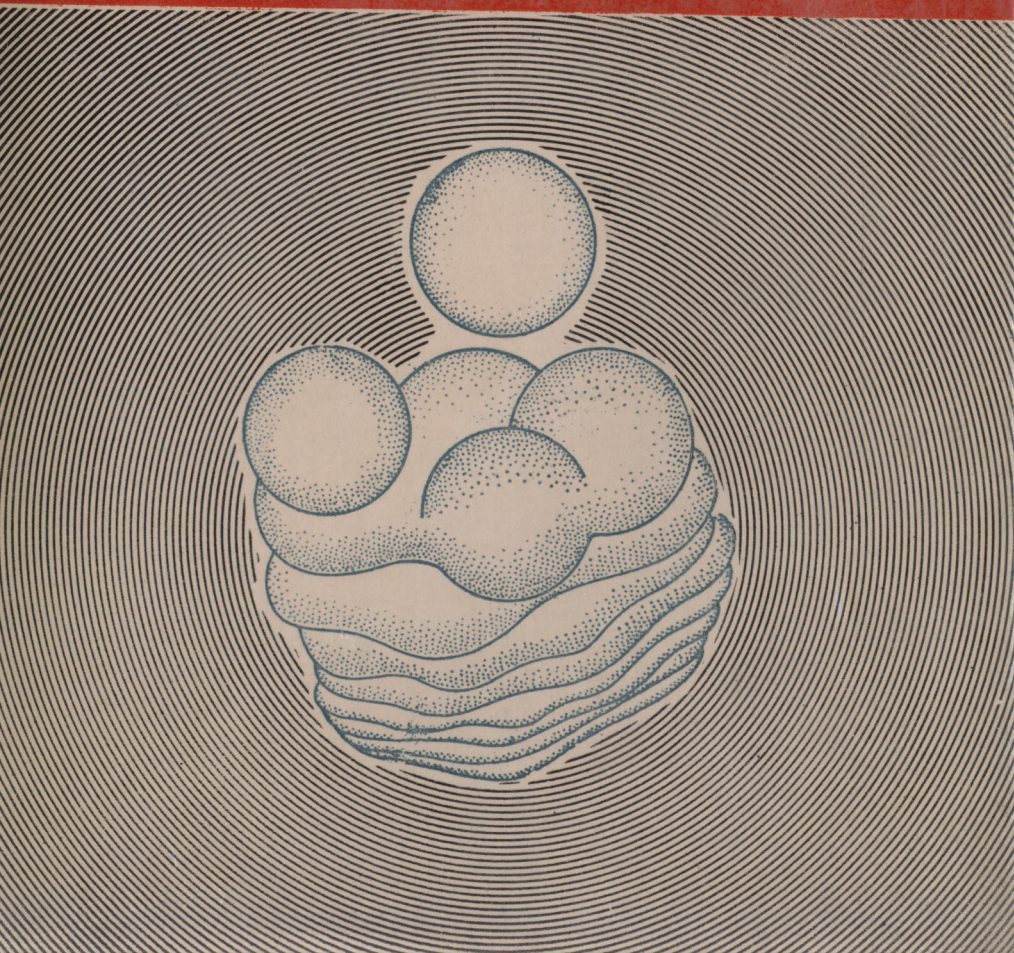
GUPTA
JANGIR

THE CELL AND BIOTECHNOLOGY



THE CELL AND BIOTECHNOLOGY

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PREFACE

The present book is the result of long experience in teaching of cell biology. Since the 1960s the study of cells has become one of the dominating activities in all of science. Many disciplines - biochemistry, molecular biology, genetics, biophysics, physiology, etc. now contribute to the continuing growth in understanding about how cells function and how they are constructed. This is an exciting enterprise, which as an intellectual achievement contributes greatly to our understanding of the phenomenon of life. Researches on cells provide an expanding foundation for advances in medical sciences and for new industrial and agricultural technologies.

