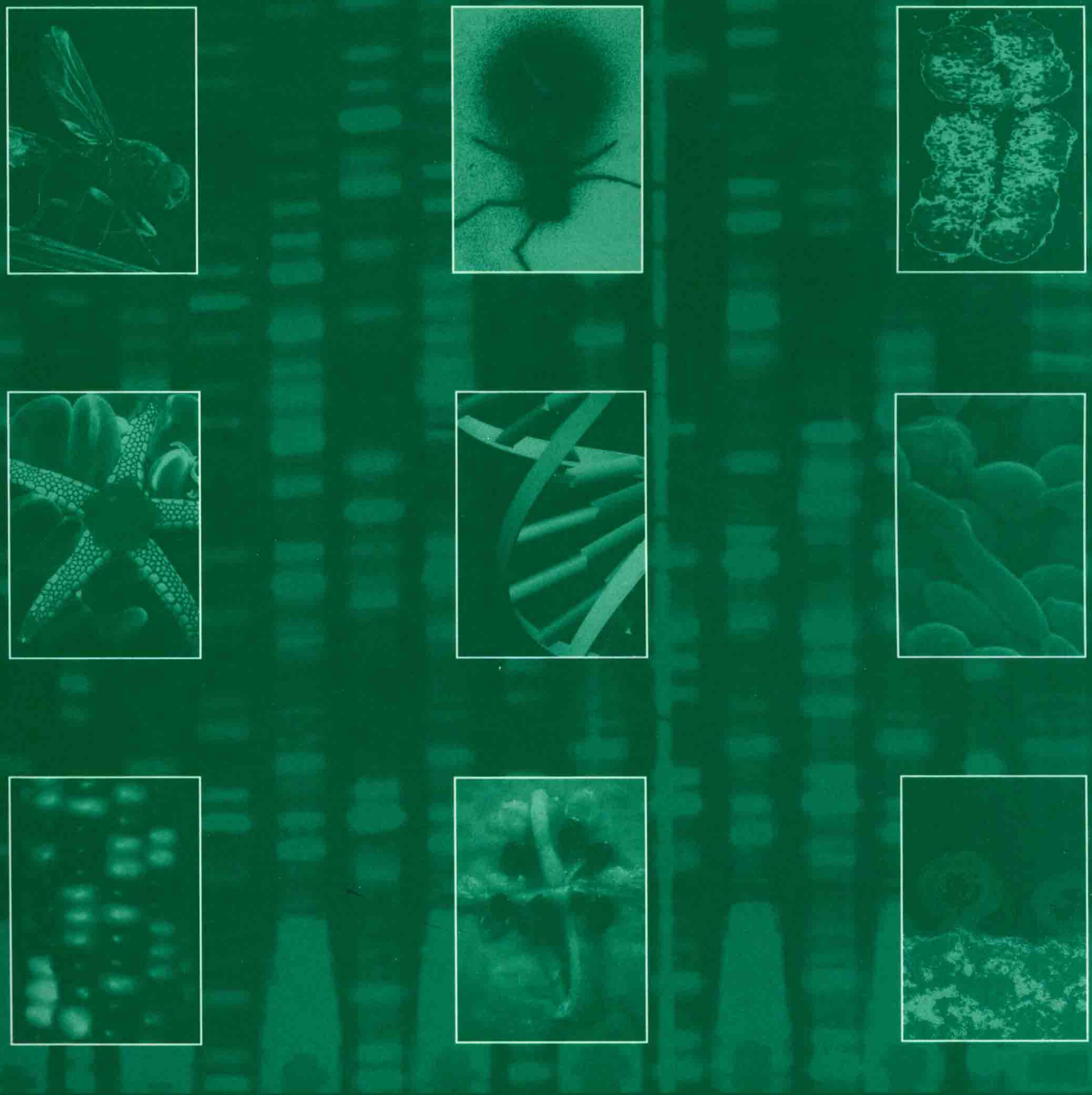

Study Guide and Problems Workbook

Featuring Complete Answers and Solutions to all Text Questions and Problems

PRINCIPLES OF GENETICS

SNUSTAD • SIMMONS • JENKINS

H. JAMES PRICE

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Featuring Complete Answers and Solutions to all Text Questions and Problems

