

# Applications of Genetics

**Jennifer Gregory**

**Series editor: Mary Jones**



Cambridge University Press  
978-0-521-78725-3 - Applications of Genetics  
Jennifer Gregory  
Frontmatter  
[More information](#)

CAMBRIDGE UNIVERSITY PRESS

Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press

The Edinburgh Building, Cambridge CB2 8RU, UK

[www.cambridge.org](http://www.cambridge.org)

Information on this title: [www.cambridge.org/9780521787253](http://www.cambridge.org/9780521787253)

© Cambridge University Press 2000

First published 2000

7th printing 2007

Printed in Dubai by Oriental Press

*A catalogue record for this publication is available from the British Library*

ISBN 978-0-521-78725-3 paperback

Front cover photograph: SEM of human X and Y chromosomes/Biophoto Associates/Science Photo Library

NOTICE TO TEACHERS

It is illegal to reproduce any part of this work in material form (including photocopying and electronic storage) except under the following circumstances:

- (i) where you are abiding by a licence granted to your school or institution by the copyright Licensing Agency;
- (ii) where no such licence exists, or where you wish to exceed the terms of a licence, and you have gained the written permission of Cambridge University Press;
- (iii) where you are allowed to reproduce without permission under the provisions of Chapter 3 of the Copyright, Designs and Patents Act 1988, which covers, for example, the reproduction of short passages within certain types of educational anthology and reproduction for the purposes of setting examination questions.

# Contents

Introduction	v		
Acknowledgements	vi		
<b>1 Variation</b>	<b>1</b>		
Mutation	1		
Discontinuous and continuous variation	3		
Variance	3		
The genetic basis of discontinuous and continuous variation	3		
Both genotype and environment contribute to phenotypic variance	7		
Interactions at one locus and between loci	8		
Linkage	10		
The $\chi^2$ (chi-squared) test	13		
<b>2 Selective breeding</b>	<b>16</b>		
Selective breeding	16		
Heritability	17		
Selective breeding compared with evolution	18		
Selective breeding of plants	18		
Selective breeding of animals	21		
Artificial insemination (AI)	22		
AI in humans	22		
In vitro fertilisation (IVF)	23		
Cloning and embryo transplantation	24		
<b>3 Genetic diversity</b>	<b>27</b>		
The problems of inbreeding	27		
The need to maintain a gene bank	28		
Wild populations and rare breeds	29		
Seed banks	29		
Sperm banks and frozen embryos	31		
Cloning plants from tissue culture	31		
The genetic basis of resistance	32		
Selective breeding of disease-resistant varieties of plants: wheat	33		
Selective breeding of disease-resistant animals	34		
The evolution of antibiotic resistance in bacteria	35		
The evolution of insecticide resistance in insects	38		
<b>4 Genetic engineering</b>		<b>42</b>	
Organisms can be modified by genetic engineering		42	
Obtaining the wanted gene		42	
Restriction enzymes		43	
Vectors		44	
Inserting a gene into a host		47	
Genetic engineering in agriculture		49	
Genetically engineered livestock		51	
Benefits and hazards of genetic engineering		52	
Ethical implications of genetic engineering		54	
The debate about genetically modified foods		55	
<b>5 Human genetics</b>		<b>56</b>	
Genetic disorders in humans		56	
Pedigree analysis		61	
Genetic screening		62	
Genetic counselling		62	
Gene therapy		64	
The possible benefits and hazards of gene therapy		65	
Genetic fingerprinting (DNA profiling)		66	
Genetic compatibility in transplant surgery		70	
Answers to self-assessment questions		74	
Glossary		79	
Index		81	

# Introduction

## Cambridge Advanced Sciences

The *Cambridge Advanced Sciences* series has been developed to meet the demands of all the new AS and A level science examinations. In particular, it has been endorsed by OCR as providing complete coverage of their specifications. The AS material is presented as a single text for each of biology, chemistry and physics. Material for the A2 year comprises six books in each subject: one of core material and one for each option. Some material has been drawn from the existing *Cambridge Modular Sciences* books; however, the majority is entirely new.