During the last three decades, great advancements have been made in the fields of biotechnologies. Biotechnological processes have played a great role in economic development. Being a privileged area of research for microbiologists and enzymologists, biotechnologies have recently benefited from decisive progress made in virology, bacteriology, cell biology, moleclar genetics and especially from the discovery of technique to modify and transfer DNA between organisms. Cell and molecular biology, along with other branches of science are intimately associated with the field of biotechnology.

The cell biology is included in syllabi of almost all the universities. The biotechnology as subject makes part of syllabi of only a few universities, although various aspects of this branch are being taught in classes of molecular biology, genetics, microbiology, medicine, etc.

The book has been divided into two sections - Section 'A' deals with the cell structure and functions, and Section 'B' with biotechnology. Section 'A' contains 13 chapters describing various cellular organelles in detail. In chapter-2 some of the latest techniques useful in studying the cells have been detailed. Section 'B' contains 5 chapters dealing with various aspects of biotechnology. Special care has been taken to include maximum illustrations, tables and graphs explaining every aspect of structure and function of cellular organelles and various biotechnological processes. An exhaustive list of subject index is given in the end.

We express our thanks to M/s Agro Botanical Publishers (India) for bringing out the book in the shortest possible period.

We wish to acknowledge our debt to our families whom we left waiting on several evenings, while we were busy in finalizing the manuscript or the illustrations for the book.

We shall feel obliged in receiving constructive suggestions from the readers for further inprovement of the book.

November, 1990

M. L. Gupta
M. L. Jangir

CONTENTS

PREFACE

THE CELL AND ITS DIVERSITY (1-21)
Discovery of the cell and cell theory-1, Diversity of cells-9, Viruses-10, Icosahedral symmetry-10, Helical symmetry-10, Complex symmetry-10, Prokaryotes-13, Bacteria-13, Coccus bacteria-13,Bacillus bacteria-14, Spirillum-14, Spirochaetes-14 Blue Green Algae-15, Eukaryotes-17.

HOW A CELL IS STUDIED (22-47)
Cytochemistry-22, Detection of proteins by Millon's reaction-23, Procedure-23, Detection of polysaccharides by periodic acid-Schiff (PAS) reaction-24, Detection of lipids by Sudan black B staining-24, Procedure-24, Detection of DNA by Feulgen method-25, Procedure-25, Detection of DNA and RNA by Acridine orange staining-25, Detection of DNA and RNA by methyl-green-pyronin Y method-26, Cell fractionation and centrifugation-26, Cytophotometery and cytofluorometry -27, Autoradiography-29, Immunofluorescence-30, Freeze fracture replication and freeze etching-31, X-ray diffraction-34, Cell culture-36, Microscopy-36, Light microscopy-37, Bright field microscopy-37, Phase contrast microscopy-38, The Nomarski interference-contrast

microscopy-41, The interference microscopy-42, The fluorescent microscopy-43, The polarizing microscope-44, The electron microscope-45, Video microscopy-45.

