citrus fruits, fish oils, and sea foods.

3.5 Food as remedies and Anti-nutritional Factors present in Foods (20 L):

Food as remedies: Nutraceuticals bridging the gap between food and drug, Nutraceuticals in treatment for cognitive decline, Nutraceutical remedies for common disorders like Arthritis, Bronchitis, circulatory problems, hypoglycemia, Nephrological disorders, Liver disorders, Osteoporosis, Psoriasis and Ulcers etc. Brief idea about some Nutraceutical rich supplements e. g. Bee pollen, Caffeine, Green tea, Lecithin, Mushroom extract, Chlorophyll, Kelp and *Spirulina* etc.

Anti-nutritional Factors present in Foods: Types of inhibitors present in various foods and how they can be inactivated. General idea about role of Probiotics and Prebiotics as nutraceuticals. Recent advances in techniques & feeding of substrates. Assessment of nutritional status and Recommended Daily allowances.

3.6 Nutritional Genomics (20 L):

As a tool for production of Nutraceuticals. Plants as bioreactors. 'Tailor-made' carbohydrates and lipids of plant and non-plant origin. Transgenic plants for the large scale production of proteins for pharmaceutical and industrial uses. Plants as an alternative for biotransformation of raw materials into special chemicals. Production technology for recombinant therapeutic products using *E.coli* with examples like human insulin, growth hormones, interferons, erythropoietin.

Suggested Reference Books:

1. Handbook of Nutraceuticals and Functional Foods Edited by Robert E.C. Wildman, Routledge Publishers.
2. Nutraceuticals by L. Rapport and B. Lockwood, Pharmaceutical Press.

3. Methods of Analysis for Functional Foods and Nutraceuticals Edited by W. Jeffrey, Hursts, Routledge Publishers.
4. Food is Medicine by P.J Cousion; Duncan Baird Publishers, London.
5. Dietary Supplements of Plant Origin, M. Maffei (Ed.), Taylor & Francis, 2003.
6. Nutraceutical beverages Chemistry, Nutrition and health Effects, Shahidi and Weerasinghe (Ed.), American Chemical Society, 2004.
7. Dietary Fiber: Handbook of Dietary Fiber, Susan Sungsoo Cho, Mark L. Dreher.
8. Bioprocesses and Biotechnology for Functional Foods and Nutraceuticals, Jean - Richard Neeser & J. Bruce German, Marcel Dekker, Inc., 2004.
9. Herbal Products -Timotht S. Tracy, Richard L. Kingston.
10. Ayurveda Aahar (Food / Diet)-Prof. P.H.Kulkarni.
11. Dietary Supplements and Alternative Medicines -W. Marvin Davis.
12. Flavour in Food-Andree' Voilley, Patrick Etievant.
13. Dietary Supplements and Functional Foods -Geoffrey P. Webb.
14. A Guide to Understanding Dietary Supplements-Shawn M. Talbott.
15. Introduction to the Chemical Analysis of Foods-S. Suzanne Nielsen.
16. An Evidence - Based Approach to Dietary Phytochemicals -Jane Higdon.

PAPER IV

Biostatistics, Instrumentation and Biological Evaluation

4.1 Biostatistics-I (20 L):

General Account, Terms and Symbols used in Biostatistics, Methods of Sampling and Data Collection, Classification, Tabulation and Graphic Representation of Data, Types of Measures of Central Tendency; Mathematical Average; Averages of Position; Measures of Partition Values. Meaning of Dispersion; Range; Quartile Deviation; Mean Deviation; Standard Deviation; Significance of Difference in Means; Standard Error of Mean; Standard Error of Standard Deviation; Variance.

4.2 Biostatistics-II(20 L):

Types of Theoretical Probability; Normal, Binomial and Poisson distribution, Tests of Significance -- Z- Test; Student's 't' Test; The Chi-Square Test. Types of Probability; types of Correlation; Properties of Coefficient of Correlation; Methods of Studying Correlation, Regression Analysis; Kinds of Regression Analysis, Vital Statistics -- Measures of Vital Statistics; Measurement of Mortality; Life Tables.

