CHAPTER 2
THE STUDY OF HEREDITY

Chapter 2 presents a general, comprehensive introduction to the study of genetics. The focus in this chapter is to present the basic principles of genetics that are necessary for an understanding of evolutionary theory. The implications of genetics and many of the new advances in the field have been placed in Chapter 3.

The field of genetics is undergoing very rapid and major changes. However, many of these would be overwhelming to introductory students. While we mention many of the new developments in the next chapter, here we focus on genetics as a necessary component in the understanding of the mechanism of evolution. We start with simple Mendelian genetics. Next we move on to cytogenetics, the genetics of the cell. Finally, we focus on molecular genetics, where we examine the DNA and RNA molecules.

Chapter Summary

The basic principles of heredity were first worked out using nonhuman organisms. Through careful experimentation with the common pea plant, Gregor Mendel was the first scientist to discover the basic principles of heredity. The principle of segregation states that in the formation of sex cells, the hereditary factors separate, forming sex cells that contain either one or the other of the paired factors. The principle of independent assortment states that the inheritance patterns of differing traits are independent of one another. At the most basic level, these principles are universal among all living organisms, including the human species.

Early geneticists began to search for the physical reality of the gene. Their work led them to the cell and to small bodies within the nucleus of the cell, the chromosomes. Each chromosome consists of two strands, the chromatids, held together by the centromere. For a particular species, there is a characteristic chromosome number, which in humans is 46.

There are two basic forms of cell division. Mitosis is the division of body cells, while meiosis is the production of gametes—sperm and ova. Studies of the behavior of chromosomes during cell division have provided a physical explanation for Mendelian genetics. Deeper probing of the mechanisms of inheritance has shown that Mendel's principles do not always apply, simply because hereditary mechanisms are usually more complex than those postulated by Mendel.

Scientists also began investigating the chemical nature of genetic transmission. The genetic material is a nucleic acid, DNA. DNA controls cell activities and hence determines physical characteristics. DNA has the ability to replicate itself. It is, in part, this ability of DNA to replicate that is the mechanism through which one generation passes its characteristics on to the next.

The information contained in the DNA molecule is coded by the arrangement of base pairs. The information on the nuclear DNA molecule is transmitted by messenger RNA to the ribosome, the site of protein manufacture, where transfer RNA functions to bring the appropriate amino acids into position. On the molecular level, a gene is a segment of the DNA molecule that codes for a particular protein or segment of a protein. When random changes occur in this code they increase genotypic variation by creating "new" alleles. The various alleles of a particular gene are simply slight variants in the code itself.

Student Learning Outcomes for Chapter 2

Upon satisfactory completion of Chapter 2, students should be able to:

1. Explain the basic concepts of Mendelian genetics, cytogenetics, and molecular genetics.
2. Explain the importance of genetic theory to the understanding of the mechanisms of evolution.

Learning Objectives for Chapter 2

Upon satisfactory completion of Chapter 2, students should be able to:

1. Explain the basic terminology used in the study of genetics.
2. Describe the work of Gregor Mendel, including the principles of inheritance, and the ways in which Mendel's work disproved the blending theory of inheritance and the concept of pangenesis.
3. Analyze how both inheritance and other factors are involved in the expression of a trait.

4. Describe the basics mechanisms of cell division and describe how the nature of chromosomes and cell division relates to Mendel's principles.
5. Know the structure and functions of DNA.
6. Illustrate how DNA controls cellular activity and, in general, the process of protein synthesis.
7. How are all plant and animal life variations of the same basic biological mechanisms.

Chapter Outline

Discovering the Mechanisms of Heredity
- Problems in the Study of Heredity
- The Work of Gregor Mendel
- A Model of Genetic Events
- What is a Trait?
- Mendelian Inheritance in Humans
- Summary

Cytogenetics
- The Chromosomes
- Cell Division
- Reexamining Mendelian Genetics
- Summary

The Molecular Basis of Heredity
- Molecules of Life
- The Nucleic Acids
- Protein Synthesis
- Summary

Box 2-1 Gregor Mendel and the Discovery of the Laws of Heredity
Box 2-2 Solving Simple Genetic Problems
Box 2-3 Facts about DNA

Discussion Launchers

1. Why is an understanding of genetics so important to an overall understanding of evolution? How does genetic knowledge show that earlier ideas about evolution and inheritance, such as those of Lamarck, cannot be correct?
2. How does some of the current research in the field of epigenetics seem to conform, at least in part, to some of Lamarck's ideas?
3. Why is DNA so well suited to being the hereditary material?

Films and Videos

Cell Division: Mitosis, Meiosis, and Cytokinesis (20 minutes). Looking at cell division through video and 3-D animation. [Carolina Biological Supply]

Cracking the Code: The Continuing Saga of Genetics (5-part series-30 minutes each). Reveals the history and development of genetics, reconstructing its journey from the 1700s to the cutting edge of 21st-century microbiology. [Films Media Group, Insight Media]

DNA (300 minutes). The story of DNA. [PBS VIDEO]

DNA – Secret of Photo 51 (56 minutes). The story of the discovery of the structure of DNA and the role played by Rosalind Franklin. [PBS VIDEO]

DNA and the Evidence for Evolution (20 minutes). Discusses the general structure and functioning of DNA. [Films Media Group]

The DNA Obsession (30 minutes). The story of the discovery of DNA and its structure. [Films Media Group]

The Gene Machine (30 minutes). Discusses the role of RNA in protein syntheses, mutagenic agents, and restriction enzymes. [Films Media Group]

Genes and Inheritance: Priests, Peas, Punnets, and Pedigrees (32 minutes). Examines Mendelian inheritance including punnet squares, gene linkage, sex linkage, and crossing over. [Insight Media]

Lifelines: Darwin and the theory of Inheritance (30 minutes). Richard Dawkins and others discuss Charles Darwin, Gregor Mendel, and Friedrich Meischer. [Films Media Group]

Patterns of Inheritance (28 minutes). Defines and illustrates basic terms and concepts of Mendelian inheritance. [Insight Media]

Peas in a Pod (30 minutes). Explores discoveries in the 18th and 19th centuries that gave birth to the science of genetics. [Films Media Group]

The Theory of Inheritance (26 minutes). Explains the ideas of Lamarck, Weismann, Mendel, and the role of DNA. [Films Media Group]

Understanding Genetics: The Molecular Basis of Inheritance (37 minutes). Presents Mendel's experiments. Shows DNA's relationship to genes and chromosomes and examines its components. [Insight Media]

Here are two short videos you may wish to watch: *The Story of You: ENCODE and the Human Genome* (http://www.youtube.com/watch?v=TwXXgEz9o4w) and *ENCODE: Encyclopedia of DNA Elements*(http://www.youtube.com/watch?v=Y3V2thsJ1Wc).

TED TALKS: There are many interesting talks in the TED TALK lectures that relate to this second chapter.

Some of the speakers are James Watson, Craig Venter, and Barry Schuler. For a complete list see: http://www.ted.com/talks/tags/genetics

Other Resources Including Resources for Distance Learning

An excellent site with a wealth of information and slideshows is Learn.Genetics from The University of Utah at http://learn.genetics.utah.edu.

Resources about Gregor Mendel can be found at MendelWeb at http://www.mendelweb.org.

The company "23 and Me" has a series of short but instructive videos on various introductory genetic topics. You can find it at: https://www.23andme.com/gen101/genes.

A nice piece on human eye color can be found at Stanford University School of Medicine at http://museum.thetech.org/ugenetics/eyeCalc/eyecalculator.html.

A source of information and photographs on cytogenetics is Cytogenetics Gallery at http://www.pathology.washington.edu/galleries/Cytogallery/main.php?file=intro.

James Watson recounts the story of the discovery of the structure of DNA in his 2005 TED lecture video, available at www.ted.com/index.php/talks/james_watson_on_how_he_discovered_dna.html.