CELL MEMBRANE: STRUCTURE AND FUNCTION (48-132)
Introduction-48, Variations among membranes-49, Isolation and analysis of plasma membranes-50, Molecular organization (Chemical composition) of the cell membrane-51, Lipids-53, Phospholipids-53, Glycerophospholipids-54, Sphingophospholipids-54, Glycolipids-54, Cerebrosides-55, Gangliosides (Ceramide sugars)-55, Phytosterols-56, Ergosterol-56, Carbohydrates-56, Membrane proteins-57, Major polypeptides of the red cell membrane-58, Peripheral membrane proteins-61, Bands 1 and 2 (Spectrin)-61, Band 4-61, Band 5 (Actin)-62, Band 6-62, Integral membrane proteins-63, Band 3-63, Band 7-64, PAS-1 and PAS-2 (Glycophorin A)-64, PAS 3-66, PAS 4-67, Minor glycopeptides-67, Proteo lipids-67, Acetylcholinesterase (AChe)-67, ATPase-67, Asymmetrical Distribution of proteins-67, Techniques for labelling membrane proteins-68, Functions of the membrane proteins-69, Asymmetrical distribution of enzymes-69, Molecular models of the cell membrane-70, Unit membrane structure (The greater membrane model)-71, Protein crystal model (Green's model)-74, Fluid mosaic model-76, Fluidity-84, The diffusion of membrane proteins after cell fusion-86, Patching and capping-87, The importance of membrane fluidity-91, Membrane functions-92, Inter cellular interactions-93, Transfer of information-93, Compartmentalization-94, Regulation of the movements of materials-94, Locus for biochemical activities-94, Secretion-95, Endocytosis and exocytosis-95, Antigen specificity-96, Chemoreception-96, Energy transduction-96, Conductors of nervous impulses-96, Miscellaneous-97, Cell permeability and transport-97, Membrane permeability-98, Permeability of the plasma membrane to water-100, Permeability of cells to solutes-102, Concentration gradient-102, Partition coefficient and molecular size-103, Movement of ions-105, Donnan equilibrium-106, Membrane transport mechanisms-112, Passive diffusion-112, Facilitated diffusion-114, Active transport-118, Primary active transport-121, The sodium - potassium pump-121, The calcium pump-127, Secondary active transport-127, Group translocation-129, Anion transport in erythrocytes-131.

THE CELL SURFACE AND CELLULAR INTERACTIONS(132-153)
Introduction-133, The cell coat and extracellular materials-133,

Modifications of plasma membrane and inter-cellular junctions-141, Microvilli-142, Tight junctions-143, Desmosomes-144, Gap junctions-146, Cell adhesion and interacellular recognition-147, Cell-noncellular surface adhesion-147, Cell-Cell surface adhesion-148, Sponge cell adhesion-149, Vertebrate cell adhesion-151.

THE CYTOSKELETON (154-165)
Introduction-154, Cytoskeletal elements-155, Microtubles-155, Structure-155, Functions-158, Shaping of the cell and mechanical support-158, Transport-158, Morphogenesis-158, Cellular motility-159, Microfilaments-159, Structure-159, Functions-161, Intermediate filaments-161, Structure-161, Keratin filaments-162, Glial filaments-162, Neuro filaments-163, Desmin filaments-163, Vimentin containing filaments-164, Synemin containing filaments-164, Cytoplasmic microtrabecular system (Lattice)-164.

MITOCHONDRIA AND CELL ENERGETICS (166-208)
Introduction-166, Morphology of mitochondria-168, Shape-168, Size-168, Distribution-168, Orientation-169, Number-169, Movement-170, Sensitivity-172, Mitochondrial structure-172, Mitochondrial cristae-174, F particles-175, Head piece-176, Stalk-176, Base piece-176, Isolation and chemical composition-177, Proteins-177, Lipids-177, Sialic acid-178, Enzymes-178, Enzyme distribution in mitochondria-178, Matrix-179, Mitochondrial DNA (mtDNA)-179, Mitochondrial RNA (mtRNA)-179, Bioenergetics : Molecular organization and function of mitochondria-179, Glycolysis-180, Krebs cycle (TCA cycle)-182, Electron transport system-183, Respiratory chain complexes-183, Complex I (NADH-Q-reductase)-184, Complex II (Succinate - Q - reductase)-184, Complex III (QH - cytochrome-reductase)-184, Complex IV (Cytochrome-c-oxidase)-184, Components of the respiratory chain-187, Oxidative phosphorylation-194, Direct chemical coupling hypothesis-196, Chemiosmotic theory-197, The chemical - conformation hypothesis-203, Over all energy balance-207.