H. JAMES PRICE
Texas A&M University

to accompany

PRINCIPLES OF GENETICS

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To The Student

This companion to *Principles of Genetics* , 1st Edition, by Peter Snustad, Michael Simmons, and John Jenkins is written to be a hands-on workbook to help you learn and reinforce terminology and concepts, develop problem solving skills, and challenge your mind. Learning introductory genetics requires both communication of knowledge and solution of problems. To communicate your newly acquired knowledge involves learning new terminology. Solving genetics problems requires the ability to analyze and interpret data. The science of genetics becomes fascinating and interesting as your confidence in understanding and using your newly acquired knowledge and skills grows.

How to Use This Problems Workbook and Study Guide

You should use this workbook after you have read your textbook and attended the lectures on each topic. The manual is divided into two parts. **Part I** contains a series of chapters designed to help review concepts and develop problem solving skills. **Part II** contains the complete answers and solutions to the text questions and answers.

In part I, each chapter begins with an outline of the corresponding chapter in Snustad et al. A summary of **Important Concepts** follows to help you organize your studies.

Next are lists of **Important Terms** and **Important Names**. In the space allotted, you are asked to define concisely what each term means or to identify the contribution(s) made by an individual or group. A few short and well-worded sentences are better than rambling answers. More importantly, try to understand the real importance of the terms, and the contributions of the scientists.

The **Testing Your Knowledge** section is designed to allow you to determine your understanding of genetic concepts and terminology and to help develop problem-solving skills. As you progress through this section, the questions become more complex and involve more problem working. The more problems you work, the better you will become at problem solving. Space is allotted in the workbook for your calculations.

A **Thought Challenging Exercise** is included in each chapter. It is intended to stimulate additional thought and discussion. I encourage you to discuss these with your fellow students.

A **Key Figures** section follows. It contains important figures from the textbook for easy reference during your studies.

A **Summary of Key Points** section lists the Key Points presented in the text, thereby providing another summary of important concepts to help you study.

Answers to Questions and Problems are given. The **Approaches to Problem Solving** section is designed to help you learn genetics problem-solving skills. In many cases, a problem is much easier to work if it is broken down into simpler components. This approach is emphasized throughout.

Now that you have the resources to study, i.e., your professor, *Principles of Genetics*, 1st Edition, this workbook, and your inquisitive mind, it is time to embark on your fascinating study of genetics. Study hard, devote time to study each day, and watch your interest and knowledge grow. I encourage you to study in small groups after you have used this book and have attempted to work all the problems. Explaining concepts and discussing solutions to problems helps the learning process.

Acknowledgments

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PART I

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PART I I

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THE PRINCIPLES OF GENETICS: AN OVERVIEW

IMPORTANT CONCEPTS

A. Two fundamental laws that form the foundation of the modern science of genetics were discovered and reported by Gregor Johann Mendel in 1865.
1. Mendel proposed that cells had pairs of factors (genes) that determine a specific trait.
   a. Members of each gene pair segregate from each other during the process of sex cell formation, so that each gamete contains one member of each gene pair.
   b. The segregation of each pair of factors was independent of the segregation of other pairs of factors.
2. Mendel's observations and interpretations were not recognized for 35 years.

B. The spectacular unfolding of modern genetic concepts has occurred during the 20th century.
1. Genetics has grown from Mendel's obscure units of segregation and independent assortment, that affected the appearance of the organism, to an understanding of the organization, composition and expression of genes.
2. Genetics is a vital and dynamic science that touches all facets of our being.
3. Genetics has given us powerful molecular tools for the study of genes.
   a. One application of genetics, *DNA fingerprinting*, provides a powerful forensic science tool.
      (1) A molecular genetic analysis of a small sample of tissue can be used to positively identify or exclude a person as a crime suspect.

