Chapter 1

Introduction to Genetics

Matching

Key advances and evolution of the science of genetics: for questions 1-8, match the scientist's name to the proposed theory and experimental findings.

1. Matthias Jacob Schleiden **(b)**	a. Theory of evolution through selection
2. Theodor Schwann **(b)**	b. Cell theory
3. Charles Darwin **(a)**	c. Observation of chromosome division and mitosis
4. Walther Flemming **(c)**	d. Germ-plasm theory
5. August Weismann **(d)**	e. Experiments with plants on the principles of heredity
6. Gregor Mendel (**e)**	f. Experiments with fruit flies on transmission genetics
7. Walter Sutton **(f)**	g. Discovery of DNA structure
8. James Watson and Francis Crick **(g)**	

For questions 9-16, match the research focus to the subdiscipline of genetics in which that phenomenon is primarily studied.

9. Evolution **(c)**	a. Transmission genetics
10. Chemical nature of a gene **(b)**	b. Molecular genetics
11. Gene expression regulation **(b)**	c. Population genetics
12. Arrangement of genes on chromosomes **(a)**	
13. Gene mapping **(a)**	
14. Differences in allele frequencies in wet and dry environments (**c)**	
15. Differences in gene function in wet and dry environments **(b)**	
16. Transcription and translation **(b)**	

True/False

17. Humans first applied genetics to the domestication of plants (wheat, peas, etc.) and animals (dogs, goats, etc.) between approximately 10,000 and 12,000 years ago. **(T)**

18. The theory of pangenesis states that the inheritance of acquired characteristics during one's lifetime cannot be passed on to offspring. **(F)**

19. Many human traits, such as skin and hair color, exhibit blending inheritance, in which genetic information is mixed and is not separated in future generations. **(F)**

20. Bacteria and viruses can be used to study genes and inheritance, even though they are structurally and metabolically different from animal and plant cells. **(T)**

21. Individuals carrying the albino gene(s) have an increased skin cancer risk and poor eyesight. **(T)**

22. Charles Darwin accurately described the laws of inheritance in his landmark book *On the Origin of Species*. **(F)**

23. Albinism requires a mutation in all of the four genes that control the synthesis and storage of melanin in the skin tissue. **(F)**

24. Most phenotypes or traits, such as hair color, are determined solely by the information provided by a single gene. **(F)**

25. Evolution cannot occur without genetic changes in populations. **(T)**

Multiple Choice

26. Genetics contribute to advances in:
    a. agriculture.
    b. pharmaceuticals.
    c. medicine.
    d. modern biology.
    *e. All of the above.

27. Genetic information can be carried in which of the following biomolecules?
    a. proteins
    b. DNA and not RNA
    c. RNA and not DNA
    *d. Either DNA or RNA

28. Which of the following species is considered a genetic model organism?
    a. The plant, *Linaria vulgaris*
    b. The deer mouse, *Peromyscus maniculatus*
    *c. The worm, *Caenorhabditis elegans*
    d. The frog, *Hyla chrysoscelis*

e. The chimpanzee, *Pan troglodytes*

29. The three-dimensional structure of DNA was first deciphered based on the work of:
    a. James Watson.
    b. Francis Crick.
    c. Maurice Wilkins.
    d. Rosalind Franklin.
    *e. All of the above.

30. The form of albinism found in the Hopis is most likely due to a defect in the _____ gene located in chromosome 15.
    a. APC
    b. BRCA1
    *c. OCA
    d. GPR143

31. Which of the following scientists contributed significantly to the foundations of molecular genetics?
    *a. James Watson
    b. Thomas Hunt Morgan
    c. John B. S. Haldane
    d. Charles Darwin

32. The contribution Charles Darwin made to genetics was to
    a. demonstrate the connection between Mendel's principles of inheritance and evolution.
    *b. propose that evolution occurs by natural selection.
    c. develop the theory of evolution, based on earlier theories of population genetics.
    d. connect the fields of evolution and molecular genetics.

33. The function(s) of a DNA repair gene is studied by the subdivision of genetics called:
    a. population genetics.
    b. transmission genetics.
    *c. *molecular genetics.

34. Which of the following is not a component within a single nucleotide of a nucleic acid?
    b. nitrogenous base
    c. sugar
    d. *polymerase
    e. phosphate

Fill in the Blank

35. **Bioinformatics** is a field in genetics that combines molecular biology and computer science.

36. A measurable or observable trait or characteristic of an organism is called a(n) **phenotype.**

37. The complete genetic makeup of any organism is its **genome**.

38. A form of a gene that has a slightly different sequence than other forms of the same gene but encodes the same type of a protein is called a(n) **allele**.

