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# THE SCIENCE OF GENETICS

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6<sup>th</sup>  
EDITION



GEORGE W. BURNS  
PAUL J. BOTTINO

# THE SCIENCE OF GENETICS

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SIXTH EDITION

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# PREFACE

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Genetic knowledge is expanding at an explosive rate, one that extends the boundaries of understanding by a factor of approximately eight during a four-year college career. It is important to include in any new edition of a text as much of this most recent knowledge as possible without allowing an unreasonably encyclopedic expansion. Our overall approach has been to update the book without changing the basic strengths that have appealed to users of earlier editions.

This sixth edition includes a major rearrangement of topics as well as a new introductory chapter that attempts to develop the concept of the gene through a historical approach. It has been written primarily to enhance student interest. Other chapters have been combined into single chapters; sex determination with inheritance related to sex, multiple alleles with blood group genetics, and polygenic inheritance with statistics. Totally new chapters on mutation and recombinant DNA have been added. The chapters on DNA structure and function and gene expression have been moved to a position earlier in the book so that almost every topic than Mendelian genetics can be dealt with on the molecular level. The chapters on molecular aspects remain in a block for those instructors who prefer to start a course with this material. In addition to the new material in the text, boxes of information have been added to cover new, or controversial, topics in genetics. Some new problems have been added and others retained from the fifth edition. These are designed to lead the student through necessary reasoning steps to a fuller grasp of genetic principles. A hand calculator will be useful in solving many of these problems.

A number of people have been very helpful during the course of preparing this edition. A large group of individuals are acknowledged in the figure legends for photographs which they kindly provided. A number of colleagues at the University of Maryland have been helpful over the years with stimulating discussion and information, including: Neal Barnett, Steve Wolniak, John Watson, Richard Imberski. Listed below are our reviewers who provided a great amount of constructive criticism, but as usual the final burden of responsibility falls on the authors: Alan G. Atherly, Iowa State University; Glenn C. Bewley, North Carolina State University; Darrel S. English, Northern Arizona University; John Erickson, Western Washington University; David J. Fox, Biological Consultants; Jack R. Girton, Iowa State University; Robert M. Kitchin, University of Wyoming; Joyce B. Maxwell, California

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G. W. B.

P. J. B.



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# INTRODUCTION TO GENETICS

## CHAPTER

# 1

What is the science of **genetics**? Very simply, it is the study of two main subjects, **heredity** and **variation**. Heredity is the cause of the similarities between individuals. This is the reason that brothers and sisters with the same parents resemble each other. Variation is the cause of the differences between individuals. This is the reason that brothers and sisters who do resemble each other are still unique individuals. The science of genetics attempts to explain the mechanism and the basis for both similarities and differences between related individuals.

In addition to understanding the mechanisms of heredity and variation, genetics is also involved with other interesting subjects. The explanation for the tremendous variation one encounters in all forms of life is a major question addressed by genetics. This variation provides the raw materials on which the processes of speciation act. Another area of interest to geneticists is the question of development. All organisms begin their life cycle as a single cell. Yet, in multicellular forms, this single cell gives rise to the very complex multicellular organism, containing numerous cell types. How this process of development occurs is a major question in genetics.

From the beginning of the domestication of plants and animals by humans, genetic principles have been applied for their improvement for human consumption. At first, people chose only those plants and animals most desirable to produce the next generation. As the scientific basis of these desirable characteristics became known, specific genetic principles were applied to the breeding of crop plants and animals for use in specific environments.

The medical aspects of genetics are among the most recent. There are now about three thousand human inherited diseases. Many hospital

beds are occupied by persons with these diseases, most of which do not have a cure. Understanding the nature and pattern of inheritance of these diseases allows genetic counselors to give meaningful information to young couples so that they may make intelligent decisions regarding the planning of their families.

Finally, applications from the emerging field of biotechnology are making important contributions in medicine, diagnosing and treating diseases, and in agriculture, developing new varieties of plants and animals for food.

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## DEVELOPMENT OF THE GENE CONCEPT

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Genetics revolves around one central concept, the **gene**. Since the 1860s, geneticists have devoted their efforts to defining and understanding this central theme. To appreciate this fact, we must remember that almost since the beginning of time, humans have tried to explain the patterns of their inheritance observed in populations. Most of the incorrect theories to explain inheritance were based on one central idea, the blending or mixing of characteristics from the two parents to produce offspring, which appeared intermediate between the parents.

There were various theories advanced to explain the mechanism of this blending inheritance; however, the correct explanation came with the publishing of the work of **Gregor Mendel** (Figure 1-1) in 1866. Based on hybridization experiments with peas, Mendel proposed the concept



FIGURE 1-1. *Gregor Mendel, Ca 1860.*  
(Photo used exclusively with the permission of Dr. Hugh Iltis, Botany Department, University of Wisconsin.)