4.3 Biological testing, organoleptic responses and bioassays (20 L):

Testing drugs *in-vitro* and *in-vivo*, Sampling for microbiological assays, Laboratory set up for microbiological testing, Microbiological Assays, Microbiological testing for Nutraceuticals, Basics of organoleptic responses, evaluation methodologies for taste, aroma, etc. Evaluation of toxicity and safety for new products, emerging new models for testing the claims.

4.4 Preclinical testing and clinical trials (20 L):

Basic Toxicology, Acute Toxicity studies, Multiple exposure studies, Basic Pharmacology and pharmaceutical chemistry, Phases of clinical trials, Metabolism studies, Clinical trials and Regulatory affairs.

4.5 Introduction to Instrumentation Techniques (20 L):

Centrifuge techniques: zonal, density, gradient and ultra-centrifugation techniques and their applications. Electrophoresis: zonal, paper, gel electrophoresis and iso-electric focusing and their application. Spectroscopy: Basic concepts, Beer-Lambert law & brief description of colorimetry, UV-VIS, IR, NMR, fluorescence, mass spectroscopy, flame photometry and x-ray diffraction.

4.6 Advanced Instrumentation Techniques (20 L):

Radio-isotopic techniques:- Nature of radioactivity properties of alpha, beta & gamma rays. Application of radio-isotopes. Measurement of radioactivity and radiation hazards. Chromatography: Paper, TLC, adsorption, ion exchange, gel

filtration, affinity, GC & HPLC. General idea about hyphenated techniques chromatography. Techniques of cellular fractionation.

Recommended Referenced Books:

1. Biostatistics the Bare Essentials. 2nd Edition, 2000, Norman & Streiner, B.C. Decker Inc
2. Handbook of Analytical Techniques Vol. I, Gunzler and Williams, Wiley-VCH, 2002.
3. Handbook of Analytical Techniques Vol. II, Gunzler and Williams, Wiley-VCH, 2002.
4. Instrumental analysis, Skoog, Holler, Crouch Brooks/Cole, 2007.
5. Bioanalysis Principles & Practices -Richard F Venn.
6. Chromatography: Liquid Chromatography, Mass Spectrometry, W M A Niesson, 2nd and 3rd Ed.
7. Chromatography: Gas Chromatography (Basic)-Harhold M Mcnair, James M Miller.
8. Chromatography: Gas Chromatography Modern Practice (4th Ed.)-Robert L Grab, Eugene F Barry.
9. Columns for Gas Chromatography -Barry & Grob
10. Capillary Electrophoresis Proteins-Tim Wehr/ Roberto Rodriguez- Diaz/ Mingde Zhu.
11. Capillary Electrophoresis of Nucleic Acids, Vol-1 & II -K. R. Mitchelson / jing Cheng
12. HPLC: Modern HPCL for Practicing Scientists-Michael W Dong
13. HPLC made to measures-Stavros Kromidas
14. HPLC: Practical HPLC-Veronika R Meyer
15. HPLC Quantitative Analysis of Pharmaceutical Formulations-Dr. P D Sethi
16. HPTLC(High Performance Thin Layer Chromatography)-Dr. P D Sethi
17. Herbal Medicines PDR 3rd ed. -Thomson
18. Herbal Medicine: Pharmacodynamic basis of Herbal Medicine 2nd ed-Manuchair Ebadi
19. HPLC: A Practical handbook of Preparative HPLC-Donald A Welling
20. HPLC for Pharmaceutical Scientists-Yuri Kazakevich
21. HPLC: A Practical user's Guide-Marvin C. McMaster
22. Mass Spectrometry (a Foundation Course)-K. Downard
23. Mass Spectrometry (Principle & Application)-E. Hoffmann & V. Stroobant
24. Solvent Extraction (Principles & Practices)-Jan Rydberg, Claude Musikas
25. Spectroscopy for the Biological Science.-HAMMES
26. Fundamental Toxicology-John H.Duffus and Howard G J Worth

PAPER V

Microbiology, Quality and Process Control for nutraceuticals.