C. Modern genetics has had a profound impact on medicine.
1. Geneticists now understand the metabolic basis for several hundred inherited diseases.
2. Mutant genes have been isolated that cause inherited disorders such as cystic fibrosis, Duchene muscular dystrophy, and Huntington's disease.
3. Gene therapy, made possible only after a gene has been isolated, provides a new approach to treating some genetic disorders.
   a. It has been successfully used to treat a devastating immune system disorder called combined immunodeficiency disease.
   b. Gene therapy may soon prove successful in the treatment of other genetic diseases such as cystic fibrosis, various types of cancer, hemophilia and AIDS.
4. Cancer is a genetic disease and mutations that cause cancer are being identified and studied intensely.

a. The isolation of the breast cancer genes BRCA1 and BRCA2 and their mutant forms is creating important social and ethical issues.

D. To date, the greatest impact of genetics has been on modern agriculture.

1. The development of hybrid corn was the first great achievement in the application of genetics principles to agriculture.
   a. During the period from 1940 to 1980, the average corn yield increased over 250%.
2. The use of genetic principles in plant breeding has resulted in dramatic increases in yield of nearly all important food crops.
   a. Selective breeding has altered the growth form of plants such as the tomato to make them agronomically more desirable.
   b. Genes that confer resistance to pests or pathogens such as insects, nematodes, and fungi have been bred into modern plant varieties.
3. In the 1950s through the 1970s, Norman Borlaug's group used classical genetic principles in developing Mexican wheat strains that perform well under stressed conditions.
   a. Borlaug launched what is called the "green revolution." He was awarded a Nobel Prize in 1970.
4. The use of genetic principles in selective breeding programs has produced improvements in domesticated food animals.
   a. Modern chickens are meatier, grow faster, are disease resistant, and lay more eggs.
   b. Cattle and pigs grow faster, are more efficient in converting feed to meat, and are better adapted to regional environments.
   c. Selective breeding has resulted in dramatic increases in milk production per cow.
5. The genetic engineering of crop plants has become a reality and has enormous potential.
   a. Inserting genes conferring resistance to insects and pathogens is becoming a major weapon in fighting devastating pests.
   b. Genetic technology is also being used to improve nutritional quality of plants, and to help plants synthesize their own nitrogen.
   c. The *"flavr savr"*tomato is an example of a genetically manipulated plant.

E. Genetic discoveries often have a direct impact on society.

1. They may hold promise for cures of fatal diseases, or may help create new food products.
2. Sometimes, genetic discoveries create complex, moral dilemmas.
   a. Do insurance companies have the right to deny health insurance to families at risk of developing certain inherited diseases?
   b. What rights or obligations do insurance companies have in the prevention of genetic birth defects?
   c. What responsibilities do parents who are at risk have in the prevention of genetic disorders?

F. Genetics has great potential for good, but also may be misused.

1. Eugenics movements, based upon prejudice and misuse and misunderstanding of genetics, gained strength in the United States in the early part of the twentieth century.
2. The eugenics movements took its most perverted form in Nazi Germany where the Hitler regime attempted to exterminate individuals of "inferior" genetic material.
3. While the application of genetic principles resulted in dramatic increases in agricultural production in the United States in the period from 1937 to 1964, agricultural production in the Soviet Union was stagnant.
   a. The stagnant agricultural program in the Soviet Union resulted from its control by one individual, T. D. Lysenko, who rejected the principles of genetics, and based his plant improvement program on an erroneous belief in the inheritance of environmentally - induced characters.

G. Three major questions at the core of modern genetics are addressed in the text.

1. What is the chemical nature of genetic material?
2. How is genetic material transmitted?
3. What does the genetic material do?

IMPORTANT TERMS

In the space allotted, concisely define each term.

classical genetics:

molecular genetics:

polymerase chain reaction:

human genome project:

eugenics:

green revolution:

IMPORTANT NAMES

In the space allotted, concisely state the major contribution made by the following individual.

Charles Darwin:

Gregor Johann Mendel:

Kary Mullis:

Sir Archibald Garrod:

Nancy Wexler:

Norman Borlaug:

Francis Galton:

T. D. Lysenko:

TESTING YOUR KNOWLEDGE

In this section, fill in the blank or answer the question in the space allotted.

