Answers to All Questions and Problems

CHAPTER 1

1.1 In a few sentences, what were Mendel's key ideas about inheritance?

ANS: Mendel postulated transmissible factors—genes—to explain the inheritance of traits. He discovered that genes exist in different forms, which we now call alleles. Each organism carries two copies of each gene. During reproduction, one of the gene copies is randomly incorporated into each gamete. When the male and female gametes unite at fertilization, the gene copy number is restored to two. Different alleles may coexist in an organism. During the production of gametes, they separate from each other without having been altered by coexistence.

1.2 Both DNA and RNA are composed of nucleotides. What molecules combine to form a nucleotide?

ANS: Each nucleotide consists of a sugar, a nitrogen-containing base, and a phosphate.

1.3 Which bases are present in DNA? Which bases are present in RNA? Which sugars are present in each of these nucleic acids?

ANS: The bases present in DNA are adenine, thymine, guanine, and cytosine; the bases present in RNA are adenine, uracil, guanine, and cytosine. The sugar in DNA is deoxyribose; the sugar in RNA is ribose.

1.4 What is a genome?

ANS: A genome is the set of all the DNA molecules that are characteristic of an organism. Each DNA molecule forms one chromosome in a cell of the organism.

1.5 The sequence of a strand of DNA is ATTGCCGTC. If this strand serves as the template for DNA synthesis, what will be the sequence of the newly synthesized strand?

ANS: TAACGGCAG

1.6 A gene contains 141 codons. How many nucleotides are present in the gene's coding sequence? How many amino acids are expected to be present in the polypeptide encoded by this gene?

ANS: There are $3 \times 141 = 423$ nucleotides in the gene's coding sequence. Its polypeptide product will contain 141 amino acids.

1.7 The template strand of a gene being transcribed is CTTGCCAGT. What will be the sequence of the RNA made from this template?

ANS: GAACGGUCT

1.8 What is the difference between transcription and translation?

ANS: Transcription is the production of an RNA chain using a DNA chain as a template. Translation is the production of a chain of amino acids—that is, a polypeptide—using an RNA chain as a template.

1.9 RNA is synthesized using DNA as a template. Is DNA ever synthesized using RNA as a template? Explain.

ANS: Sometimes, DNA is synthesized from RNA in a process called reverse transcription. This process plays an important role in the life cycles of some viruses.

1.10 The gene for α-globin is present in all vertebrate species. Over millions of years, the DNA sequence of this gene has changed in the lineage of each species. Consequently, the amino acid sequence of α-globin has also changed in these lineages. Among the 141 amino acid positions in this polypeptide, human α-globin differs from shark α-globin in 79 positions; it differs from carp α-globin in 68 and from cow α-globin in 17. Do these data suggest an evolutionary phylogeny for these vertebrate species?

ANS: The human and cow α-globins are least different; therefore, on the assumption that differences in α-globin reflect the degree of phylogenetic relationship, the human and the cow are the most closely related organisms among those mentioned. The next closest "relative" of humans is the carp, and the most distant relative is the shark.

1.11 Sickle-cell anemia is caused by a mutation in one of the codons in the gene for β-globin; because of this mutation, the sixth amino acid in the β-globin polypeptide is a valine instead of a glutamic acid. A less severe type of anemia is caused by a mutation that changes this same codon

to one specifying lysine as the sixth amino acid in the β-globin polypeptide. What word is used to describe the two mutant forms of this gene? Do you think that an individual carrying these two mutant forms of the β-globin gene would suffer from anemia? Explain.

ANS: The two mutant forms of the β-globin gene are properly described as alleles. Because neither of the mutant alleles can specify a "normal" polypeptide, an individual who carries each of them would probably suffer from anemia.