5.1. Basic Microbiology Including Fermentation Technology (20 L):

Basic Microbiology: Microbial Cell structure, Study of Characteristics of microorganisms: microscope and microscopic methods, morphology, cultivation, reproduction and growth (growth curve), isolation techniques, Culture media, Culture preservation, Biosynthetic pathways for nutraceuticals, mutation and genetics for strain improvement), Sterilization methods physical, chemical methods and use of antibiotics,

Fermentation Technology: Submerged fermentation, Media for microbial fermentation, nutritional requirements, environmental requirements, medium formulation and optimization for cell growth and product formation, Scale up of a microbial process, Bioreactor designs and types of bioreactors, process parameters, sterility and contamination control, aeration and agitation, primary and secondary metabolites, Solid state fermentations.

5.2 Biological controls and Monitoring of food quality (20 L):

Need and packaging containers for packaging (glass, metal, plastics, molded pulp and aluminum foil), dispensing devices, Microbiological quality control for Nutraceuticals.

5.3. Products of microbial fermentations and downstream processing (20 L):

Products of microbial fermentations:

Organic acids, amino acids, organic acids, vitamins, nucleosides and nucleotide, enzymes, Probiotics, Fermented Food—development and use of microbial starters, Production of yeast biomass, cheese, beer yogurt, PUFA, Arachidonic acid, γ -Linolenic acid.

Downstream processing:

Product recovery and downstream processing: Separation techniques, centrifugation, precipitation, purification processes like chromatographic techniques ultra-filtration, ion exchange, Tangential flow filtration, micro and nanofiltration techniques, reverse osmosis, etc.

5.4 Nutraceutical Industry and Market information (20 L):

Nutraceutical industries in India and abroad (study of 10 reputed Indian and International industries involved in production and development of Nutraceuticals and functional foods).

5.5. Unit operations in manufacturing-I (20 L):

Various heating processes and heat transfer mechanisms. Mass transfer operations: drying, evaporation, concentration, particle size reduction micronization, solvent extraction, filter pressing operation, filtration, centrifugation, crystallization.

5.6. Unit Operations in Manufacturing- II (20 L):

Procurement of herbal raw material, preservation and storage of herbal raw material, Processing techniques for nutraceutical ingredients to be obtained from leaves, flowers, bark/stem, fruits, seeds and animal tissue.

Recommended Selected Readings

1. Microbiology, by M. J. Pelczar, 4th edition, McGraw-Hill. Inc. N.Y. 1977.
2. General Microbiology, by R. Y. Steiner, 5th edition, Macmillan Education Ltd. London. 1987.
3. Biotechnology, by H. J. Rehm and G. Reed, Vol 1-12, 2nd edition, VCH Publications, Germany.
4. Operation modes of bioreactors, Butterworth-Heinmann Ltd.
5. Process Biotechnology fundamentals, by S. N. Mukhopadhyay, Viva book Pvt Ltd.
6. Comprehensive Biotechnology, by Murray Moo Young, Pergamon press, 1985
7. Separation and Process in Biotechnology, by Juan A. Asenjo, CRC press Taylor and Francis group, FL. 1990.
8. Culture and Animal Cells, by R. J. Freshney, 3rd edition, Wiley-liss, Inc. New York, NY. 1994.
9. Plant Tissue Culture: Theory and Practice, by S.S. Bhojwani and M. K. Razadan, Elsevier Science, The Netherlands, 1996.
10. Principles of fermentation Technology, Stanbury, Whitaker and Hall, Butterworth Heinemann (1997), Indian Edition.
11. Basic Biotechnology. Ratledge & Kristiansen, Cambridge press (2001).
12. Biotechnology-a text book of industrial microbiology. Cruger and Cruger, Panima Publishing corporation, New Delhi (2005).
13. Bioprocess Engineering –basic concepts. Shuler and Kargi, Prentice Hall of India (2005).
14. Quality Management in Nutraceuticals , Chi Tang Ho & Quan Yi Zheng (Ed.), American Chem. Soc., 2002
15. Regulations and Quality : Pharmaceutical Manufacturing Handbook, Shayne Cox God (Ed.), Wiley Interscience 2008
16. Aroma Active Compounds in Foods Chemistry and Sensory Properties -Gary R. Takeoka, Matthias Giintert, Karl - Heinz Engel

PAPER VI

Development and marketing of Nutraceutical products: Product Development, Packaging, label claims, consumer acceptance, future prospects

6.1 Nutraceuticals and the Future of Medical Science along with Consumers' views on nutraceuticals (20 L)

Nutraceuticals and the Future of Medical Science

Increasing role of Nutraceuticals in management of health and diseases, development of designer foods for specific chronic diseases like diabetes, cardiovascular diseases, AIDS and degenerative diseases like Parkinson, functional foods for specific sports, oligosaccharides, dietary fibers of microbial and plant origin as Nutraceuticals of future, Role of changing food preferences and globalization on selection of Nutraceutical products.

Consumers' views on nutraceuticals

Consumer as a layman when it comes to technical jargon, Need to look back and then forward for industry when it is nomenclature for new product, Categories of concepts, media messages and evolving communication techniques for effectively conveying the information, the Consumer view on function Nutraceuticals, What is the level of awareness of consumers today?, What are the barriers to acceptance by the consumer? - Value added? credibility? Ethical issues? What is in the best interest of consumer?

6.2. New technologies in development of Nutraceuticals and functional foods and Relationship between Chemoprevention and Nutraceuticals (20 L)

New technologies in development of Nutraceuticals and functional foods

Supercritical food extraction technology-basics and application for extraction of nutraceuticals from various sources, Application of pressurized low polarity water extraction, use of membranes separation technology, distillation and dehydration technologies, application of bioprocess technology for production and enhancement of properties of nutraceuticals.

Chemoprevention and Nutraceuticals

Role of chemoprevention in health, Role of nutraceuticals in management of health and disease, whether nutraceutical will compliment or replace drugs in management of health and curing of diseases.

6.3 Packaging strategies for nutraceutical products (20 L)

Introduction to packaging, plastic as packaging material- structure, optical and mechanical properties of plastic, paper and paper-based packaging material, glass packaging material, concept of aseptic packaging of foods or Nutraceuticals, packaging of dairy products, cereals and snack foods. The changing scenario in food and pharma industry regarding quality standards and its compliance

6.4 The food industry's role in promoting functional foods (20 L)

Introduction about what is considered as functional food as against ordinary food, use of functional food to improve /maintain health, treatment of diseases, slowing of biological ageing, etc., Will the nutraceutical be introduced as replacement of current food or it will be an addition?, Role of FDA in release of new nutraceutical, moral responsibility of food industry, impact of NLEA on claims to be made by industry, Problems associated with advertising of nutraceuticals.

6.5 Labeling and claims for Nutraceuticals products (20L)

Overview of dietary supplements labeling, need for specific regulation governing dietary supplements, outline for compliance review of dietary supplements compliance label review , designation of ingredients, nutrition labeling for dietary supplements with examples like labeling and claims for multiple vitamins, dietary supplements, amino acids, herbs, etc., Nutritional content claims, health claims and exemption from FDA requirements, Dietary supplements labeling issues, regulatory agencies views on label claims.

6.6 The role of marketing Communication in the introduction of functional foods to the Consumer (20 L)

Introduction to marketing and consumer buying behavior, food purchase habits of people, The basics of communication processes used to convey the message- written and oral communication, Legislation and its impact on advertising and labeling of nutraceuticals, how to do targeting of food with a health message?, How to communicate health claims for functional foods? , importance of sensory quality & food acceptance by consumers, the art and science of consumer persuasion.

• Suggested Reference Books:

1. Food packaging principals and practice, Gordon L. Robertson, Marcel and Dekker Inc. New York. 19993. Chapters 1,2,3,6, 7, 9,13,17,18 & 19 for point 6.7.
2. Packaging technologies of functional foods *in* Functional food ingredients and Nutraceuticals processing technologies John Shi (Ed.) CRC Taylor & Francis group, 2007 for point 6.7.
3. Functional foods, designer foods, pharma foods, Nutraceuticals, Israel Goldberg (Ed.), Aspen publishers Inc., Gaithersburg, Maryland, USA, 1999. Chapter 21 page 495 for point 6.5.
4. Nutrition labeling handbook, Ralph Shapiro (Ed.), Marcel Dekker, N.Y., 1995 for point 6.8.
5. Dietary Supplements labeling-compliance review (third edition), James L. Summers (Ed.), Blackwell Publishing for point 6.8.
6. Functional foods, designer foods, pharma foods, Nutraceuticals, Israel Goldberg (Ed.), Aspen publishers Inc., Gaithersburg, Maryland, USA, 1999. Chapter 22 page 512 for point 6.6.

7. Functional foods, designer foods, pharma foods, Nutraceuticals, Israel Goldberg (Ed.), Aspen publishers Inc., Gaithersburg, Maryland, USA, 1999. Chapters 21, 22, 23 & 24.
8. Biotechnology: Food Fermentation Vol I and II by Joshi and Pandey, 1999. Educational Publishers and Distributors, Kerala.
9. Food processing: Biotechnological Applications by Marvaha and Arora, 2000, Asiatech Publishers New Delhi.
10. Consumer's guide to Dietary supplements and alternative medicines servings of Hope, W. Marvin Davis, Pharmaceutical Products Press, 2006

PAPER VII

Molecular Biology and Biotechnology for Nutraceuticals and Functional Foods

7.1. Genetic engineering, Library construction & screenings (20 L):

Genetic engineering

Scope of Genetic engineering, Genetic engineering guidelines, Restriction enzymes: Nomenclature & classification. Gene cloning vector for animals and plants-- Plasmids, bacteriophages, phagemids, cosmids, Artificial chromosomes. cDNA synthesis and cloning, mRNA enrichment, reverse transcription, DNA primers, linkers, adapters.

Library construction & screenings

Cloning interacting genes, differential expression of genes. Gene with tissue specific expression, mutant complementation. Vector engineering & codon optimization, host engineering, Application of cloning in human health and Crop improvement. Brief idea about Bioremediation. *In-vitro* transcription & translation expression in bacteria, yeast, insects, mammalian cells & plants. Antisense technology and ribozyme technology.

7.2. Plant Biotechnology and Plants as factories (20 L):

Plant Biotechnology

Plant tissue culture, micropropagation, meristem, shoot apices, embryo culture, embryo rescue, production of haploid plants, somatic hybridization, somaclonal variations, plant transformation by T & R plasmids & viruses. Direct DNA transfer methods. Transgene stability & genes silencing.

Plants as factories

For the production of Nutraceuticals. Commercial transgenic crops like herbicide resistant soybean, maize, vegetables, fruit crops, golden rice.

7.3. Animal Biotechnology (20 L):

Evolution and development of cell lines,. Equipments & materials for animal cell culture, culture media, role of various constituents of culture media. Basic techniques of mammalian cell culture, *in-vitro* maintenance of cell cultures, cell synchronization. Cell transformation, cloning & micro manipulation, cell growth phase, growth cycle, cell cycle time, measurement of viability, cytotoxicity, apoptosis, stem cell culture. *In-vitro* fertilization & embryo transfer technology and transgenic animals.

7.4 Metabolic engineering & industrial products (20 L):

Control mechanism & manipulation of phenyl propanoid pathway and Shikimate pathway, alkaloids, industrial enzymes, biodegradable plastics, therapeutic proteins.

7.5. Development of Novel Food and food Ingredients (20 L):

Polysaccharides, low caloric sweeteners. Naturally produced flavor modifiers, Single Cell Proteins, Marine algae as food supplements, Food supplements and food Ingredients as by-products – Fishery, poultry/animal husbandry and agriculture/dairy industries.

7.6 Bioinformatics (20 L)

History, Scope and Importance of Bioinformatics, Sequencing Development; Applications of Bioinformatics; Challenges and Opportunities.

• Suggested Reference Books:

1. Introduction to Practical Molecular Biology, by P.D. Dabre, John Wiley & sons Ltd., New York, 1988.
2. Molecular Biology and Biotechnology, By A comprehensive desk reference, R.A. Meyers (Ed.) VCH Publishers, Inc., New York, 1995.
3. Molecular Biology Lab, Fax, T.A. Brown (Ed.), Bios scientific Publishers Ltd., Oxford, 1991.
4. Methods in Enzymology Vol 185, Gene Expression Technology, D.V. Goeddel, Academic Press, Inc., San Diego, 1990
5. Methods in Enzymology Vol. 152, Guide to Molecular Cloning Techniques, S.L. Berger and A.R. Kimmel, Academic Press, Inc. San Diego, 1998
6. Molecular and Cellular Methods in Biology and Medicine, P.B. Kaufman, W.Wu. D. Kim and L.J. Cseke, CRC Press, Florida, 1995
7. Molecular biology & Biotechnology a guide for teachers, Helen Kreuzer & Adrianne Massey, ASM Press, 2008.
8. Biotechnological strategies in agroprocessing by Marwaha and Arora, 2003. Asiatech Publishers, New Delhi.
9. Biotechnology Science for the new Millennium, Ellyn Daugherty, CBS Publishers, New Delhi (2008).

10. Biotechnology, by H. J. Rehm and G. Reed, Vol 1-12, 2nd edition, VCH Publications, Germany.
11. Comprehensive Biotechnology, by Murray Moo Young, Pergamon press, 1985.
12. Manual of Industrial Microbiology and Biotechnology. 2nd ed. Demain and Davies (Ed.), ASM Press (1999).
13. Bioinformatics & Computational Biotechnology -John M Hancock, Marketa J Zvelebil.
14. Bioinformatics Elementary -Imtiyaz Alam Khan.
15. Bioinformatics Introduction -T K Attwood, D J Parry-Smith.
16. Bioinformatics Methods & Application-S C Rastogi.
17. Bioinformatics: The New Avenues in Bioinformatics-J. Seckback & E. Rubin.

PAPER VIII

Quality Control & Assurance, Regulatory Affairs and Intellectual Property Rights

8.1. Quality Control and Quality Assurance (20 L):

Quality Assurance

Introduction, what is QC? Requirements for implementing QC, QC concepts in Nutraceuticals and food products, Label claims and their support.

Quality Assurance

Introduction, What is QA? Requirements for implementing QA, QA concepts in Nutraceuticals and food products, Personnel Responsibilities in QA

8.2. Medicinal Plants: Ethnomedicine in India (20 L)

Traditional Herbal Medicines for Healthcare and Management of Human Diseases, Future of Ethnobiology, Biopiracy of Medicinal plants; Importance of traditional medicine in future materia-medica of world.

8.3. Intellectual Property Rights (IPR)-1: (20 L)

Definition, WTO, Need for harmonization of laws related to IPR, TRIPs and introduction to the articles in TRIPs document, types of TRIPs- patents, copy rights, trademarks, logos, service marks, geographical indicators, Impact of IPR on global trade and economies of poor countries, Filing of patents: Criteria to be satisfied like patentability, inventiveness, non-obviousness, novelty, utility, sufficiency of disclosure, etc. Benefits of creating and / or owning patents.

8.4. Chemi-informatics and Pharma-informatics (20 L):

Use of Chemical Libraries; Discovering a Drug, Target, Identification and Validation.

8.5. Intellectual Property Rights (IPR)-2: (20 L)

International Agreements related to patents: Paris Convention, Budapest treaty, PCT. Patent offices and their role in patenting, Indian patent laws, Mail box provision, Exclusive marketing rights, prevention of evergreening of patents, etc. patent management including lab documentation, pre- and post-grant opposition and servicing of patents.

8.6. R Regulatory Affairs and Regulatory certifications (20 L)

Regulatory Affairs

Regulatory aspects of functional products. Marketing issues for functional foods and Nutraceuticals, Salient features of The prevention of Food Adulteration Act 1954 (India) and The Food Safety & Standards Act, 2006 (34 of 2006). International laws pertaining to safety of nutraceuticals.

Regulatory certifications

FPO regulations, Manufacturing guidelines, Manufacturing and marketing licenses, AGMARK, Green Label certification, Organic food certifications, Certifications for GMFs. Export regulations for Nutraceuticals.

• Suggested Reference Books:

1. Intellectual Property rights: Unleashing the Knowledge Economy. Ganguli, Tata Macgraw Publishing company (2001).
2. Manual of Industrial Microbiology and Biotechnology. 2nd ed. Demain and Davies (Ed.), ASM Press (1999).
3. Principals of Gene Manipulation and Genomics-S.B. Primrose and R.M. Twyman.
4. Quality Management in Nutraceuticals, Chi Tang Ho n& Quan Yi Zheng (Ed.), American Chem. Soc. 2002.
5. Regulations and Quality: Pharmaceutical Manufacturing Handbook, Shayne Cox God (Ed.), Wiley Interscience 2008.
6. Food processing: Biotechnological Applications by Marvaha and Arora, 2000, Asiatech Publishers New Delhi.
7. Consumer's guide to Dietary supplements and alternative medicines. Servings of Hope, W. Marvin Davis, Pharmaceutical Products Press, 2006.
8. Dietary Supplements of Plant origin a nutrition and health approach, Massimo Maffei (Es.), Taylor and Francis, 2003.
9. Herbal beauty products with formulation & processes-H. Panda.
10. Herbal Drugs & its plant Sources-H. Panda.
11. Herbal Drugs: Potential Antimalarial Herbal Drugs from South Asia-CCRUM.
12. Herbal Medicine & Botanical Medical Fads-Frank Hoffmann, Martin Manning.
13. Herbal Medicines-H. Panda.
14. Medicinal HERBS with uses-H. Panda.

15. Medicinal Plants (Cultivation & their uses)-H. Panda.
 16. Medicinal Plants (Traditional Knowledge)-P C Trivedi.
 17. Medicinal Plants of the World-Ben-Erik, Van Wyk, Michael Wimk
 18. Medicinal Plants Of the World Vol-3 -Ivan A Ross
 19. Medicinal Plants: Chemistry of Medicinal Plants Part - I-CCRUM
-

PRACTICAL I SEMESTER I

1. Study of mitosis and meiosis from given plant/animal material.
2. Study of ANY TEN I P monographs and their identification using characteristic features of nutraceutically important plants like; *Phyllanthus emlica*, *Curcuma longa*, *Ginziber officinalis*, Solanaceae (*Withania somanifera*), *Aloe vera*, Lilliaceae (*Alium sativum*), Lamiaceae (*Ocimum sanctum*), Apiaceae (*Coriandrum sps*) and Liliaceae (*Asparagus sps.*) *Centella asiatica*.
3. Study of following Parasites/Vectors/pests: Identification, Habits and control measures (museum specimens / slides):
Entamoeba histolytica, *Taenia sps*, *Ascaris lumbricoides*, *Ancylostoma dueodenaei*, *Trichinella spiralis*, *Trichura trichuris*, Mosquito (*Culex and Anopheles*), House fly, Green bottle fly, Head Louse, Cockroach (*Periplanata & Blatta*), bed bug, *Mus sps.* (Mouse) and *Rattus sps.* (House rat)

SEMESTER II

4. TLC separation of Plant pigments – Curcumin and carotene.
5. To isolate DNA and RNA from given plant/animal material and estimate DNA by Diphenyl method and RNA by Orcinol reagent.
6. Extraction, purification and evaluation of activity of any one digestive enzyme (e.g. Beta amylase from sweet potato.)
7. Estimation of crude fiber/pectic substances from plant material.

PRACTICAL II

Semester I

Problem solving using statistical software.

Reactions of mono, di and polysaccharides and their identification in unknown mixtures.

Determination of Acid value, Saponification and Iodine number of natural fats & oils.

Estimation of proteins with Bradford's and other methods.

Semester II

Estimation of ascorbic acid from lemon & amla juice by titration method.

Estimation of Ca, Na and K in various foodstuffs by flame photometry.

Detection and estimation of metals – ANY ONE from - Fe, Cu, Zn, Mg, Se, and ANY ONE from - As, Hg, Pb,

Assessment of purity and quality using appropriate standard tests for the following ;

- Milk and Paneer
- Butter/ ghee and hydrogenated fat (Vanaspati Ghee)
- Spices and condiments
- Tea and coffee
- Fruit juice
- Pulses

Estimation of bio burden by Viable Count method.

PRACTICAL III

SEMESTER I

1. Extraction and estimation of total sugars from food products (dairy product, fruit juices, bread).
2. Estimation of crude fat contents of foods by Soxhlet's method (Butter, Margarine, edible oil).
3. Estimation of total Nitrogen of foods by Kjeldahl and Micro Kjeldahl methods.
4. To separate the Milk proteins on Native and SDS gels.
5. To prepare plasmid DNA from given sample and its digestion by restriction enzymes and separation of DNA fragments by gel electrophoresis (Suitable teaching kits may be used)

SEMESTER II

6. To study nutritional composition (Proteins, carbohydrates, lipids, vitamin C and presence of secondary metabolites) of the following: Bee honey, Mushrooms, dairy products, Beans, Spinach, Carrot, Apple, Amla, Pineapple, Papaya, Lentil and Soya.
7. Extraction and estimation of oil or crude fat content in oil seeds.
8. Estimation of total phenols and chlorogenic acid (Phenolic compound) in plant material.
9. Qualitative test for tannins, phenolics and alkaloids using TLC.
10. To estimate cholesterol content in given sample by Liebermann-Burchard method.

PRACTICAL IV

Semester I & II

- Students must submit a Report of the Industrial Visits and a Field Note Book of their Visits.
- Marks will be allotted as follows;
 - 10 marks for Report of Industrial visit & Field Note Book of visits
 - 15 marks for presentation on topics allotted for seminar
 - 25 marks for viva based on entire Syllabus of Part I

PRACTICAL V

SEMESTER III

1. Estimation of preservatives and antioxidants from food sample. (repeat ?)
2. Estimation of protein quality using any one method. (to be elaborated . .)
3. Separation and identification of essential amino acids by TLC from given food sample.
4. Fractionation of proteins from given sample (milk / Soya milk / Liver homogenate) using ammonium sulphate precipitation.
5. To study the gluten formation and factors affecting them.

SEMESTER IV

6. To study the gelatinization and factors affecting them.
7. Detection of food additives (list to be given – MSG, Flavours, Colours biological and non-biological etc.) in packaged food products.
8. Study of comparative antimicrobial activity of the following: Penicillin and Curcuma / thyme .
9. Microbial examination of water -- total and coliform count.
10. Microbial production of citric acid by *Aspergillus niger*.

PRACTICAL VI

SEMESTER III

1. Demonstration of the following;
 - a. Demonstration of PCR
 - b. Demonstration of Automated DNA sequencing.
2. To prepare a market survey report on the any one Nutraceutical functional food product.
3. Preparation of Functional food/ Nutraceutical product (Any Four)
 - a. Rich in Vitamins
 - b. Rich in Minerals
 - c. Rich in proteins
 - d. Rich in carotenoids and vitamin A
 - e. Rich in medicinally important secondary metabolites
 - f. Rich in antioxidants

SEMESTER IV

4. Assessment of quality of beverages -- tea and coffee.
5. Microbial Role in production of alcohol – (arishta / asavas) .
6. Production of industrially important enzymes by micro-organisms (Protease and amylase).
7. Microbial production of antibiotics (Penicillin).
8. Estimation of enzymatic browning in foods.

PRACTICAL VIII

SEMESTER III

1. Isolation and estimation of Vitamin B2 by HPLC
2. HPLC estimation of Eugenol from Clove and clove oil.
3. TLC estimation of piperine from Pepper.
4. Extraction of free amino acid in given sample (repeat).
5. Estimation of Curcumin/Lycopene.
6. Estimation of choline.

SEMESTER IV

7. Preparation of traditional health products – e.g. Satavari kalp, gulkand, Amla syrup, bilwa jam.
8. Extraction and identification of Isoflavones by TLC.
9. Estimation of concentration of starch in a given sample.
10. Study of search tools--- FASTA and BLAST.
11. Estimation of volatile substances from food products / beverages using GC.

PRACTICAL VII

SEMESTER III

- REPORT OF PROJECTS UNDERTAKEN
 - The project should involve industrial training of 8 to 12 weeks period
 - Project must involve application of knowledge and skills as prescribed in the syllabus and data evaluation must involve application of biostatistics.
 - The project report (including Mentor's report) and observations / data generated will be presented and defended before the panel of examiners.
-