

CELL BIOLOGY

Cytology, Biomolecules and Molecular Biology



S. CHAND

**P S VERMA
V K AGARWAL**

CELL BIOLOGY

(Cytology, Biomolecules and Molecular Biology)

About the Authors

Dr. P. S. Verma, M.Sc., PhD, F.E.S.I. and F.A.Z, has immense teaching experience. He taught Zoology to undergraduate and postgraduate students at Meerut College, Meerut till 2000. Dr. Verma has engaged in active research, and also successfully guided several PhD students. He has to his credit publication of several research papers.

A celebrated author, Dr. Verma has written several books on Zoology. His books include Biology for Schools, and Biology for classes XI and XII (CBSE and ISC). He has also written several books for undergraduate and postgraduate courses. His books have been very popular among the student community.

His famous books include Invertebrate Zoology, Chordate Zoology, Practical Zoology (Invertebrate), Practical Zoology (Chordate), Cell Biology, Genetics, Cytology, Chordate Embryology, Textbook of Biology for class IX, Textbook of Biology for classes XI and XII and ISC Biology for classes XI and XII.

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Dr. Agarwal has to his credit the authorship of several widely acclaimed books such as Cytology, Genetics, Chordate Embryology (Developmental Biology), Ecology (Environmental Biology), Ethology (Animal Behaviour), Zoology for B.Sc. - I (includes Invertebrate Zoology), Molecular Biology, Genetic Engineering, and a multi-coloured edition of Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. The author has also co-authored CBSE – IX Biology. He has also published few research papers on Insect Physiology and Toxicology.

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(Cytology, Biomolecules and Molecular Biology)

[For B.Sc., B.Sc. (Hons.) and M.Sc. Classes of All Indian Universities]

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PREFACE

Cell Biology deals with cells, biomolecules, genomes and proteoms. Myriad of biomolecules have interacted to control the morphology, physiology, molecular biology, evolution and growth of the cells. Cell Biology tries to understand various intricacies of functions which govern the life of the cell. In this tune, readers may come across in this textbook the topics of Induction, Differentiation, Stem cells, Cancer, Aging, Cell death, etc. Cell Biology has touched many vital aspects of human life. It has proved to be a boon as well as a curse in the hands of human beings as the following paradox indicates.

In the year 2012, Jennifer A. Doudna, a biochemist at the University of California, Berkeley, U.S.A., helped make one of the most monumental discoveries in Cell Biology regarding cellular defense system; a relatively easy way to alter any organism's DNA just as a computer user can edit a word in a document. Doudna's CRISPR-Cas9 genome editing technique (using the guide RNA) is already widely used in laboratory studies, and scientists hope it may one day help rewrite flawed genes in people, opening tremendous new possibilities for treating, even curing the dreaded diseases. (CRISPR = clustered regularly interspaced short palindromic repeats; Cas9 is the name of bacterium which has synthesized the protein for cutting the DNA.) However, many scientists including Ms Doudna are now worried that this technique could also be used to alter genes in human embryos, sperms and eggs in ways that can passed from generation to generation. The prospect raises fears of a dystopian future in which scientists create an elite population of designer babies with enhanced intelligence, beauty or other traits (Andrew Pollack, in Indian Express, 17th May 2015).

This book of Cell Biology has been developed according to the latest U.G.C. syllabi and is meant to cater to the needs of B.Sc. and M.Sc. students of almost all Indian Universities.

This book of **Cell Biology**, has been written in a simple and lucid language. Illustrations of the book have been redrawn from various standard resources. Main motives of the authors have remained to be quite authentic, modern, yet straightforward in their approach. For revision and practice of our readers, a variety of exercise questions such as Long Answer Questions, Short Answer Questions, Very Short Answer Questions, Fill in the Blanks, Multiple Choice Questions, etc., have been provided at the end of each chapter of this book. Appropriate answers to Very Short Answer Questions, Fill in the Blanks and Multiple Choice Questions have also been provided in the book.

At the end of the book, our readers may go through an exhaustive Glossary.

We hope our readers may appreciate our painstaking efforts to serve them in every cognitive ways.

Errors and shortcomings in the book are regretted and feedbacks from our readers will help the authors for corrections and improvements in the future editions of this book.

Our heartfelt thanks to our respective families for their cooperation and support to this endeavour.

Our sincere thanks to the Management and the team of young wizards of Editorial Department and D.T.P. Section of S.Chand & Company Pvt. Ltd., New Delhi, for help and support in the publication of this book.

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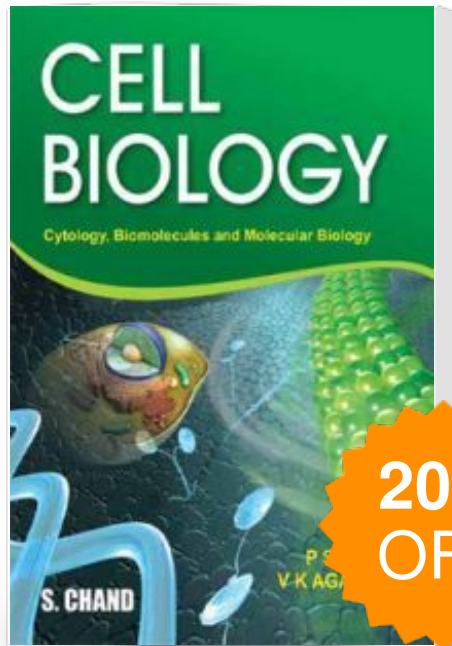
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chemical mutagens on nucleotide sequence, Classification of mutation according to the origin—spontaneous mutations, induced mutations, Classification of mutation according to direction—forward mutations, reverse or backward mutations, classification of mutation according to magnitude of phenotypic effect—dominant mutations, recessive mutations, isoalleles, lethal mutations, classification of mutation according to consequent changes in amino acid sequence, classification of mutation according to the types of chromosomes—autosomal mutations, sex chromosomal mutations, mutations rate; Method of detection of sex-linked lethal mutation; Significance of mutation; Questions.

- 38. GENETIC CODE** **781–796**
 Basis of cryptanalysis; Codon assignment (cracking the code or deciphering the code); theoretical approach, the *in vitro* codon assignment, the *in vivo* codon assignment; Characteristics of genetic code: the code is a triplet codon, the code is non-overlapping, the code is commaless, the code is non-ambiguous, the code has polarity, the code is degenerate, some codes act as start codons, some codes act as stop codons, the code is universal; codon and anticodon; wobble hypothesis; deviations from universality of genetic code; Evolution of genetic code; Questions.
- 39. TRANSCRIPTION AND mRNAs, rRNAs AND tRNAs** **797–819**
 Chemical composition of non-genetic ribonucleic acid (RNA); Comparison between DNA replication and transcription; Mechanism of prokaryotic transcription: enzymatic synthesis of RNA, the RNA polymerase enzyme, binding of RNA polymerase to promoter: initiation, elongation and termination, classes of RNA molecules and processing, mechanism of eukaryotic transcription, initiation of eukaryotic transcription, elongation of RNA chain in eukaryotes, termination of eukaryotic transcription, chromatin structure and transcription; Types of non-genetic RNA and processing; ribosomal RNA (rRNA), messenger RNA (mRNA) life span of mRNA, transfer RNA (tRNA), Questions.
- 40. PROTEIN SYNTHESIS** **820–841**
 Central dogma and central dogma reverse; Minimum necessary materials for translation, overview of mechanism of protein synthesis; Mechanism of translation or protein synthesis: aminoacylation of tRNA (attachment of amino acid to transfer RNA), few characteristics of aminoacyl-tRNA synthetases, initiation of translation, elongation, termination; antibiotics and protein synthesis; Questions.
- 41. REGULATION OF GENE ACTION** **842–869**
 Regulation of gene action in prokaryotes, discovery of prokaryotic gene regulatory proteins, types of gene regulation in prokaryotes, constitutive genes and inducible genes, transcriptional control mechanisms, the Operon model, examples of operons: *lac* operon (inducible system), catabolic repression of *lac* operon (inducible system), catabolic repression of *lac* Operon (glucose effect), TRP operon, mode of action of gene regulatory proteins, molecular recognition, helix turn-helix motif, homeodomain protein, translational control, post-translational control (feedback inhibition or end product inhibition); Operons of phage λ life cycle; Regulation of gene action in eukaryotes: regulation of gene action at the level of genome, regulation of gene action at the level of transcription, post-transcriptional regulation; translational control, post-translation modification of proteins to make them active ones, hormonal control of gene expression; Questions.
- 42. CELL COMMITMENT** **870–882**
 Cell commitments: levels of commitment; Specification; Questions.

- 43. INDUCTION** **883–897**
Lateral inhibition; inductive interaction; mode of action of inducers; discovery of organizer, discovery of primary embryonic induction, how does the organizer forms; Questions.
- 44. CELL DIFFERENTIATION** **898–921**
Differential gene expression, anatomy of gene: active and repressed chromatin, structure of an eukaryotic gene, functions of transcription factors; differential nRNA processing, example of nuclear RNA selection, examples of differential nRNA splicing; differential mRNA translation; differential mRNA longevity, selective inhibition of mRNA translation (stored oocyte mRNAs), role of microRNAs (miRNAs) in cleaning of used mRNAs from the early embryos, control of RNA expression by cytoplasmic localization, stored mRNAs in brain cells; differential protein modification; hormonal control of gene expression; Questions.
- 45. STEM CELL CONCEPT AND CELL REPLACEMENT THERAPY** **922–934**
The stem cell concept; History; Classification of stem cells; Adult stem cells: types of adult stem cells, adult stem cell niches (or regulatory microenvironment)–stem cell niche in mouse incisors, hair follicle stem cell migration and differentiation, haematopoiesis, mesenchymal stem cells (multipotent adult stem cell); cell replacement therapy: cell replacement therapy with oligodendrocytes, somatic cell nuclear transfer (SCNT), precautions for working with iP cells, transdifferentiation; Questions.
- 46. CELL GROWTH, CELL CYCLE AND MITOSIS** **935–965**
Historical; Types of cell division, amitosis, mitosis and cell cycle; cell growth: factors regulating cell growth, types of mitogens, extracellular growth factors stimulate cell growth, extracellular survival factors, anchorage dependence and cell shape; cell cycle; mitosis: prophase, prometaphase-centrosome cycle, dissolution of nuclear membrane, metaphase, anaphase, forces required for chromosome movements at anaphase, spindle assembly check point (SAC), motor proteins involved in mitotic movement; Cytokinesis–partitioning of cytoplasmic organelles; significance of mitosis; regulation of cell cycle; mitotic poisons (mitotic inhibitors); chalone; induced disassembly of cytoskeletal microtubules; dynamism of microtubules in plants; Questions.
- 47. MEIOSIS AND REPRODUCTIVE CYCLE** **966–980**
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- 48. REPRODUCTION** **981–986**
Asexual reproduction: fission, budding, gemmule formation, regeneration, sexual reproduction; syngamy, conjugation, automixis, parthenogenesis, Questions.
- 49. GAMETOGENESIS** **987–1013**
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