CHLOROPLAST (209-231)
Introduction-209, Structure-210, Starch granules-213, Osmiophilic granules-213, Pyrenoids-213, Molecular organization of chloroplasts-214, Lipids-214, Carotene-216, Carotenols-216, Proteins-216, Photosystem I (PSI)-217, Photosystem II (PSII)-217, Cytochrome b/f-217, ATP synthetase-217, Light-harvesting complex (LCH)-219, Photosynthesis-219, Phase I Reac-

nucleolus-360, 5S RNA biosynthesis-362, Ribosomal biogenesis can be followed under the EM-363, Ribosomes and protein synthesis-364, The small subunit binds to the mRNA ribosome binding site-365, IF_1 , IF_2 and IF_3 protein factors that initiate protein synthesis-366, Chain elongation factors (EFTu, EFTs and EFG)-369, Chain termination involves releasing factors-371, The signal hypothesis-371.

CENTRIOLOES (374-392)
Introduction-374, Fine structure of centrioles-376, The molecular composition-381, Biology of centrioles-383, Centriole formation-383, Centriole degeneration-385, Regulation of centriole number-385, Centriole cycle-386, Functions of centrioles-389, Role in mitosis-389, Microtubule generation-389, Ciliogenesis-390, Spermiogenesis-391.

INTERPHASE NUCLEUS (393-438)
Introduction-393, Morphology-394, Occurrence-394, Shape-394, Size-395, Number-395, Position-396, Ultrastructure-396, The nucleoli-397, The nuclear envelope-400, Ultrastructure-400, The nuclear membranes-400, Perinuclear space-401, Nuclear pores-402, Annulate lamellae-403, The nuclear lamina-404, Chemical composition-405, Biochemical analysis-405, Cytochemical studies-407, Functions-407, Nucleo-cytoplasmic exchange-409, Exchange of macromolecules across nuclear pores-409, Blebbing-412, Direct passage across the membranes-412, Exchange through the ER-413, Small organic molecules-413, Ions-413, Attachment of chromatin and other nuclear components-415, Attachment of structural elements of the cytoplasm-417, Contribution to other intracellular membranes-417, Protein synthesis-418, Electron transport activity-418, Chromatin-418, Chromatin is a complex of DNA and Histones-419, DNA-419, Properties of DNA-419, Absorbance-419, Hypochromicity-420, Ionic interactions-420, Denaturation-420, Renaturation (or reannealing)-420, Viscosity-421, Molecular weight-421, Sedimentation-421, EM structure of chromatin-beaded structure-423, The nucleosome-423, The 30 nm fiber-a nucleosome solenoid-426, Chromatin structure of active genes-427, Heterochromatin-427, Types-428, Constitutive heterochromatin-428, Centromeric-428, Telomeric-429, Nucleolus-organizers-429, Intercalary-429, Entire chromosomes-429, Facultative heterochromatin-429, Properties-430, Genetically inactive-430, Muller-430, Position effect-430, Temporary genetic inactivity-431. Absence of template activity in vitro-431, Late

replication in the synthetic phase-431, Repititive DNA in constitutive heterochromatin-431, Heterochromatin is not transcribed-431, Breakage-431, Abnormal mitotic coiling-431, Specific staining with certain fluorochrome dyes-432, Allocycle or heteropycnosity-432, Banding-432, The nucleolus-432, Isolation and cytochemistry-432, EM structure of the nucleolus-433, Granular zone-433, Fibrillar zone-434, Pars amorphus or the matrix-435, The nucleolus associated chromatin-435, Formation of the nucleolus-435, Functions of the nucleolus-437, Nucleoli and as mediators of protein biosynthesis-437, Ribosomal RNA synthesis-438, Biogenesis of ribosomes-438.

BIOTECHNOLOGY: AN INTRODUCTION AND HISTORY (439-443)
Definition-439, Introduction-439, History-440.