1. The two fundamental genetics laws were discovered by _____.

2. The study of the relationship between the units of inheritance and the physical appearance of an organism falls into the discipline of _____.

3. The study of the biochemical nature of genes and how genes express their encoded information is called _____.

4. The international effort with the goal of mapping and sequencing all human genes is called the _____.

5. The first great success from applying genetic principles to plant breeding was _____.

6. The first commercially produced fruit which included genetic engineering in the breeding program was the _____.

7. Why weren't Mendel's observations and interpretations recognized as such for 35 years?

THOUGHT CHALLENGING EXERCISE

Before you continue further into your study of genetics, prepare a list of the ways in which you think genetics has directly and indirectly influenced your life. Save this list. At the end of your genetics course, prepare another list of how genetics has affected your life. Prepare the last list without referring to the first one. Then compare the two lists.

ANSWERS TO QUESTIONS

1) Gregor Mendel **2)** classical genetics **3)** molecular genetics **4)** human genome project **5)** hybrid corn **6)** *flavr savr* tomato **7)** A major reason that Mendel's work was essentially unrecognized for 35 years was due to the state of biological knowledge at the time in which he lived. In the mid-1800s, little was known about chromosomes and the process by which cells divide. However, mitosis and meiosis had been characterized by 1900. When Mendel's laws were rediscovered at the beginning of the 20th century, it was soon hypothesized that the segregation and independent assortment of chromosomes were the physical bases of segregation and independent assortment of genes located on the chromosomes. Another reason why Mendel's laws were not appreciated was that Mendel did not aggressively bring them to the attention of the scientific world. Also, other scientists simply did not understand his numerical analysis of data. Mendel's primary duties were as a priest and an abbot. Although he was well-educated in science, science was his hobby.

2

Reproduction as the Basis of Heredity

IMPORTANT CONCEPTS

A. The two basic types of cells are prokaryotic and eukaryotic.

1. Prokaryotic cells are the simpler of the two types.
   a. They have a cell wall constructed of peptidoglycan surrounding a cytoplasmic membrane that encloses the cytoplasm.
   b. There is no membrane-bound nucleus. Their DNA is concentrated in a region of the cytoplasm called the nucleoid.
   c. An example of a prokaryotic organism is bacteria.
2. Eukaryotic cells are more complex.
   a. They contain a membrane-bound true nucleus which houses the chromosomes, that is comprised of DNA, RNA, and various proteins.
   b. In the nucleoplasm are found one or more nucleoli which function in the production of a specific class of RNAs called ribosomal RNAs.
   c. The components of eukaryotic cells are encapsulated by a phospholipid plasma membrane which has a variety of glycoproteins embedded in it. The plasma membrane functions as a barrier between the extracellular and intracellular matrices, and in regulating the flow of molecules into and out of the cell.
   d. Membrane-bound organelles such as mitochondria, lysosomes, Golgi complex, peroxisomes, and vacuoles occur in the cytoplasm. The endoplasmic reticulum is a cytoplasmic system of membranes that functions in protein synthesis.
   e. All eukaryotic cells have a network of protein filaments, called a cytoskeleton, which gives the cell its shape, its ability to move, and its ability to organize its organelles

within the cytoplasm. The two most important filaments are microfilaments and microtubules.

f. Some eukaryotic cells such as those of plants have a wall surrounding the exterior to the plasma membrane that is comprised of cellulose and other constituents, but never peptidoglycan.

B. Chromosomes, which contain the genetic material, function in the transmission of genetic information and the ordered release of this information to control cellular function and development.

1. As viewed using light microscopy, chromosomes at prophase and metaphase are made up of two sister chromatids held together by a centromere.
2. The kinetochore is a protein structure at the centromere that functions in chromosome movement during the cell cycle.
3. The ends of the chromosome are called telomeres.

