

Course structure at a glance

BIOTECHNOLOGY-2018

CORE COURSE

| Course | Title | Credit | Marks |
|--------|---------------------------------------|--------|-------|
| CC-1 | Biochemistry and Metabolism (Th) 4 CR | 6 | 75 |
| | Biochemistry and Metabolism (Pr) 2CR | | |
| CC-2 | Cell Biology (Th) 4 CR | 6 | 75 |
| | Cell Biology (Pr) 2CR | | |
| CC-3 | Mammalian Physiology (Th) 4 CR | 6 | 75 |
| | Mammalian Physiology (Pr) 2CR | | |
| CC-4 | Plant Physiology (Th) 4CR | 6 | 75 |
| | Plant Physiology(Pr) 2 CR | | |
| CC-5 | Genetics (Th) 4CR | 6 | 75 |
| | Genetics (Pr) 2 CR | | |
| CC-6 | General Microbiology (Th) 4 CR | 6 | 75 |
| | General Microbiology (Pr) 2 CR | | |
| CC-7 | Chemistry-1 (Th) 4 CR | 6 | 75 |
| | Chemistry-1 (Pr) 2 CR | | |
| CC-8 | Molecular Biology (Th) 4 CR | 6 | 75 |
| | Molecular Biology(Pr) 2 CR | | |
| CC-9 | Immunology (Th) 4 CR | 6 | 75 |
| | Immunology (Pr) 2 CR | | |
| CC-10 | Chemistry-II (Th) 4 CR | 6 | 75 |
| | Chemistry-II (Pr) 2 CR | | |
| CC-11 | Bioprocess Technology (Th) 4 CR | 6 | 75 |
| | Bioprocess Technology (Pr) 2 CR | | |
| CC-12 | Recombinant Biotechnology (Th) 4 CR | 6 | 75 |
| | Recombinant Biotechnology (Pr) 2 CR | | |
| CC-13 | Bio analytical Tools (Th) 4 CR | 6 | 75 |
| | Bio analytical Tools (Pr) 2 CR | | |
| CC-14 | Genomics & Proteomics (Th) 4 CR | 6 | 75 |
| | Genomics & Proteomics (Pr) 2 CR | | |

DISCIPLINE SPECIFIC ELECTIVE (ANY FOUR)

| DISCIPLINE SPECIFIC ELECTIVE | Title | Credit | Marks |
|------------------------------|---------------------------------------|--------|-------|
| DSE | Animal Biotechnology (Th) 4 CR | 6 | 75 |
| | Animal Biotechnology (Pr) 2 CR | | |
| DSE | Plant Biotechnology (Th) 4CR | 6 | 75 |
| | Plant Biotechnology (Pr) 2CR | | |
| DSE | Biostatistics (Th) 4 CR | 6 | 75 |
| | Biostatistics (Pr) 2 CR | | |
| DSE | Bioinformatics (Th) 4 CR | 6 | 75 |
| | Bioinformatics (Pr) 2 CR | | |
| DSE | Medical Microbiology (Th) 4CR | 6 | 75 |
| | Medical Microbiology (Pr) 2 CR | | |
| DSE-6 | Environmental Biotechnology (Th) 4CR | 6 | 75 |
| | Environmental Biotechnology (Pr) 2 CR | | |

GENERIC ELECTIVE [For other discipline(s)]

| Generic Elective | Title | Credit | Marks |
|------------------|---|--------|-------|
| GE | Entrepreneurship Development (Th) 4 CR | 6 | 75 |
| | Entrepreneurship Development (Pr) 2 CR | | |
| GE | Bioethics & Biosafety (Th) 4 CR | 6 | 75 |
| | Bioethics & Biosafety (Pr) 2 CR | | |
| GE | Biotechnology & Human Welfare (Th) 4 CR | 6 | 75 |
| | Biotechnology & Human Welfare (Pr) 2 CR | | |
| GE | Development Biology (Th) 4 CR | 6 | 75 |
| | Development Biology (Pr) 2 CR | | |
| GE | Microbial Physiology (Th) 4 CR | 6 | 75 |
| | Microbial Physiology (Pr) 2 CR | | |
| GE | Biophysics & Instrumentation (Th) 4 CR | 6 | 75 |
| | Biophysics & Instrumentation (Pr) 2 CR | | |