CELL AND TISSUE CULTURE (444-468)
Introduction-444, Primary and Established cell lines-444, Kinetics of cell growth-447, Established cell lines-447, Lag phase-447, Logarithmic (log)phase-447, Stationary phase-447, Primary cell lines-448, Interaction among cells-449, Genetics of cultured cells-449, Metabolism-450, Microbial culture-450, Energy source-451, Mineral salts-451, Growth factors-451, Temperature-451, Animal cell and tissue culture-451, Mechanical technique-453, Biochemical technique-453, Plant cell and tissue culture-453, Animal tissue culture media-455, Culture media containing naturally occurring ingredients -455, Blood plasma-456, Blood serum-456, Preparation of chicken serum-457, Preparation of mammalian serum-457, Tissue extracts-458, Preparation of embryo extract-458, Complex natural media-458, Supplemented hanks-simms medium-458, Supplemented bovine amniotic fluid medium-459, Serum-supplemented yeast extract medium-459, Serum-supplemented lactalbumin hydrolystate and yeast extract medium-459, Chemically defined media-459, Medium No.612-461, Medium No. 635-461, Medium No. 858-461, Medium No. 866-461, Medium CMRL-1066-461, Plant tissue culture media-462, Gauthered medium (1942)-462, Hidebrandt et al. medium (1946)-462, Burkholder and Nickell Medium (1949)-463, Nitsch medium (1951)-463, Heller medium (1953)-463, Reinert and white medium (1956)-463, Murashige and skoog medium (1962)-464, White medium (1963)-464, Camborg et al. medium (1968)-464, Schenk and Hildebrandt medium (1972)-464, Applications of tissue culture-465, Morphological studies-465, Quantitative studies-465, Tissue cultures in

Biochemical Research - Genetics-465, Karyological studies-465, Identification and study of heteditary metabolic disorders-466, Somatic cell genetics-466, Tissue cultures in biomedical research - Virology and Host-parasite relationship-466, Tissue cultures in biomedical research - Cancer-467, Tissue culture and plant productivity-467.

GENETIC ENGINEERING (469-486)
Introduction-469, Recombinant DNA Technology-473, Identification and Isolation of Desired Gene-473, Insertion of DNA (Gene) into Bacteria-474, Gene Insertion in Mammalian cells-476, Cell-Cell Fusion-476, Insertion of Recombinant DNA-476, Genetic Engineering in Plants-478, Biosynthesis of Human Insulin-481, Biosynthesis of Huuman Growth Hormone (hGH) or Somatotropin-482, Production of Interferons-484, Production by Blood Cells and Fibroblasts-484, Production by Genetically Engineered Microorganisms-485.

HYBRIDOMAS (487-496)
Introduction-487, Hybridoma Technology-488, Monoclonal Antibodies: Their Production and Applications-490, Production-490, Fusion and Culture of Hybridomas-491, Cloning and Preservation of Hybridomas-493, Production of Antibodies-493, Applications-495.

INDUSTRIAL MICROBIOLOGY (497-528)
Introduction-497, Fermentation in dustry-499, Regulatory Mechanisms and Industrial Fermentations-499, Enzyme induction-501, Feedback repression-502, Catabolite repression-502, Hyperproduction by Deregulated Mutants- Gene Dosage-505, Production Process-505, Fermentation medium-505, Aeration-506, pH-506, Temperature-506, Immobilized Enzymes-506, Production of Pharmaceuticals-507, Antibiotics-508, Penicillin-508, Cephalosporin -509, Streptomycin-509, Steroids-509, Human Proteins-510, Vaccines-512, Vitamins-512, Production of Organic Acids-513, Acetic Acid-513, Gluconic Acid-513, Citric Acid-514, Itaconic Acid-514, Gibberellic Acid-514, Lactic Acid-515, Fumaric Acid-515, Production of Amino Acids-515, Lysine-516, Glutamic Acid-516, Production of Enzymes-517, Proteases-517, Amylases-517, Other Enzymes-518, Production of Fuels-518, Ethanol-518, Methane-519, Other Fuels-522, Production of Single Cell Protein-523, Recovery of Mineral Resources-525, Bioleaching of Metals-525, Oil Recovery-526.

THE CELL AND ITS DIVERSITY

1

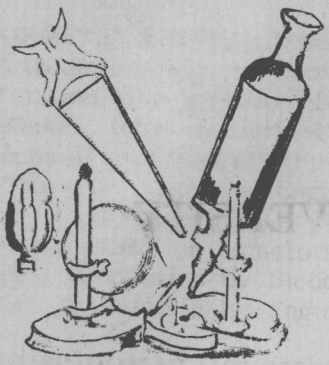
DISCOVERY OF THE CELL AND CELL THEORY

The cytology is comparatively a young biological science and had taken its individual entity by the end of the 19th century. The development of cytology is intimately associated with the discovery of lenses and microscopes. There are evidences that lenses were used in 13th century.

The early microscopes were different from the modern ones. One type consisted of two lenses mounted in a short round tube. The object to be examined was fastened at one end of the tube. da Vinci (1485) stressed upon the use of lenses in observing small objects. Insects were examined first by these crude microscopes because of their abundance and ease with which they could be caught.

In 1665, Robert Hooke, an english physicist dicovered the cell for the first time while examining a thin slice of

cork cut with a pen-knife under his crude microscope. He observed honey-combed or porous structures. He gave them the name 'cells' (Lt. **cellula** = little room). What Hooke had seen was mainly the thick cellulose walls of the dead cells. He confirmed his discovery in other plant materials also.



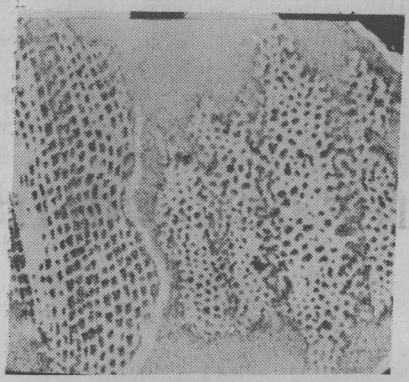


Fig. 1.1 (A) The microscope used by Robert Hooke. (B) Robert Hooke's drawing of cork showing compartments(cells).

M. Malpighi, an Italian anatomist and N. Grew, an English physicianin in 1672 reported that certain parts of plants were made up of minute elementary organisms - 'utricles', 'sacs' and 'vesicles'. They did not use the word 'cell'. Antony von Leeuwenhoek (1632-1723) discovered the animalcules infusoria (protozoa), bacteria, etc. and made microscopical observations on many protozoans, ants, aphids, spermatozoa, red blood cells, muscles, nerves, skin, and certain plants. During the 18th century only little knowledge was added to cytology. A few workers produced the work on plant cells and referred them by different names- fibres by Haller and Bonnet (1757); cylinders by Fontana (1781); utricus by Brisseau-Mirabel and elementary vesicles by Oken.

In 19th century, certain important cytological discoveries were made - occurrence of cell division by Turpin (1826); mammalian ovum (Karl Von Baer, 1827); Brownian movement (Robert Brown, 1828); Nucleus (Robert Brown, 1831); description of cell division (H. von Mohl, 1835). Felix Dujardin (1835) observed jelly like structure within the cells and termed it as 'saccode'.

Although many workers were able to observe a variety of different types of plant cells as well as single celled organisms, the realization that all plants and animals regardless of their diverse outward appearence, were composed of component cells was not clearly stated untill the 1830s following the development of microscopes with better quality optics. Matthias J. Schleiden (1838), a German botanist concluded from his research on plants that regardless of a particular tissue's appearance, plants were made up of cells and that the plant embryo arose from a single cell. In 1939, Theodor Schwann, a German zoologist published a report stating that the animals were also composed of cells. The work of Schleiden and Schwann led to the formulation of the '**cell theory**', which stated that all animals and plants were composed of cells which are units of life. Advancements in cell biochemistry, cell physiology, genetics, etc. unfolded some new factes regarding cells. Modern status of cell theory comprises:

(i) All living beings- animals and plants are composed of cells.

(ii) New cells arise from pre-existing cells.

(iii) Cells represent the metabolic (physiological) units also.

(iv) Cells are units of hetedity since these contain the hereditary material.

(v) There are fundamental similarities in the chemical composition and metabolic activities of all cells. The function of the organism as a whole was also recognised to be a result of the activities and interactions of the cell units.

(vi) Viruses, bacteria, certain fungi and protozoans are exceptions to cell theory.

Important discoveries made after early 19th century are listed in Table 1.1.

Table 1.1. Chronological description of important discoveries made from 19th century.

1824 **R.J.H. Dutrochet**	Animals and plants are composed of cells which remain united by simple adhesive forces.
1824 **P. Prevost and J.B.A.Dumas**	Described cell division by studying cleavage of the frog's eggs.
1825 **F.V.Raspail**	Developed frozen section technique.
1826 **Turpin**	Reported occurrence of cell division.
1827 **Karl von Baer**	Discovered the mammalian ovum.
1828 **Robert Brown**	Described Brownian movement of the cellular particles.
1830 **G. B. Arniel**	Described fertilization in plants.
1831 **Robert Brown**	Reported the nucleus in plant cells.
1835 **Felix Dujardin**	Described protoplasm as 'sarcode' in protozoa.
1835 **H.Von Mohl**	Described cell division in animals.
1838 **M. J. Schleiden**	Proposed cell theory with Schwann and described nucleolus also.
1839 **T. Schwann**	Proposed cell theory with Schleiden.
1840 **J. E. Purkinje**	Coined the term protoplasm for the cell contents.
1845 **A. Donne**	Studied spermatozoa and used photo-microscopy for the first time.
1846 **H. Von Mohl**	Described importance of protoplasm in cellular activities.
1848 **W. Hofmeister**	Drew outline sketches of chromo-somes of the pollen mother cells

Table 1.1 contu.....

	of **Tradescantia** and described nuclear division.
1855 **R. Virchow**	Stated that all cells arise from pre-existing cells.
1861 **Schultze**	Stated that the cell is the living substance possessing nucleus and the cell membrane.
1863 **W. E. Waldeyer**	Described chromosomes.
1866 **E. Haeckel**	Coined the term plastids.
1867 **L. St. George**	Described the structure which was later called Golgi-complex.
1870 **W. His**	Developed microtomes for cutting sections.
1870 **H. Fol**	Described spindle and astral rays.
1871 **F. Miescher**	Discovered nucleoproteins and nucleic acids (nuclein).
1876 **O. Hertwig**	Demonstrated that fertilization is the result of fusion of two cells.
1879 **H. Fol**	Observed the penetration of sperm in an ovum.
1879 **W. Flemming**	Introduced the term chromatin and described the splitting of chromosomes.
1882 **W. Pfitzner**	Discovered chromomeres on the chromosomes.
1883 **W. Roux**	Proposed that chromosomes contain hereditary material.
1883 **Schimper**	Introduced the term chloroplast.

Table 1.1 contu.....

1886 **R. Altman**	Studied mitochondria and suggested their role in respiration.
1887 **Van Benden**	Discovered the centrioles.
1888 **T. Boveri**	Desctibed the centrioles.
1892 **A. Weismann**	Proposed 'germ plasm' theory.
1898 **C. Benda**	Coined the term mitochondria.
1898 **C. Golgi**	Described the Golgi complex in the nerve cells of owl.
1901 **T. H. Montgomery**	Showed that homologous chromosomes undergo pairing during reduction division.
1901 **Strasburger**	Introduced the term plasmodesmata.
1903 **W.S.Sutton**	Proposed chromosome theory of heredity.
1903 **E. Büchner**	Discovered the enzyme and received Nobel prize.
1905 **J.B.Farmer** and **J.E.Moore**	Coined the term meiosis.
1906 **M. Tswett**	Discovered chromatography.
1907 **R.G.Harrison**	Developed tissue culture technique.
1910 **A. Kossel**	Described the chemistry of nucleus and honoured by Nobel prize.
1915 **R.M. Willstatier**	Honoured by Nobel prize for the investigation of chlorophyll.
1924 **A. Feulgen** and **H. Rossenbeck**	Described Feulgen test for DNA.
1926 **T. Svedberg**	Honoured by Nobel prize for ultracentrigugation technique.