C. The eukaryotic cell cycle is characterized by duplication of the DNA and other chromosomal material (the S phase), followed by a G2 phase during which the nucleus prepares for division. The G2 phase is followed by the division phase (M), and the G1 phase during which the cell grows preceding the next S phase.

D. There are two types of eukaryotic cell division, mitosis and meiosis.

1. The key feature of mitosis is that the two daughter cells are identical to each other and to the parent cell.
   a. In interphase of mitosis, the DNA of the chromosomes replicates and the synthesis of a variety of proteins necessary for mitosis occurs.
   b. In prophase, the chromosomes become progressively more condensed and each chromosome appears as two rod-shaped identical sister chromatids that are held together at the centromere. In late prophase, the nuclear membrane and nucleolus disappear and the chromosomes move toward the equator of the cell. Microtubules invade the nuclear region and become attached to each chromatid at the kinetochore.
   c. The fully contracted chromosomes line up on the equatorial plate at metaphase.
   d. At anaphase, the centromere divides and the sister chromatids (now chromosomes) move to opposite poles.
   e. Telophase begins when the chromosomes reach the poles. During telophase the chromosomes decondense, the microtubules disappear, and the nuclear membrane reforms. Cytokinesis follows in which the cytoplasm divides to produce two identical daughter cells. Plant cell cytokinesis involves the formation of a cell plate between the daughter cells, on which the cellulose walls are deposited.
2. Meiosis is a process in which diploid cells divide to produce genetically different haploid cells. One round of DNA replication is followed by two rounds of cell division.
   a. During prophase of meiosis I, replicated homologous chromosomes synapse (pair), condense, and crossover.
   b. The homologous pairs (bivalents) line up on the equatorial plane during metaphase.
   c. During anaphase I the members of each bivalent segregate and go to opposite poles, completing their migration at telophase I.
   d. The chromatids of each chromosome do not separate from each other during meiosis I.
   e. During meiosis II, the chromosomes line up on the equatorial plane at metaphase II.
   f. At anaphase II, the centromere divides and the sister chromatids migrate to opposite poles.
   g. After completing two meiotic divisions, a single diploid nucleus has produced four haploid nuclei, each containing one member of each chromosome pair.
   h. Meiosis recombines the maternal and paternal genetic material into haploid gametes or spores. Recombination results from both independent assortment of chromosome pairs and from crossing over between non-sister homologous chromatids.
   I. Meiosis and fertilization have the potential to produce an almost infinite variety of new genetic combinations upon which evolutionary forces can act.

3. Occasionally, chromosomes or chromatids may fail to separate from each other during mitosis or meiosis. This phenomenon, called nondisjuction, leads to nuclei with abnormal numbers of chromosomes.
   a. Nuclei with abnormal chromosomal constitutions generally result in abnormal phenotypes, such as Down syndrome in humans who have three instead of the normal two chromosomes number 21.
4. In animals, meiosis accompanies gamete formation; oogenesis in females and spermatogenesis in males.
   a. In females, primary oocytes undergo meiosis I to form a secondary oocyte and a primary polar body, and meiosis II to produce the egg and another polar body.
   b. In spermatogenesis, primary spermatocytes undergo meiosis I to produce two secondary spermatocytes and meiosis II to produce four spermatids. The spermatids differentiate into spermatozoa.
5. In plants, meiosis produces haploid spores that in turn undergo mitotic divisions and differentiate into gametophytes.
   a. The haploid gametophytes produce the haploid gametes.
   b. Fertilization produces a diploid zygote that divides and differentiates into the sporophyte.
6. The life cycles of species such as *Neurospora*, corn, *Drosophila*, and humans represent strategies that have evolved for the reshuffling of the genetic material as it is transmitted from one generation to the next.

IMPORTANT TERMS

In the space allotted, concisely define each term.

prokaryotic cell:

eukaryotic cell:

cytoplasm:

peptidoglycan:

nucleoid:

nucleus:

chromosome:

nucleolus:

ribosomes:

nucleoplasm:

endoplasmic reticulum (ER):

Golgi complex:

lysosomes:

peroxisomes:

vacuoles:

mitochondria:

chloroplasts: