

BIOLOGY

TEXTBOOK FOR CLASS XII



12083



राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

ISBN 81-7450-639-X

First Edition

December 2006 Pausa 1928

Reprinted

November 2007 Kartika 1929

January 2009 Pausa 1930

December 2009 Pausa 1931

January 2011 Magha 1932

January 2012 Magha 1933

November 2012 Kartika 1934

November 2013 Kartika 1935

December 2014 Pausa 1936

January 2015 Pausa 1937

January 2017 Pausa 1938

January 2018 Magha 1939

January 2019 Magha 1940

August 2019 Bhadrapada 1941

PD 450T BS

**© National Council of Educational
Research and Training, 2006**

₹ 195.00

*Printed on 80 GSM paper with NCERT
watermark*

Published at the Publication Division by the
Secretary, National Council of Educational
Research and Training, Sri Aurobindo Marg,
New Delhi 110 016 and printed at Nova
Publications, C-51, Focal Point Extn.,
Jalandhar-144 004

ALL RIGHTS RESERVED

- ❑ No part of this publication may be reproduced, stored in a retrieval system or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior permission of the publisher.
- ❑ This book is sold subject to the condition that it shall not, by way of trade, be lent, re-sold, hired out or otherwise disposed of without the publisher's consent, in any form of binding or cover other than that in which it is published.
- ❑ The correct price of this publication is the price printed on this page. Any revised price indicated by a rubber stamp or by a sticker or by any other means is incorrect and should be unacceptable.

**OFFICES OF THE PUBLICATION
DIVISION, NCERT**

NCERT Campus
Sri Aurobindo Marg
New Delhi 110 016

Phone : 011-26562708

108, 100 Feet Road
Hosdakere Halli Extension
Banashankari III Stage
Bengaluru 560 085

Phone : 080-26725740

Navjivan Trust Building
P.O. Navjivan
Ahmedabad 380 014

Phone : 079-27541446

CWC Campus
Opp. Dhankal Bus Stop
Panihati
Kolkata 700 114

Phone : 033-25530454

CWC Complex
Maligaon
Guwahati 781 021

Phone : 0361-2674869

Publication Team

Head, Publication Division : *M. Siraj Anwar*

Chief Editor : *Shveta Uppal*

Chief Production Officer : *Arun Chitkara*

Chief Business Manager : *Bibash Kumar Das*

Assistant Editor : *Shashi Chadha*

Production Assistant : *Mukesh Gaur*

Cover and Layout

Shveta Rao

Illustrations

Lalit Maurya

FOREWORD

The National Curriculum Framework (NCF) 2005, recommends that children's life at school must be linked to their life outside the school. This principle marks a departure from the legacy of bookish learning which continues to shape our system and causes a gap between the school, home and community. The syllabi and textbooks developed on the basis of NCF signify an attempt to implement this basic idea. They also attempt to discourage rote learning and the maintenance of sharp boundaries between different subject areas. We hope these measures will take us significantly further in the direction of a child-centred system of education outlined in the National Policy on Education (1986).

The success of this effort depends on the steps that school principals and teachers will take to encourage children to reflect on their own learning and to pursue imaginative activities and questions. We must recognise that, given space, time and freedom, children generate new knowledge by engaging with the information passed on to them by adults. Treating the prescribed textbook as the sole basis of examination is one of the key reasons why other resources and sites of learning are ignored. Inculcating creativity and initiative is possible if we perceive and treat children as participants in learning, not as receivers of a fixed body of knowledge.

These aims imply considerable change in school routines and mode of functioning. Flexibility in the daily time-table is as necessary as rigour in implementing the annual calendar so that the required number of teaching days are actually devoted to teaching. The methods used for teaching and evaluation will also determine how effective this textbook proves for making children's life at school a happy experience, rather than a source of stress or boredom. Syllabus designers have tried to address the problem of curricular burden by restructuring and reorienting knowledge at different stages with greater consideration for child psychology and the time available for teaching. The textbook attempts to enhance this endeavour by giving higher priority and space to opportunities for contemplation and wondering, discussion in small groups, and activities requiring hands-on experience.

The National Council of Educational Research and Training (NCERT) appreciates the hard work done by the textbook development committee responsible for this book. We wish to thank the Chairperson of the advisory group in science and mathematics, Professor J.V. Narlikar and the Chief Advisor for this book, Professor K. Muralidhar, Department of Zoology, University of Delhi, Delhi for guiding the work of this committee. Several teachers contributed to the development of this textbook. We are grateful to their principals for making this possible. We are indebted to the institutions and organisations which have generously permitted us to draw upon their resources, material and personnel. We are especially grateful to the members of the National Monitoring Committee, appointed



by the Department of Secondary and Higher Education, Ministry of Human Resource Development under the Chairmanship of Professor Mrinal Miri and Professor G.P. Deshpande, for their valuable time and contribution.

As an organisation committed to systemic reform and continuous improvement in the quality of its products, NCERT welcomes comments and suggestions which will enable us to undertake further revision and refinement.

New Delhi
20 November 2006

Director
National Council of Educational
Research and Training

© NCERT
not to be republished

PREFACE

Biology is the study of life in its entirety. The growth of biology as a natural science during the last 1000 years is interesting from many points of view. One feature of this growth is changing emphasis. Initially it was description of life forms. Identification, nomenclature, classification of all recorded living forms enjoyed the attention of scientists for a long time. Description of their habitats and (in the case of animals) their behaviour was included in this study. In later years, the focus was physiology and internal morphology or anatomy. Darwinian ideas of evolution by natural selection changed the perception completely. Classical descriptive and clueless biology found a theoretical framework in the evolutionary theory of Darwin.

In the nineteenth and twentieth centuries, Physics and Chemistry were applied to Biology and the new science of Biochemistry soon became the dominant face of biology. On one hand Biochemistry was integrating with Physiology, becoming almost synonymous with it. On the other hand it gave rise to Structural Biology (structure of biomacromolecules), originally called Molecular Biology. The work of Bernal, Pauling, Watson and Crick, Hodgkins, Perutz and Kendrew, Delbruck, Luria, Monod, Beadle and Tatum, Lederberg, Brenner, Benzer, Nirenberg, Khorana, McIntock, Sanger, Cohen, Boyer, Kornbergs (father and son), Leder, Chambon and scores of others brought in and established a modern version of Molecular Biology dealing with life processes at molecular level.

Physics and Chemistry dominated public perception of science for a long time. Daytoday life of man was influenced by developments in Physics, Chemistry and their respective manufacturing industries. Slowly and steadily, Biology, not to be left behind, demonstrated its utility for human welfare. Medical practice, especially diagnostics, green revolution and the newly emerging biotechnology and its success stories made the presence of biology felt by the common man. Patent laws brought biology into political domain and commercial value of biology became obvious.

For more than a century, classical and so-called reductionist biology fought artificial battles. The fact is both are important. Ecology brought in synthesis of both approaches and emphasised integrated understanding of biology. Form and process are both equally important. Systems biology, using mathematical tools, is bringing about a modern synthesis of both the aspects of Biology.

The Class XI and XII textbooks in biology essentially were to reflect these threads of biological thought. While the Class XI book dealt with morphology, taxonomy, molecular and cellular aspects of physiology, the Class XII book deals with the physiological process of reproduction in flowering plants and humans, the principles of inheritance, the nature of genetic material and its function, the contributions of biology to human welfare, basic principles of biotechnological processes and their applications and achievements. The Class XII book also relates genes to evolution on one hand and presents ecological interactions, behaviour of populations and ecosystems on the other. Most important, the guidelines under NCF-2005 have been followed in letter and spirit. The total learning load has been reduced

considerably and themes like environmental issues, adolescent problems and reproductive health have been dealt with in some detail. Studied together, the class XI and class XII textbooks in Biology would enable the student to —

- (i) become familiar with the diversity of biological material.
- (ii) appreciate and believe in the Darwinian evolutionary process exhibited by the living world.
- (iii) understand the dynamic state of constituents of living bodies, i.e., metabolic basis of all physiological processes in plants, animals and microbes.
- (iv) realise the structure and function of genetic material in directing the inherited phenotype pattern as well as a mediator of evolutionary process.
- (v) appreciate the profound contributions of biology to human welfare.
- (vi) reflect on the physico-chemical basis of living processes and at the same time realise the limitation of reductionism in understanding behaviour of organisms.
- (vii) experience the humbling effect of this realisation that all living organisms are related to each other by virtue of shared genetic material.
- (viii) realise that biology is the story of the struggle of living organisms for existence and survival.

One may notice a perceptible change in the writing style. Most of the chapters are written in an easy dialogue style engaging the student constantly while some chapters are in the form of critical comments on the subject matter. A number of questions have been provided at the end of each chapter though answers to some may not be found in the text. Students have to read supplementary material, upon advice from the teacher, to answer such questions.

I am thankful to Professor Krishna Kumar, Director NCERT; Professor G. Ravindra, Joint Director, NCERT and Professor Hukum Singh, Head, DESM, NCERT for constant support. I must place on record my deep appreciation for Dr B.K. Tripathi, *Reader*, DESM, NCERT for his relentless efforts as coordinator in bringing out the Biology textbook for both the Class XI and XII. All the members of the development team, the experts and reviewers, and the school teachers have contributed enormously in the preparation of this book. I thank them all. I am indeed highly thankful to the members of monitoring committee constituted by Ministry of Human Resource Development for their valuable observation that helped in the improvement of the book at the final stage. The book is prepared keeping in mind the guidelines of the NCF-2005 especially the emphasis on reducing the learning load. We hope that the book would meet the expectations of all the stakeholders. All suggestions for further improvement are always welcome.

Department of Zoology
University of Delhi

K. MURALIDHAR
Chief Advisor
Biology Textbook for Class XII

TEXTBOOK DEVELOPMENT COMMITTEE

CHAIRPERSON, ADVISORY GROUP FOR TEXTBOOKS IN SCIENCE AND MATHEMATICS

J.V. Narlikar, *Emeritus Professor*, Inter University Centre for Astronomy and Astrophysics (IUCAA), Pune University, Pune

CHIEF ADVISOR

K. Muralidhar, *Professor*, Department of Zoology, University of Delhi, Delhi

MEMBERS

Ajit Kumar Kavathekar, *Reader* (Botany), Sri Venkateswara College, University of Delhi, Delhi

B.B.P. Gupta, *Professor*, Department of Zoology, North-Eastern Hill University, Shillong

B.N. Pandey, *Principal*, Ordinance Factory Higher Secondary School, Dehradun

C.V. Shimray, *Lecturer*, Department of Education in Science and Mathematics, NCERT, New Delhi

Dinesh Kumar, *Reader*, Department of Education in Science and Mathematics, NCERT, New Delhi

J.P. Gaur, *Professor*, Department of Botany, Banaras Hindu University, Varanasi

J.S. Viridi, *Reader*, Department of Microbiology, University of Delhi, South Campus, New Delhi

K. Sarath Chandran, *Reader* (Zoology), Sri Venkateswara College, University of Delhi, Delhi

L.C. Rai, *Professor*, Department of Botany, Banaras Hindu University, Varanasi

M.M. Chaturvedi, *Professor*, Department of Zoology, University of Delhi, Delhi

N.V.S.R.K. Prasad, *Reader* (Botany), Sri Venkateswara College, University of Delhi, Delhi

Sangeeta Sharma, *PGT* (Biology), Kendriya Vidyalaya, JNU, New Delhi

Savithri Singh, *Principal*, Acharya Narendra Dev College, University of Delhi, Delhi

Shanti Chandrashekar, *Principal Scientist*, Division of Genetics, I.A.R.I., New Delhi

Shardendu, *Reader*, Department of Botany, Science College, Patna University, Patna

Simminder K. Thukral, *Assistant Professor*, NIIT Institute of Information Technology, New Delhi

Sunaina Sharma, *Lecturer* (Biology), Rajkiya Pratibha Vikas Vidyalaya, Dwarka, New Delhi

T.R. Rao, *Professor* (Retd.) School of Environmental Studies, University of Delhi, Delhi

V.K. Kakaria, *Reader*, Regional Institute of Education, Bhopal

V.V. Anand, *Reader*, Regional Institute of Education, Mysore

MEMBER-COORDINATOR

B.K. Tripathi, *Reader*, Department of Education in Science and Mathematics, NCERT, New Delhi

ACKNOWLEDGEMENTS

National Council of Educational Research and Training (NCERT) gratefully acknowledges the valuable contribution of K.R. Shivanna, *Professor (Retd.)*, Department of Botany, University of Delhi, Delhi; S.K. Saidapur, *Professor*, Department of Zoology, Karnataka University Dharwad; Vani Brahmachari, *Professor*, Ambedkar Centre for Biomedical Research, University of Delhi, Delhi; A.N. Lahiri Majumdar, *Professor*, Bose Institute, Kolkata; Anil Tripathi, *Professor*, Department of Biotechnology, Banaras Hindu University, Varanasi; J.L. Jain, *Senior Physician*, WUS Health Centre, University of Delhi, Delhi, in the development of the Biology textbook for Class XII. NCERT is also grateful to K.R. Shivanna and T.Subramanyam, IIT, Kanpur for some of the photographs used in the book.

NCERT sincerely acknowledges the contributions of the members who participated in the review of the manuscripts – A.S. Dixit, *Reader*, Department of Zoology, North-Eastern Hill University, Shillong; S.L. Varte, *Lecturer*, Department of Education in Science and Mathematics, NCERT, New Delhi; Sushma Jairath, *Reader*, Department of Women's Education, NCERT, New Delhi; Mona Yadav, *Lecturer*, Department of Women's Education, NCERT, New Delhi; Poonam A. Kant, *Reader* (Zoology), Acharya Narendra Dev College, New Delhi; Mrs. Suvarna Fonseca è Antao, *Gr. I Teacher* (Biology), Carmel Higher Secondary School, Nuvem, Goa; Rashmi Mishra, *PGT* (Biology), Carmel Convent Senior Secondary School, BHEL, Bhopal; Ishwant Kaur, *PGT* (Biology), D.M. School, RIE, Bhopal; A.K. Singh, *PGT (Biology)*, Kendriya Vidyalaya, Cantt, Varanasi; R.P. Singh, *Lecturer* (Biology), Rajkiya Pratibha Vikash Vidyalaya, Kishan ganj, Delhi; M.K. Tiwari, *PGT* (Biology), Kendriya Vidyalaya, Mandsaur, Madhya Pradesh; A.K. Ganguly, *PGT* (Biology), Jawahar Navodaya Vidyalaya, Roshnabad, Haridwar; Chaitali Dixit, *PGT* (Biology), St. Anthony's Higher Secondary School (Don Bosco), Shillong and Abhishek Chari, Acharya Narendra Dev College, New Delhi.

Special thanks are due to Rita Sharma, *Retd. Professor*, RIE Bhopal, A.K. Mohapatra *Professor*, RIE Bhubaneswar, J.S. Gill, *Retd. Professor*, DESM, NIE, G.V. Gopal, *Professor*, RIE Mysore, Jaydeep Mandal, *Professor*, RIE Bhopal, C. Padmija, *Professor*, RIE Mysore, Dr. Pushplata Verma, *Associate Professor*, DESM, NIE, Ishwant Kaur, *Vice Principal*, DM School Ajmer for their valuable contribution in review and updation of the textbook.

The Council is highly thankful to Hukum Singh, *Professor and Head*, Department of Education in Science and Mathematics, NCERT for his valuable support throughout the making of this book.

The contributions of Deepak Kapoor, *Incharge*, Computer Station; Seema Mehmi and Arvind Sharma, *DTP operators*; Deepti Sharma, *Copy Editor*; Rachna Dogra and Abhimanu Mohanty, *Proof Readers* and APC office and administrative staff of Department of Education in Science and Mathematics, NCERT also acknowledged.

The efforts of the Publication Department, NCERT, in bringing out this publication are highly appreciated.

CONTENTS

FOREWORD *iii*

PREFACE *v*

UNIT VI

REPRODUCTION **1-66**

Chapter 1 : Reproduction in Organisms 3

Chapter 2 : Sexual Reproduction in Flowering Plants 19

Chapter 3 : Human Reproduction 42

Chapter 4 : Reproductive Health 57

UNIT VII

GENETICS AND EVOLUTION **67-142**

Chapter 5 : Principles of Inheritance and Variation 69

Chapter 6 : Molecular Basis of Inheritance 95

Chapter 7 : Evolution 126

UNIT VIII

BIOLOGY IN HUMAN WELFARE **143-190**

Chapter 8 : Human Health and Disease 145

Chapter 9 : Strategies for Enhancement in Food Production 165

Chapter 10 : Microbes in Human Welfare 179

UNIT IX

BIOTECHNOLOGY 191-216

Chapter 11 : Biotechnology : Principles and Processes	193
Chapter 12 : Biotechnology and its Applications	207

UNIT X

ECOLOGY 217-286

Chapter 13 : Organisms and Populations	219
Chapter 14 : Ecosystem	241
Chapter 15 : Biodiversity and Conservation	258
Chapter 16 : Environmental Issues	270