During the development of this series, the opportunity has been taken to improve the design, and a complete and thorough new writing and editing process has been applied. Much more material is now presented in colour. Although the existing *Cambridge Modular Sciences* texts do cover some of the new specifications, the *Cambridge Advanced Sciences* books cover every OCR learning objective in detail. They are the key to success in the new AS and A level examinations.

OCR is one of the three unitary awarding bodies offering the full range of academic and vocational qualifications in the UK. For full details of the new specifications, please contact OCR:

OCR, 1 Hills Rd, Cambridge CB1 2EU  
 Tel: 01223 553311

### The presentation of units

You will find that the books in this series use a bracketed convention in the presentation of units within tables and on graph axes. For example, ionisation energies of  $1000 \text{ kJ mol}^{-1}$  and  $2000 \text{ kJ mol}^{-1}$  will be represented in this way:

Measurement	Ionisation energy ( $\text{kJ mol}^{-1}$ )
1	1000
2	2000

OCR examination papers use the solidus as a convention, thus:

Measurement	Ionisation energy / $\text{kJ mol}^{-1}$
1	1000
2	2000

Any numbers appearing in brackets with the units, for example ( $10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$ ), should be treated in exactly the same way as when preceded by the solidus,  $/10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$ .

## Applications of Genetics – an A2 option text

*Applications of Genetics* contains everything needed to cover the A2 option of the same name. It combines entirely new text and illustrations with revised and updated material from the first edition, formerly available in the *Cambridge Modular Sciences* series. In a further improvement, *Applications of Genetics* is now in full colour, greatly enhancing its accessibility and usefulness.

The book is divided into five chapters, corresponding to the modules Variation, Selective Breeding, Genetic Diversity, Genetic Engineering, and Human Genetics. A glossary of terms is also included and, throughout the text, mention is made of some of the latest developments in this fast-moving subject.

## 6 Energy and ecosystems

### Acknowledgements

#### Photographs

1.4a, John Daniels/Ardea; 1.4b, ©Jean-Paul Ferrero 1979/Ardea; 1.6, Dr Jeremy Burgess/Science Photo Library; 1.8, ©Biophoto Associates; 2.3, 2.7 top left, 2.7 top right, 4.9, Nigel Cattlin/Holt Studios International; 2.4, Kit Houghton Photography; 2.5, Hank Morgan/Science Photo Library; 5.17, Science Photo Library; 2.6, Environmental Images; 2.7 bottom, Wayne Hutchinson/Holt Studios International; 3.1, 3.2, Connecticut Agricultural Experiment Station; 3.3, Michael Major/Holt Studios International; 3.4, Holt Studios International; 3.5, Philippe Plailly/Science Photo Library; 3.6, Sinclair Stammers/Science Photo Library; 3.9, Professor Stanley Cohen/Science Photo Library; 3.11, Dr L Caro/Science Photo Library; 4.7, Richard Rawlins/Custom Medical Stock Photo/Science Photo Library; 4.12, reproduced by permission of *Nature* 370, 16–22, copyright (1982) Macmillan Magazines Ltd; 5.2, 5.3, CNRI/Science Photo Library; 5.8, Wellcome Trust Medical Photographic Library, 5.10, 5.14, Peter Menzel/Science Photo Library; 5.15, J C Revy/Science Photo Library

#### Diagrams

1.7, after fig 5.1 *Elementary Genetics* Wilma George, 1965, 2nd ed. Macmillan; 3.8, after *Dalton's Introduction to Practical Animal Breeding* Willis, 1991, Blackwell Scientific Publications; 3.13, data replotted from Metcalf, *Scientific American*, October 1952; 3.14, modified from *Ecological impact of pesticide use in developing countries* van der Valk & Koeman, 1988, Ministry of Housing, Physical Planning and Environment, Hague, Netherlands, and World Wide Fund for Nature, UK, Data Support for Education Service, July 1990; 5.5, from *Applied Genetics* Hayward, 1990, Macmillan Science 16–19 Project, Macmillan; 5.9, after *Genetics and Evolution* M. Carter, 1993, Hodder and Stoughton.

#### Tables

3.1, data from *Handbook of Genetics* Whitten *et al.*, vol. 3, 1975, ed. R. C. King, Plenum Press, New York; 4.2, data modified from Cory *et al.* reprinted with permission from *Nature* 370, 138–40, copyright (1994) Macmillan Magazines Ltd.