Barry Schuyler explains DNA, genomes, and genomics, and the possible applications of our knowledge of genomics in his 2008 TED lecture video available at http://www.ted.com/index.php/talks/barry_schuler_genomics_101.html.

Here are some addition websites that might be of interest:

Go to the Learn.Genetics website of the University of Utah at http://learn.genetics.utah.edu/content/begin/traits/ and click on "What Is a Trait?" and "PTC: The Genetics of Bitter Taste."

For more information, go to Learn.Genetics of The University of Utah at http://learn.genetics.utah.edu. Click on "Genetics & Health" in the center band. This will bring you to the "Genetic Disorders Library."

Perhaps the most complete listing of inherited conditions is the Online Mendelian Inheritance in Man (OMIM) of the National Center for Biotechnology Information at http://www.ncbi.nlm.nih.gov/sites/entrez?db=omim, with a total of 20,951 entries as of November 23, 2011.

A less formidable presentation, with a lot of useful information on the most commonly encountered conditions, can be found at Medline Plus at http://www.nlm.nih.gov/medlineplus/geneticdisorders.html, a service of the U.S. National Library of Medicine and the National Institutes of Health. There are many websites available for specific conditions, some of which are listed in Medline Plus.

Exam Questions

Multiple Choice Questions

1. A fundamental principle of modern genetics is:
A) pangenesis
B) the inheritance of acquired characteristics
C) the blending theory
D) none of the above
Answer: D

2. The blending theory is the idea that:
A) inherited characteristics of offspring are intermediate between maternal and paternal characteristics
B) individuals inherit some traits from the mother and some from the father
C) inherited traits can be altered by the environment
D) none of the above
Answer: A

3. Pangenesis is:
A) based on the principle that acquired characteristics can be passed on
B) a "Noah's Ark" explanation for the origin of life
C) an explanation for the origin of all life
D) none of the above
Answer: A

4. The basic principles of heredity were first worked out by:
A) Charles Darwin B) Gregor Mendel C) Carolus Linnaeus D) Jean Lamarck
Answer: B

5. Gregor Mendel's work, published in 1866, was:
A) not generally known until 1900
B) immediately accepted by Mendel's contemporaries
C) footnoted extensively by Charles Darwin in *The Origin of Species*
D) used by Francis Galton in his studies of human heredity
Answer: A

6. Gregor Mendel's success was the result, in part, of the fact that he:
A) used pairs of sharply contrasting features
B) precisely defined the traits he studied
C) quantified the results of the breeding experiments
D) all of the above
Answer: D

7. True-breeding means:
A) hybrid
B) bred only with the same kind and shows the same trait or traits over many generations

C) only the dominant characteristics will express themselves
D) only the recessive traits will express themselves
Answer: B

8. One of Gregor Mendel's major contributions to science was his:
A) explanation of the mechanisms of heredity
B) discovery of the process of mutation
C) description of chromosomes
D) discovery of DNA within the nucleus of the cell
Answer: A

9. Gregor Mendel demonstrated that the hereditary units:
A) are discrete
B) blend with one another
C) are composed of DNA
D) all of the above
Answer: A

10. Males sex cells are called:
A) pollen B) sperm C) ova D) a and b
Answer: D

11. In the production of sex cells, paired hereditary units separate into different sex cells. This is termed the principle of:
A) segregation
B) hybridization
C) independent assortment
D) heterozygosity
Answer: A

12. When Mendel crossed a true-breeding tall with a true-breeding dwarf plant, all of the F_1 generation was tall. Therefore we may conclude that the allele for dwarfism in the pea plant is:
A) recessive
B) codominant
C) dominant
D) intermediate in expression
Answer: A

13. "The inheritance patterns of differing traits are independent of one another." This is the principle of:
A) segregation
B) independent assortment
C) dominance
D) recessiveness
Answer: B

14. The principles of heredity, developed by Gregor Mendel, apply to:
A) plants only
B) plants and "lower" animals
C) all plants and animals, except humans
D) all living organisms
Answer: D

15. “A simplified representation of a real-world phenomena” best defines a(n):
A) theory
B) model
C) experiment
D) control
Answer: B