SKILL ENHANCEMENT COURSES (ANY TWO)

| Skill Enhancement Courses | Title | Credit | Marks |
|---------------------------|----------------------------------|--------|-------|
| SEC | Molecular Diagnostics (Th) | 2 | 50 |
| SEC | Industrial Fermentation (Th) | 2 | 50 |
| SEC | Enzymology (Th) | 2 | 50 |
| SEC | Basics of Forensic Sciences (Th) | 2 | 50 |

ABILITY ENHANCEMENT COMPULSORY

| AECC | Title | Credit | Marks |
|--------|-----------------------------------|--------|-------|
| AECC-1 | ENVS (Th) | 2 | 50 |
| AECC-2 | English/MIL Communication (Th) | 2 | 50 |

CHOICE BASED CREDIT SYSTEM

B.Sc (Hons) Biotechnology

SEMESTER -I (1st YEAR)

CC1- BIOCHEMISTRY AND METABOLISM (THEORY)

4 CREDITS

1. Carbohydrates: Definition; structure of carbohydrates- monosaccharide, aldohexoses and ketohexoses with examples; Haworth structure, anomeric structures of D-glucose, mutarotation, pyranose and furanose rings. Oligo- and polysaccharides, reducing (maltose) and non-reducing (sucrose), disaccharides; glycoproteins, proteoglycans. **10L**

2. Amino acids: Peptides and proteins; structures and important properties, classification of amino acids, important physical and chemical properties of amino acids (optical isomerism, UV-absorption, ionization, reactions due to amino group and carboxyl group). Primary structure of peptides. Primary, secondary, tertiary and quaternary structures, classification of proteins (based on solubility and composition). C and N terminal amino acid determination. **10L**

3. Lipids: Definition, distinction between fats and oils, structure of lipids (fatty acids, glycerolipids, sphingolipids) **5L**

4. Nucleic acids: Structure of nucleic acids; nucleosides, nucleotides, primary structure, A, B and Z form of DNA; preliminary idea of secondary structures of RNA and DNA; melting point and denaturation of DNA **8L**

5. Enzymes: Definition of enzymes, important terms (enzyme unit, specific activity), classification of enzymes; physico-chemical properties, factors affecting activity; mechanism of enzyme action, coenzymes, cofactors. **8L**

6. Carbohydrates metabolism: Reaction, energetic & regulation. Glycolysis: Fate of pyruvate under aerobic & anaerobic condition. Pentose phosphate pathway & its digestion. Gluconeogenesis, Glycogenolysis & Glycogen synthesis. TCA Cycle, Electron transfer chain, Oxidative phosphorylation, beta oxidation of fatty acids. **9L**

CC1- BIOCHEMISTRY (PRACTICAL)

1. Qualitative tests for sugars, amino acids, proteins & lipids; separation of amino acids by PC/TLC methods.
2. Quantitative estimation of sugars (DNS method) and proteins (Folin-Phenol).
3. Isolation and quantification of DNA (diphenylamine method) and RNA (orcinol method) analysis, saponification value of fat.
4. Quantitative assay for protein & catalase.
5. To study the effect of Ph, Temperature on the activity of salivary amylase

SUGGESTED READING

1. Berg, J. M., Tymoczko, J. L. and Stryer, L. (2006). Biochemistry. VI Edition. W.H Freeman and Co.
2. Buchanan, B., Gruissem, W. and Jones, R. (2000) Biochemistry and Molecular Biology of Plants. American Society of Plant Biologists.
3. Nelson, D.L., Cox, M.M. (2004) Lehninger Principles of Biochemistry, 4th Edition, WH Freeman and Company, New York, USA.
4. Hopkins, W.G. and Huner, P.A. (2008) Introduction to Plant Physiology. John Wiley and Sons.
5. Salisbury, F.B. and Ross, C.W. (1991) Plant Physiology, Wadsworth Publishing Co. Ltd.

CC2- CELL BIOLOGY (THEORY)

4 CREDITS

1. Cellular basis of life: Cell doctrine, cells in general, diversity of cell size and shape, cell theory; structure of eukaryotes and prokaryotes cells (including viruses) **6L**
2. Cellular information: The nucleus (ultra-structure), the organization of chromosomes (euchromatin and heterochromatin), nucleosome concept and chromosome packaging. **6L**
3. The cell surface: Plasma membrane, membrane fluidity, movement across plasma membrane, Modification of plasma membrane (Plasmodesmata and desmosome); Plants and bacterial cell walls; an outline of extracellular substances of animal cells. **10L**

4. Endo-membrane system: Endoplasmic reticulum, Mitochondria, Golgi apparatus, Chloroplast, lysosomal system, plant cell vacuoles, microbodies structure and function.
10L 10L
5. The cytoskeleton: Microtubules, microfilaments and intermediate filaments. 6L
6. An outline of cell cycle: Mitosis and Meiosis. 4L
7. Cancer: Carcinogenesis, agents promoting carcinogenesis, characteristics and molecules basis of cancer. 8L

CC2- CELL BIOLOGY (PRACTICAL)

2 CREDITS

1. Preparation of Meiotic Chromosome from grasshopper.
2. Preparation of Mitotic Chromosome from onion root tip.
3. Preparation of Meiotic Chromosome from *Rhoeo* discolor.
4. Preparation and study of polytene chromosome from *Drosophila/Chironomous* salivary gland.
5. Study of sex chromatin through preparation of Barr body from buccal epithelium and Drumstick from blood film.
6. Study of chromosomal aberration induced by BHC & pesticide in onion root tips.
7. Artificial induction of polyploidy/aneuploidy in onion root through colchicines exposure.

SUGGESTED READING

1. Karp, G. 2010. Cell and Molecular Biology: Concepts and Experiments. 6th Edition. John Wiley & Sons. Inc.
2. De Robertis, E.D.P. and De Robertis, E.M.F. 2006. Cell and Molecular Biology. 8th edition. Lippincott Williams and Wilkins, Philadelphia.
3. Cooper, G.M. and Hausman, R.E. 2009. The Cell: A Molecular Approach. 5th edition. ASM Press & Sunderland, Washington, D.C.; Sinauer Associates, MA.
4. Becker, W.M., Kleinsmith, L.J., Hardin. J. and Bertoni, G. P. 2009. The World of the Cell. 7th edition. Pearson Benjamin Cummings Publishing, San Francisco.

AECC-1 ENVS

CHOICE BASED CREDIT SYSTEM

B.Sc (Hons) Biotechnology

SEMESTER II

CC3- MAMMALIAN PHYSIOLOGY (THEORY)

4 CREDITS

Digestion and Respiration

Digestion: Mechanism of digestion & absorption of carbohydrates, Proteins, Lipids and nucleic acids. Composition of bile, Saliva, Pancreatic, gastric and intestinal juice

Respiration: Exchange of gases, Transport of O₂ and CO₂, Oxygen dissociation curve, Chloride shift. **12L**

Circulation

Composition of blood, Plasma proteins & their role, blood cells, Haemopoiesis, Mechanism of coagulation of blood. Cardiac output, cardiac cycle, Origin & conduction of heart beat. **12L**

Muscle physiology and osmoregulation

Structure of cardiac, smooth & skeletal muscle, threshold stimulus, All or None rule, single muscle twitch, muscle tone, isotonic and isometric contraction, Physical, chemical & electrical events of mechanism of muscle contraction. Excretion: modes of excretion, Ornithine cycle, Mechanism of urine formation. **10L**

Nervous and endocrine coordination

Mechanism of generation & propagation of nerve impulse, structure of synapse, synaptic conduction, saltatory conduction, Neurotransmitters, Mechanism of action of hormones (insulin and steroids) Different endocrine glands– Hypothalamus, pituitary, pineal, thymus, thyroid, parathyroid and adrenals, hypo & hyper-secretions.

16L

C3- MAMMALIAN PHYSIOLOGY (PRACTICAL)

2 CREDITS

1. Finding the coagulation time of blood
2. Determination of blood groups
3. Counting of mammalian RBCs
4. Determination of TLC and DLC
5. Demonstration of action of an enzyme
6. Haemoglobin estimation

SUGGESTED READING

1. Guyton, A.C. & Hall, J.E. (2006). Textbook of Medical Physiology. XI Edition. Hecourt Asia PTE Ltd. /W.B. Saunders Company.
2. Tortora, G.J. & Grabowski, S. (2006). Principles of Anatomy & Physiology. XI Edition. John wiley & sons, Inc.

**CC4- PLANT ANATOMY AND PHYSIOLOGY (THEORY)
CREDITS**

4

Anatomy

12L

The shoot and root apical meristem and its histological organization, simple & complex permanent tissues, primary structure of shoot & root, secondary growth, growth rings, leaf anatomy (dorsi-ventral and isobilateral leaf)

Plant water relations and micro & macro nutrients

10L

Plant water relations: Importance of water to plant life, diffusion, osmosis, plasmolysis, imbibition, guttation, transpiration, stomata & their mechanism of opening & closing.

Micro & macro nutrients: criteria for identification of essentiality of nutrients, roles and deficiency systems of nutrients, mechanism of uptake of nutrients, mechanism of food transport

Carbon and nitrogen metabolism

14L

Photosynthesis- Photosynthetic pigments, concept of two photo systems, photophosphorylation, calvin cycle, C4 cycle, CAM plants, SAM, photorespiration, compensation point, Nitrogen metabolism- inorganic & molecular nitrogen fixation, nitrate reduction and ammonium assimilation in plants.

Growth and development

14L

Growth and development: Definitions, phases of growth, growth curve, growth hormones (auxins, gibberlins, cytokinins, abscisic acid, ethylene), Physiological role and mode of action, seed dormancy and seed germination, concept of photo-periodism and vernalization; phytochrome and its role.

CC4- PLANT ANATOMY AND PHYSIOLOGY (PRACTICAL)

2 CREDITS

1. Study of evolution of oxygen during photosynthesis
2. Preparation of stained mounts of anatomy of monocot and dicot's root, stem & leaf.
3. Demonstration of opening & closing of stomata
4. Preparation of root nodules from a leguminous plant.
5. Seed viability test using TTC.
6. Study of rate of transpiration per unit area of leaf.

SUGGESTED READING

1. Dickinson, W.C. Integrative Plant Anatomy. Harcourt Academic Press, USA.
2. Esau, K. Anatomy of Seed Plants. Wiley Publishers.
3. Fahn, A. Plant Anatomy. Pergmon Press, USA and UK.
4. Hopkins, W.G. and Huner, P.A. Introduction to Plant Physiology. John Wiley and Sons.

5. Mauseth, J.D. Plant Anatomy. The Benjamin/Cummings Publisher, USA.
6. Nelson, D.L., Cox, M.M. 2004 Lehninger Principles of Biochemistry, latest edition, W.H. Freeman and Company, New York, USA.
7. Salisbury, F.B. and Ross, C.W. Plant Physiology, Wadsworth Publishing Co. Ltd.
8. Taiz, L. and Zeiger, E. Plant Physiology, latest edition, Sinauer Associates Inc .MA, USA

AECC-2 English/ MIL Communication

GENERIC ELECTIVE [For other discipline(s)]

Four courses to be offered (one course in each semesters)

ENTREPRENEURSHIP DEVELOPMENT (THEORY) 4 Credits

INTRODUCTION 10 L

Meaning, Needs and Importance of Entrepreneurship, Promotion of entrepreneurship, Factors influencing entrepreneurship, Features of a successful Entrepreneurship.

ESTABLISHING AN ENTERPRISE 12 L

Forms of Business Organization, Project Identification, Selection of the product, Project formulation, Assessment of project feasibility.

FINANCING THE ENTERPRISE 15 L

Importance of finance / loans and repayments, Characteristics of Business finance, Fixed capital management: Sources of fixed capital, working capital its sources and how to move for loans, Inventory direct and indirect raw materials and its management.

MARKETING MANAGEMENT 13 L

Meaning and Importance, Marketing-mix, product management – Product line, Product mix, stages of product like cycle, marketing Research and Importance of survey, Physical Distribution and Stock Management.

ENTREPRENEURSHIP AND INTERNATIONAL BUSINESS 10 L

Meaning of International business, Selection of a product, Selection of a market for international business, Export financing, Institutional support for exports.

ENTREPRENEURSHIP DEVELOPMENT (PRACTICALS) 2 Credits

1. Planning of establishing a hypothetical biotechnology industry in India
2. Project Report on a selected product should be prepared and submitted.

SUGGESTED READING

1. Holt DH. Entrepreneurship: New Venture Creation.
2. Kaplan JM Patterns of Entrepreneurship.
3. Gupta CB, Khanka SS. Entrepreneurship and Small Business Management, Sultan Chand & Sons.

BIOETHICS & BIOSAFETY (THEORY)**4 Credits****25L**

Bioethics – Necessity of Bioethics, different paradigms of Bioethics – National & International. Ethical issues against the molecular technologies. IPR and its legal protection in research, design and development.

25L

Biosafety– Introduction to biosafety and health hazards concerning biotechnology, Biological safety cabinets. Introduction to the concept of containment level and Good Laboratory Practices (GLP) and Good Manufacturing Practices (GMP). Reservation of GMO.

BIOETHICS & BIOSAFETY (PRACTICALS)**2 CREDITS**

1. A case study on clinical trials of drugs in India with emphasis on ethical issues.
2. Case study on women health ethics.
3. Case study on medical errors and negligence.
4. Case study on handling and disposal of radioactive waste
5. Study of clinical trials of drugs in India using charts, power points.

SUGGESTED READING

1. Sateesh MK (2010) Bioethics and Biosafety, I. K. International Pvt Ltd.
2. Sree Krishna V (2007) Bioethics and Biosafety in Biotechnology, New age international publishers

BIOTECHNOLOGY AND HUMAN WELFARE (THEORY)**4 Credits**

Industry: protein engineering; enzyme and polysaccharide synthesis, alcohol and antibiotic production. **8L**

Agriculture: N₂ fixation: transfer of pest resistance genes to plants; qualitative improvement of livestock. **8L**

Environments: e.g. chlorinated and non-chlorinated organic pollutant degradation; degradation of hydrocarbons and agricultural wastes, stress management, development of biodegradable polymers such as PHB. **12L**

Forensic science: e.g. solving violent crimes such as murder and rape; solving claims of paternity and theft etc. using various methods of DNA finger printing. **8L**

Health: e.g. development of non-toxic therapeutic agents, recombinant live vaccines, gene therapy, diagnostics, monoclonal antibody, Recombinant antibody and their utility, human genome project and personalised medicine. **14L**

BIOTECHNOLOGY AND HUMAN WELFARE (PRACTICAL) 2 Credits

(Wherever wet lab experiments are not possible the principles and concepts can be demonstrated through any other material or medium including videos/virtual labs etc.)

1. Study of ethanolic fermentation using Baker's yeast
2. Study of a plant part infected with a microbe
3. Isolation and analysis of DNA from minimal available biological samples
4. Preparation of root nodules from a leguminous plant

DEVELOPMENTAL BIOLOGY (THEORY) 4 Credits

Gametogenesis and Fertilization 10 L

Definition, scope & historical perspective of development Biology, Gametogenesis – Spermatogenesis, Oogenesis Fertilization - Definition, mechanism, types of fertilization. Different types of eggs on the basis of yolk.

Early embryonic development 20 L

Cleavage: Definition, types, patterns & mechanism Blastulation: Process, types & mechanism Gastrulation: Morphogenetic movements– epiboly, emboly, extension, invagination, convergence, de-lamination. Formation & differentiation of primary germ layers, Fate Maps in early embryos.

Embryonic Differentiation 20 L

Differentiation: Cell commitment and determination- the epigenetic landscape: a model of determination and differentiation, control of differentiation at the level of genome, transcription and post-translation level Concept of embryonic induction: Primary, secondary & tertiary embryonic induction, Neural induction and induction of vertebrate lens.

Organogenesis 10 L

Neurulation, notogenesis, development of vertebrate eye. Fate of different primary germ layers Development of behaviour: constancy & plasticity, Extra embryonic membranes, placenta in Mammals.

DEVELOPMENTAL BIOLOGY (PRACTICALS) 2 Credits

1. Identification of developmental stages of chick and frog embryo using permanent mounts
2. Preparation of a temporary stained mount of chick embryo
3. Study of developmental stages of *Anopheles*.

4. Study of the developmental stages of *Drosophila* from stock culture/ photographs..
5. Study of different types of placenta.

SUGGESTED READING

1. Gilbert, S. F. (2006). Developmental Biology, VIII Edition, Sinauer Associates, Inc., Publishers, Sunderland, Massachusetts, USA.
2. Balinsky, B.I. (2008). An introduction to Embryology, International Thomson Computer Press.
3. Kalthoff, (2000). Analysis of Biological Development, II Edition, McGraw-Hill Professional.

MICROBIAL PHYSIOLOGY (THEORY)

Nutritional classification of microorganisms based on carbon, energy and electron sources, Metabolite Transport, Diffusion: Passive and facilitated, Primary active and secondary active transport, Group translocation (phosphotransferase system), symport, antiport and uniport, electrogenic and electro neutral transport, transport of Iron. **12 L**

Microbial Growth. Definition of growth, balanced and unbalanced growth, growth curve, the mathematics of growth-generation time, specific growth rate, batch and continuous culture, synchronous growth, diauxic growth curve. Measurement of microbial growth. Measurement of cell numbers, cell mass and metabolic activity **13 L**

Effect of the environment on microbial growth: Temperature- temperature ranges for microbial growth, classification based on temperature ranges and adaptations, pH-classification based on pH ranges and adaptations, solutes and water activity, oxygen concentration, radiation and pressure. Chemolithotrophic metabolism, Physiological groups of aerobic and anaerobic chemolithotrophs. Hydrogenoxidizing bacteria and methanogens. **12 L**

Phototrophic metabolism. Historical account of photosynthesis, diversity of phototrophic bacteria, anoxygenic and oxygenic photosynthesis, photosynthetic pigments: action and absorption spectrum, type, structure and location, physiology of bacterial photosynthesis: light reactions, cyclic and non-cyclic photophosphorylation. Carbon dioxide fixation, Calvin cycle and reductive TCA cycle. **13 L**

MICROBIAL PHYSIOLOGY (PRACTICALS)

2 Credits

1. To study and plot the growth curve of *E coli* using turbidometric method and to calculate specific growth rate and generation time.

2. To study and plot the growth curve of *Aspergillus niger* by radial growth measurements.
3. To study the effect of pH on the growth of *E. coli*
4. To study the effect of temperature of *Aspergillus niger* by dry weight method.
5. Demonstration of the thermal death time and decimal reduction time of *E. coli*.

SUGGESTED READING

1. Gottschalk G. (1986). Bacterial Metabolism. 2nd edition. Springer Verlag
2. Madigan MT, Martinko JM and Parker J. (2003). Brock Biology of Microorganisms. 10th edition. Pearson/ Benjamin Cummings.
3. Moat AG and Foster JW. (2002). Microbial Physiology. 4th edition. John Wiley & Sons.
4. Reddy SR and Reddy SM. (2005). Microbial Physiology. Scientific Publishers India.
5. Stanier RY, Ingrahm JI, Wheelis ML and Painter PR. (1987). General Microbiology. 5th edition, McMillan Press.
6. Willey JM, Sherwood LM, and Woolverton CJ. (2008). Prescott, Harley and Klein's Microbiology. 7th edition. McGraw Hill Higher Education.

BIOPHYSICS & INSTRUMENTATION (THEORY)

4 Credits

General Biophysical methods – Measurement of pH, Radioactive labeling & counting, autoradiography **5 L**

Separation & Identification of Materials, Concept of Chromatography; Partition Chromatography, Paper Chromatography, Adsorption Chromatography, TLC, GLC, Ion Exchange Chromatography, Gel Chromatography, HPLC, Affinity Chromatography; Gel Electrophoresis, Paper Electrophoresis **15 L**

Centrifugation - Basic Principle of Centrifugation, Instrumentation of Ultracentrifuge (Preparative Analytical), Factor affecting Sedimentation Velocity, Standard Sedimentation Coefficient. **10 L**

Microscopy- Light Microscopy, Bright & Dark Field Microscopy, Phase Contrast Microscope, Fluorescence Microscopy, TEM, SEM. **10 L**

Spectroscopy- UV visible Spectroscopy, Principle, Beer-Lambert Law, Working Principle of Colorimeter, Spectrophotometer, Fluorometer. Application to biomolecules (Protein, DNA, Hb, Chlorophyll) **10 L**

BIOPHYSICS & INSTRUMENTATION (PRACTICALS)

2 Credits

1. Separation techniques- Centrifugation, Chromatography (Paper, TLC, Silica Gel Chromatography), & Electrophoresis
2. General Concept of Colorimeter, Spectrophotometer

SUGESSTED READING

1. Principles and Techniques of Biochemistry and Molecular Biology by K.Wilson and J. Walker
2. Molecular Spectroscopy by Jack D.Gray Beal