1.12 Hemophilia is an inherited disorder in which the blood-clotting mechanism is defective. Because of this defect, people with hemophilia may die from cuts or bruises, especially if internal organs such as the liver, lungs, or kidneys have been damaged. One method of treatment involves injecting a blood-clotting factor that has been purified from blood donations. This factor is a protein encoded by a human gene. Suggest a way in which modern genetic technology could be used to produce this factor on an industrial scale. Is there a way in which the inborn error of hemophilia could be corrected by human gene therapy?

ANS: The gene for the human clotting factor could be isolated from the human genome and transferred into bacteria, which could then be grown in vats to produce large amounts of the gene's protein product. This product could be isolated from the bacteria, purified, and then injected into patients to treat hemophilia. Another approach would be to transfer a normal copy of the clotting factor gene into the cells of people who have hemophilia. If expressed properly, the transferred normal gene might be able to compensate for the mutant allele these people naturally carry. For this approach to succeed, the normal clotting factor gene would have to be transferred into the cells that produce clotting factor, or into their precursors.

CHAPTER 2

2.1 Carbohydrates and proteins are linear polymers. What types of molecules combine to form these polymers?

ANS: Sugars combine to form carbohydrates; amino acids combine to form proteins.

2.2 All cells are surrounded by a membrane; some cells are surrounded by a wall. What are the differences between cell membranes and cell walls?

ANS: Cell membranes are made of lipids and proteins; they have a fluid structure. Cell walls are made of more rigid materials such as cellulose.

2.3 What are the principal differences between prokaryotic and eukaryotic cells?

ANS: In a eukaryotic cell, the many chromosomes are contained within a membrane-bounded structure called the nucleus; the chromosomes of prokaryotic cells are not contained within a special subcellular compartment. Eukaryotic cells usually possess a well-developed internal system of membranes and they also have membrane-bounded subcellular organelles such as mitochondria and chloroplasts; prokaryotic cells do not typically have a system of internal membranes (although some do), nor do they possess membrane-bounded organelles.

2.4 Distinguish between the haploid and diploid states. What types of cells are haploid? What types of cells are diploid?

ANS: In the haploid state, each chromosome is represented once; in the diploid state, each chromosome is represented twice. Among multicellular eukaryotes, gametes are haploid and somatic cells are diploid.

2.5 Compare the sizes and structures of prokaryotic and eukaryotic chromosomes.

ANS: Prokaryotic chromosomes are typically (but not always) smaller than eukaryotic chromosomes; in addition, prokaryotic chromosomes are circular, whereas eukaryotic chromosomes are linear. For example, the circular chromosome of *E. coli*, a prokaryote, is about 1.4 mm in circumference. By contrast, a linear human chromosome may be 10–30 cm long. Prokaryotic chromosomes also have a comparatively simple composition: DNA, some RNA, and some protein. Eukaryotic chromosomes are more complex: DNA, some RNA, and a lot of protein.

2.6 With a focus on the chromosomes, what are the key events during interphase and M phase in the eukaryotic cell cycle?

ANS: During interphase, the chromosomes duplicate. During M phase (mitosis), the duplicated chromosomes, each consisting of two identical sister chromatids, condense (a feature of prophase), migrate to the equatorial plane of the cell (a feature of metaphase), and then split so that their constituent sister chromatids are separated into different daughter cells (a feature of anaphase); this last process is called sister chromatid disjunction.

2.7 Which typically lasts longer, interphase or M phase? Can you explain why one of these phases lasts longer than the other?

ANS: Interphase typically lasts longer than M phase. During interphase, DNA must be synthesized to replicate all the chromosomes. Other materials must also be synthesized to prepare for the upcoming cell division.

2.8 In what way do the microtubule organizing centers of plant and animal cells differ?

ANS: The microtubule organizing centers of animal cells have distinct centrosomes, whereas the microtubule organizing centers of plant cells do not.

2.9 Match the stages of mitosis with the events they encompass: Stages: (1) anaphase, (2) metaphase, (3) prophase, and (4) telophase. Events: (a) reformation of the nucleolus, (b) disappearance of the nuclear membrane,