16. The phenotype is the result of:
A) the genotype B) the environment C) traits D) a and b
Answer: D

17. The term phenotype refers to:
A) physical traits B) physiological traits C) personality traits D) all of the above
Answer: D

18. An individual's phenotype would include that individual's:

A) stature B) blood type C) intelligence D) all of the above
Answer: D

19. A trait is:
A) one aspect of the phenotype
B) one aspect of the genotype
C) not influenced by the environment
D) b and c
Answer: A

20. Which of the following characteristics is least influenced by the environment?
A) skin color B) stature C) PTC tasting D) intelligence
Answer: C

21. The term genotype refers to:
A) an individual's appearance
B) an individual's genetic makeup
C) an individual's observable and measurable characteristics
D) all of the above
Answer: B

22. A zygote is:
A) a fertilized ovum
B) an unfertilized ovum
C) a chromosomal pair
D) none of the above
Answer: A

23. A method for estimating environmental influence on a particular trait is through the study of:
A) twins
B) the males in the P_1 generation
C) the females in the F_1 generation
D) humans compared with other organisms
Answer: A

24. Monozygotic twins:
A) are always of same sex
B) possess the same genotype
C) are derived from one sperm and one ovum
D) all of the above
Answer: D

25. Dizygotic twins:
A) are always of the same sex
B) are produced when two zygotes combine
C) are produced from two different zygotes
D) a and b
Answer: C

26. Which of the following statements is true about twin studies?
A) Twin studies can give indications of the relationship between heredity and environment.
B) The estimates of the relative importance of environmental and genetic factors are only valid for the population on which the study is made.
C) A similarity in the phenotype of a set of monozygotic twins might be due to a common environment rather than their genetics.
D) all of the above
Answer: D

27. If a specific trait that is found in one member of a set of identical twins is found in the other 90 percent of the time, yet is found less than 25 percent of the time in both members of sets of nonidentical twins, we would conclude that the environment:
A) was the major cause of the trait
B) played a relatively great role in determining the trait
C) was as important as the genotype in determining the trait

D) played a relatively minor role in determining the trait
Answer: D

28. If a specific trait were found 7.5 percent of the time in both members of sets of monozygotic twins and 8.3 percent of the time in both members of sets of dizygotic twins, we would conclude:
A) the trait was almost exclusively a result of inheritance
B) the environment was not involved at all in its expression
C) the environment was the only factor involved in its expression
D) inheritance was a relatively unimportant factor
Answer: D

29. Homozygous means that an individual has:
A) two different alleles of the same gene
B) the same alleles of the same gene
C) the same alleles of differing genes
D) two different alleles of differing genes
Answer: B

30. A heterozygous genotype would be written as:
A) *AA* B) *Aa* C) *aa* D) *AA* and *aa*
Answer: B

31. A trait which is inherited as a recessive is expressed in the:
A) homozygous recessive individual
B) homozygous dominant individual
C) heterozygous individual
D) b and c
Answer: A

32. A trait which is inherited as a dominant is expressed in the:
A) homozygous recessive individual
B) homozygous dominant individual
C) heterozygous individual
D) b and c
Answer: D

33. An allele is:
A) a specific type of trait
B) an alternate form of a gene
C) the dominant form of a gene only
D) the recessive form of a gene only
Answer: B

34. Huntington's chorea is inherited as a dominant trait. A person who does not suffer from this abnormality would have a genotype:
A) *HH* B) *Hh* C) *hh* D) *HH* or *Hh*
Answer: C

35. The following is characteristic of dominant alleles:
A) dominant alleles are expressed in heterozygous genotypes
B) dominant alleles are alleles which are most common in populations
C) dominant alleles always cause more serious defects than recessive alleles
D) all of the above
Answer: A

36. Two nontasters for PTC will have among their offspring:
A) both nontasters and tasters
B) tasters only
C) nontasters only
D) taster males and nontaster females
Answer: C

37. Cytogenetics is defined as the study of:
A) cells
B) zygotes
C) hereditary mechanisms within the cell
D) the genetics of cytoplasm
Answer: C

38. The chromosomes are located within the cell's:
A) cytoplasm B) nucleus C) ribosome D) endoplasm
Answer: B

39. The standardized classification and arrangement of photographed chromosomes is known as a:
A) karyotype B) cytoplasm C) cytology D) chromotype
Answer: A

40. Different organisms:
A) may have different numbers of chromosomes, ranging between 2 and 1,260
B) usually have over 1,000 chromosomes per cell
C) all have between 40 and 50 chromosomes per cell
D) have half of their chromosomes in the nuclei and half in the cytoplasm of their cells
Answer: A

41. A human body cell has the following number of chromosomes:
A) 48 B) 46 C) 44 D) 23
Answer: B

42. A human body cell has the following number of autosomes:
A) 48 B) 46 C) 44 D) 23
Answer: C

43. The chromosomes that make us a pair are called:
A) homologous B) linked C) associated D) homozygous
Answer: A

44. Genes which are located on the same chromosome are said to be:
A) associated B) linked C) homologous D) homozygous
Answer: B

45. The Y chromosome:
A) carries no genes C) is smaller than the X chromosome
B) is larger than the X chromosome D) a and c
Answer: C

46. The traits that are inherited as X-linked traits:
A) follow simple Mendelian inheritance patterns C) affect females more than males
B) affect males more than females D) only affect females
Answer: B

47. X-linked means:
A) the site of the gene is unknown C) the gene lies on the X chromosome
B) the gene lies on "x" number of chromosomes D) the gene is only inherited by women
Answer: C

48. The two resulting cells formed by mitosis have:
A) the same number of chromosomes as the parent cell
B) one-half the number of chromosomes of the parent cell
C) twice the number of chromosomes of the parent cell
D) none of the above
Answer: A

49. Mitosis is the process by which:
A) single cell organisms reproduce

B) growth and replacement of cells occur in multicellular animals
C) gametes are produced
D) a and b
E) all of the above
Answer: D

50. The cell produced by mitosis in humans contains the following number of chromosomes:
A) 23 B) 24 C) 46 D) 48
Answer: C

51. A chromosome consists of two strands held together by the:
A) nucleolus B) centromere C) centriole D) spindle
Answer: B

52. The proper sequence of phases of division in mitosis is:
A) prophase, anaphase, telophase, metaphase
B) prophase, metaphase, anaphase, telophase
C) prophase, telophase, anaphase, metaphase
D) metaphase, prophase, telophase, anaphase
Answer: B

53. In mitosis the chromosomes first become visible during:
A) anaphase B) prophase C) metaphase D) telophase
E) interphase
Answer: B

54. Which of the following statements about meiosis is correct?
A) meiosis takes place only in the testes and the ovaries
B) the chromosome number is cut in half
C) there are two cycles of division
D) all of the above are correct
Answer: D

55. Meiosis differs from mitosis in that in meiosis:
A) there are two cycles of division C) crossing-over can occur
B) the chromosome number is cut in half D) all of the above
Answer: D

56. The cell produced by meiosis in humans contains the following number of chromosomes:
A) 23 B) 24 C) 46 D) 48
Answer: A

57. At the end of the first division of meiosis, each second generation cell contains:
A) 46 double stranded chromosomes C) 23 double stranded chromosomes
B) 46 single stranded chromosomes D) 23 single stranded chromosomes
Answer: C

58. In meiosis, crossing-over refers to:
A) one type of chromosomal mutation
B) a process whereby alleles from homologous chromosomes are exchanged
C) a process that occurs only on the X chromosome
D) a type of gene mutation
Answer: B

59. New combinations of alleles on the same chromosomes as a result of crossing-over is referred to as:
A) recombination B) linkage C) mitosis D) homology

Answer: A

60. Like ova production, sperm production:
A) begins during fetal development
B) is a product of meiosis
C) is a product of ovagenesis
D) none of the above
Answer: B

61. Oogenesis differs from spermatogenesis in that oogenesis:
A) leads to sex cells that, if fertilized, will contribute mtDNA to the zygote
B) begins in fetal life
C) usually produces only one mature ovum at any one time
D) all of the above
Answer: D

62. Cytogenetics shows that Mendel's principle of segregation:
A) does not work on the molecular level
B) is based on the separation of chromosomes during meiosis
C) is based on the separation of chromosomes during mitosis
D) is based on the linkage of genes on a single chromosome
Answer: B

63. The study of cytogenetics:
A) contradicts Mendelian inheritance
B) is unrelated to Mendelian inheritance
C) grounds Mendelian genetics in biology
D) a and b
Answer: C

64. In general half of the human babies born are males and half are females because:
A) the sex chromosomes segregate in the formation of sperm in males
B) the sex chromosomes segregate in the formation of ova in females
C) one half of the ova carry the male determining gene
D) none of the above
ANSWER: A

65. Which of the following statements is *correct* about human chromosomes?
A) A human karyotype shows 46 chromosomes.
B) Humans and chimpanzees possess the same number of chromosomes in each body cell.
C) DNA, a special coding protein, is located within the chromosome.
D) In humans, an individual who possesses a sex chromosome count of XXY is a female.
ANSWER: A

66. Large molecules, characteristic of living organisms, are based upon the tendency to form long chains of the atom:
A) nitrogen B) hydrogen C) carbon D) oxygen
Answer: C

67. The genetic material is classified chemically as a:
A) nucleic acid B) protein C) carbohydrate D) lipid
Answer: A

68. The basic building blocks of the nucleic acids are:
A) amino acids B) nucleotides C) fatty acids D) peptides
Answer: B

69. A nucleotide is composed of:
A) five-carbon sugar B) a phosphate C) a nitrogenous base D) all of the above
Answer: D

70. Ribose and deoxyribose are:
A) sugars B) lipids C) amino acids D) fatty acids
Answer: A

71. In the DNA molecule the base adenine always forms a complementary pair with:
A) another adenine B) guanine C) thymine D) cytosine
Answer: C

72. The basic sugar-phosphate-base unit is called a(n):
A) polypeptide B) protein C) nucleotide D) amino acid
Answer: C

73. The two categories of bases are:
A) purines and pyrimidines C) ribose and deoxyribose
B) proteins and lipids D) peptides and phosphates
Answer: A

74. Physically, the nuclear DNA molecule can be described as a:
A) single-stranded chain C) two-dimensional ladder
B) double helix D) sphere
Answer: B

75. The genetic information is coded by the sequence of triplets. Each triplet is made up of three:
A) nucleic acids B) amino acids C) proteins D) nucleotides
Answer: D

76. Proteins are chains of:
A) nucleotides B) amino acids C) lipids D) nucleic acids
Answer: B

77. Chains of amino acids are referred to as:
A) polypeptides B) carbohydrates C) lipids D) nucleic acids
Answer: A

78. In DNA replication:
A) messenger RNA translates each triplet into the corresponding amino acid
B) transfer RNA translates each triplet into the corresponding amino acid
C) the bonds holding the bases together are broken and the exposed bases attract complementary bases
D) mitochondrial DNA is formed based on the template of nuclear DNA
Answer: C

79. Proteins are manufactured with the cell in structures called:
A) mitochondria B) nuclei C) nucleoli D) ribosomes
Answer: D

80. Enzymes are:
A) nucleic acids B) proteins C) carbohydrates D) lipids
Answer: B

81. Which of the following sequences is correct in relationship to protein synthesis?
A) nDNA-mRNA-tRNA-protein synthesis C) nDNA-tRNA-mRNA-protein synthesis
B) mRNA-nDNA-tRNA-protein synthesis D) tRNA-nDNA-mRNA-protein synthesis
Answer: A

82. The nuclear DNA molecule controls the manufacture of proteins by the following process:

A) pieces of the DNA molecule break off and travel to the site of protein manufacture
B) the appropriate code is copied and transported by messenger RNA to the site of protein manufacture
C) the appropriate code is copied and transported by transfer RNA to the site of protein manufacture
D) none of the above
Answer: B

83. Each amino acid is determined by specific three-base units called:
A) ribosomes B) nucleotides C) proteins D) codons
Answer: D

84. Mitochondrial DNA is found in the:
A) nucleus of the cell B) fat cells only C) cytoplasm D) X and Y chromosomes
Answer: C

85. Mitochondrial DNA is inherited from:
A) the father only
B) the mother only
C) both the mother and the father
D) neither the mother nor the father; it develops after conception
Answer: B

86. The body uses amino acids:
A) to build protein molecules C) both of the above
B) to build nucleic acids D) neither of the above
Answer: A

Matching Questions

In questions 87 through 90, match the concept to its definition:
A. having the same alleles of the same gene
B. the inheritance patterns of differing traits are independent of one another
C. in the production of sex cells, the paired hereditary units separate into different sex cells
D. bred only with the same kind and shows the same trait over many generations
87. true-breeding Answer: D
88. segregation Answer: C
89. independent assortment Answer: B
90. homozygous Answer: A

In questions 91 through 93, match each genotype with its symbols:
A. *AA*
B. *Aa*
C. *aa*

91. homozygous dominant Answer: A
92. homozygous recessive Answer: C
93. heterozygous Answer: B

In questions 94 through 98, match each term to its description:
A. X and Y chromosomes
B. holds strands together
C. standardized arrangement of chromosomes
D. chromosomal strand
E. 22 pairs in humans

94. centromere Answer: B
95. karyotype Answer: C

96. chromatid Answer: D
97. autosomes Answer: E
98. sex chromosomes Answer: A

In questions 99 through 103, match each phase of mitosis with what occurs during that phase:
A. interim period
B. chromatids pulled to opposite poles
C. chromosomes become visible
D. spindle develops
E. new nuclear membrane forms

99. metaphase Answer: D
100. prophase Answer: C
101. anaphase Answer: B
102. interphase Answer: A
103. telophase Answer: E

In questions 104 through 107, match each nucleic acid with its description:
A. located in the mitochondria
B. transports amino acids into position
C. located in the nucleus
D. copies segments of the genetic code for protein manufacture

104. nDNA Answer: C
105. mtDNA Answer: A
106. mRNA Answer: D
107. tRNA Answer: B

Essay Questions

108. Although Charles Darwin's concept of natural selection was partially based on the observation of variability within a species, Darwin did not develop an acceptable mechanism to explain this variability. How did the work of Gregor Mendel help explain a mechanism of biological evolution?

109. Charles Darwin attempted to explain variability in terms of the blending theory. Describe the blending theory and contrast it to the concepts developed by Gregor Mendel.

110. Early studies of heredity centered on human characteristics. What are some of the explanations that explain why the discovery of the principles of heredity was first made on the basis of plant reproduction as opposed to human reproduction?

111. Many students mistakenly view the concept of dominance in terms of frequency or severity of a disease or trait. What precisely is meant by this term and how does it differ from the concept of recessiveness?

112. How does the concept of segregation differ from the concept of blending?

113. What are twin studies? How are they used in genetic research?

114. Some biologists feel that the phenotypic ratios obtained by Gregor Mendel in his experiments with pea plants were too good to be true. Did Mendel fake his data?

115. Although the basic Mendelian principles of genetics were discovered through experiments on pea plants, they also apply to all organisms, including humans. Illustrate the concepts of segregation, dominance, and independent assortment using human characteristics.

116. The construction of karyotypes has become a routine diagnostic medical tool. What kind of informa-

tion does a karyotype provide?

117. Describe the processes that occur during meiosis that demonstrate the physical basis of independent assortment and segregation.

118. In what ways do mitosis and meiosis differ from each other?

119. What is the essential difference between a male and a female in cellular terms?

120. What has the study of cytogenetics added to our understanding of Mendelian genetics?

121. In molecular terms, describe the differences between proteins and nucleic acids.

122. What are the two main types of DNA? In what ways do they differ in structure, function, and mode of inheritance?