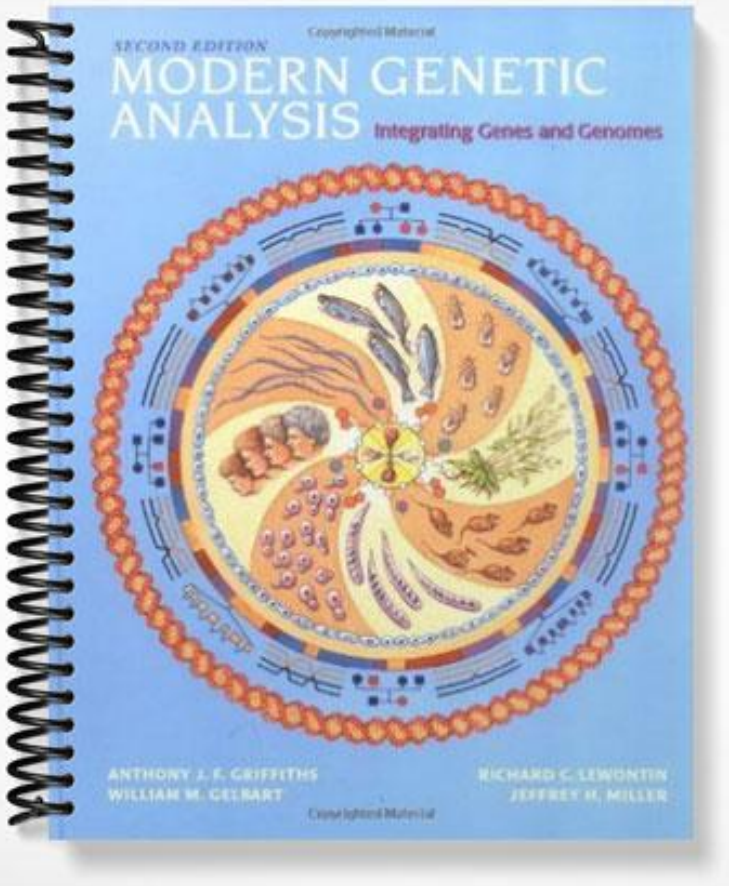
TEST BANK


SECOND EDITION
MODERN GENETIC ANALYSIS
Integrating Genes and Genomes
ANTHONY J. F. GRIFFITHS
WILLIAM M. GELBART
RICHARD C. LEWONTIN
JEFFREY H. MILLER

Chapter 2: The Structure of Genes and Genomes

Multiple-Choice Questions

1. A sample of normal double-stranded DNA was found to have a guanine content of 18%. What is the expected proportion of adenine?
   A) 9% * B) 32% C) 36% D) 68% E) 82%

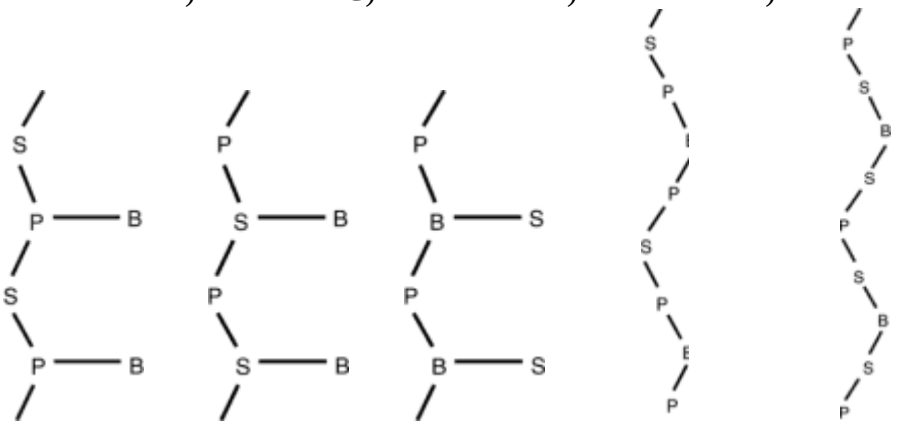
2. Which of the following *is* a component of DNA?
   * A) Cytosine B) Arginine C) Guanidinium D) Tyrosine E) Alanine

3. In one strand of DNA the nucleotide sequence is 5´-ATGC-3´. The complementary sequence in the other strand must be
   A) 5´-CGTA-3´
   B) 3´-ATGC-5´
   C) 5´-TACG-3´
   D) 5´-ATCG-3´
   * E) 3´-TACG-5´

4. How many different DNA molecules eight nucleotide pairs long are theoretically possible?
   A) 24 B) 64 * C) 65,536 D) 256 E) 32