39. Permanent, heritable changes in genetic information (DNA) are called **mutations**.

40. The *golden* mutation in zebrafish encodes a protein that participates in **calcium** uptake in melanocytes.

41. Within cells, genes are located on complex structures called **chromosomes.**

Short-Answer Discussion

42. List some traits that explain the high frequency of albinism in the Hopis.

(1) High frequency of the mutated albino gene OCA in the specific population
(2) Albinos and albinism hold a special place in Hopi culture
(3) Hopi albino males are excused from normal male labor
(4) Hopi albinos enjoy a "mating advantage" during growing season

43. Which features distinguish a prokaryotic cell from a eukaryotic cell?

Prokaryotic cells lack a nuclear membrane and possess no true membrane-bounded cell organelles, whereas eukaryotic cells possess a nucleus and membrane-bounded organelles such as chloroplasts and mitochondria.

44. List and describe two significant events in the history of genetics that occurred during the twentieth century.

(1) 1900: Mendel's previously published work on pea plants, which stated basic principles of inheritance, was rediscovered.

(2) 1902: Sutton proposed that genes are located on chromosomes.
(3) 1910: Thomas Hunt Morgan began studies of transmission genetics, using fruit fly mutants.
(4) 1930s: Fisher, Haldane, and Wright outlined the founding principles of population genetics.
(5) 1940s: Organization of chromosomes and genes studied using bacteria and viruses.
(6) 1940s–1950s: Evidence accumulated for DNA as the genetic material; Watson and Crick described DNA structure.
(7) 1966: Relationship between chemical structure of DNA and amino acid sequence of proteins determined.
(8) 1973: First recombinant DNA experiments
(9) 1977: Gilbert and Sanger methods for DNA sequencing published.
(10) 1986: Mullis develops PCR.
(11) 1990: First use of gene therapy in humans
(12) 1990s: Human Genome Project started.
(13) 1995: First genome of a free-living organism sequenced (*Haemophilus influenzae*).
(13) 1996: First genome of a eukaryote sequenced (yeast).
(14) 2000–present: Human genome sequence released.

45. What common features of heredity suggest that all life on Earth evolved from a common ancestor?

Despite the remarkable diversity of life on Earth, all genomes are encoded in nucleic acids. With few exceptions, the genetic code is common to all forms of life. Finally, the process by which genetic information is copied and decoded is remarkably similar for all forms of life.

46. What common-sense observation makes the theory of preformationism unlikely?

Preformationism states that the egg or sperm carries a miniature adult, which would mean that all characteristics come from either the mother or father. Simple observation shows that offspring have traits from both parents.

47. What common-sense observation makes the theory of acquired characteristics unlikely?

This theory states that characteristics acquired during one's lifetime are passed to offspring. However, anatomical changes, like the loss of a limb, or the removal of a mouse's tail, are not seen in offspring.

48. What common-sense observation makes the theory of blending inheritance unlikely?

This theory states that genetic information is mixed in an offspring and never separated. Some traits, however, disappear from one generation to the next, only to reappear in a subsequent generation.

49. Why might bacteria and viruses be good model organisms for studying the basics of inheritance? Describe two advantages over studying genetics in mice, dogs, or humans.

(1) They have DNA organized into genes, just like other organisms, so the basics of inheritance are the same in bacteria and viruses, as in other organisms.
(2) Their genetic systems are simple: they have fewer genes, fewer chromosomes, and less DNA.
(3) They reproduce more quickly: the generation time is shorter than for mice, dogs, or humans.
(4) They are easier to grow (take up less space, have less complicated nutritional needs) than vertebrates.

50. What is hemophilia and why can females, but not males, be carriers of hemophilia and other X-linked recessive characteristics?

Females have two X chromosomes, so one can have the defective version (allele) of the gene and one can have an allele that produces enough normal products to give the normal trait. Males have one X chromosome, so a male with the defective allele makes no normal gene product. Females can carry the defective allele without showing the effects of the trait, but males cannot.

51. Indicate which of the following theories of inheritance are recognized as supported by current evidence, and which have been proven to be incorrect.

cell theory **supported, correct**

inheritance of acquired characteristics **incorrect**

blending inheritance **incorrect**

Mendelian genetics: transmission of hereditary characteristics from parent organisms to their children **incorrect**

“the central dogma" that genetic information passes from DNA to RNA to protein **supported, correct**

germ-plasm theory **supported, correct**

Extended Answer Discussion

52. Write a paragraph explaining why genetics is considered a young science, even though people have been applying genetic principles for thousands of years.

Techniques for the observation of cells have been available only since the late 1500s, when the first microscopes were produced. The observation of chromosomes has been possible for only a century and a half, and the widespread systematic study of genes and inheritance has been conducted only in the twentieth century, since the rediscovery of Mendel's work in 1900. The structure of DNA was determined only in the mid-twentieth century and many molecular genetic techniques, like PCR, have been developed only in the last few decades. However, without understanding the nature of chromosomes and genes, plant and animal breeders have been applying the principles of inheritance for thousands of years, to obtain desired characteristics in domesticated organisms.