5. Base pairing in DNA is restricted to two base pairs, represented as follows (lines between bases signify the number of hydrogen bonds). Which is the correct answer?
   * A) A = T and G ≡ C
   B) A ≡ T and G = C
   C) A ≡ G and T = C
   D) A = C and G ≡ T
   E) A ≡ C and G = T

6. Which of the following is the best representation of nucleotide chains, where S = sugar, P = phosphate, and B = nitrogen base (A, G, C, T, or U)?
   A) * B) C) D) E)



7. The DNA of two bacterial species differs in base composition, with species A having 30% G+C and species B having 60% G+C. If the two types of DNA are centrifuged to equilibrium in cesium chloride, they will be separated on the basis of their density and form two bands in the gradient. The band with species A DNA will occur at a position that is
   A) lower in the centrifuge tube than the band with species B DNA.
   * B) higher in the centrifuge tube than the band with species B DNA.
   C) at the same position in the centrifuge tube as species B DNA.
   D) Can't tell from the information given.

8. Heterochromatin contains
   A) no genes.
   B) only nonfunctional genes.
   * C) only a few genes.
   D) the same number of genes per unit of DNA as euchromatin.
   E) more genes per unit of DNA than euchromatin.

9. Which of the following is the correct order of increasing levels of chromosome packing (smallest to largest)?
   A) Nucleosomes-loops-solenoid-supercoils
   B) Solenoid-nucleosomes-loops-supercoils
   C) Solenoid-nucleosomes-supercoils-loops
   * D) Nucleosomes-solenoid-loops-supercoils
   E) Solenoid-loops-nucleosomes-supercoils

10. The central scaffold
    A) is found only in prokaryotes.
    * B) is largely composed of the enzyme topoisomerase II.
    C) is the site where DNA polymerase binds.
    D) is the attachment site for centromeric microtubules.
    E) is made up histone proteins.

11. Which type of DNA segment codes for a protein?
    A) rDNA
    B) Centromere
    C) Telomere
    D) Nucleolus organizer
    * E) Open reading frame

12. How many telomeres are there in a non-dividing human liver cell?
    A) 1 B) 2 C) 23 D) 46 * E) 92

13. In a certain diploid plant, $2n = 24$ and there are no chromosomal abnormalities. If DNA is extracted from plant tissue and run on a pulsed field electrophoresis gel, what is the maximum number of DNA bands you would expect to see?
    A) 6 * B) 12 C) 24 D) 48 E) 96

14. If phages are labeled with radioactive sulfur and allowed to infect bacterial cells, the phage progeny resulting from lysis are expected
    * A) to be non-radioactive.
    B) to have radioactive DNA.
    C) to have radioactive proteins.
    D) to have radioactive DNA and proteins.
    E) to have radioactive carbohydrates.

15. By differentially labeling the coat protein and the DNA of phage T2, Hershey and Chase demonstrated that
    A) only the protein enters the infected cell.
    B) the entire virus enters the infected cell.
    C) a metaphase chromosome is composed of two chromatids each containing a single DNA molecule.
    * D) the phage genetic material is most probably DNA.
    E) the phage coat protein directs synthesis of new progeny phage.

True-False Questions
Circle True or False for the following statements. If false, explain why.

1. $\frac{A+G}{C+T} = 1$
   for double-stranded helical DNA.
   A) True B) False
   Answer: A

2. GC-rich DNA melts at a higher temperature than AT-rich DNA.
   A) True B) False
   Answer: A

3. In eukaryotic cells rRNA is synthesized in the cytoplasm.
   A) True B) False
   Answer: B. It is synthesized in the nucleus.

4. Histones are rich in basic amino acids.
   A) True B) False
   Answer: A

5. Introns are found in the protein coding genes of prokaryotes.
   A) True B) False
   Answer: B. They are found in eukaryotic and organellar genomes.

6. The DNA of a eukaryotic chromosome is one long double helix.
   A) True B) False
   Answer: A

7. Some somatic cells such as your liver cells are passed on to progeny.
   A) True B) False
   Answer: B. The gametes (sex cells) are passed on to the progeny.

8. A chromatid is a chromosome that has been replicated but has not yet separated from its sister chromatid.
   A) True B) False
   Answer: A

9. A centromere is always in the middle of a chromosome.
   A) True B) False
   Answer: B. It can be positioned at the end, the middle, or anywhere in between.

10. A telomere is always on the end of a chromosome.
    A) True B) False
    Answer: A

11. Most proteins are coded by single copies of DNA sequences.
    A) True B) False
    Answer: A

12. Localized coiling of DNA results in the banding pattern of polytene chromosomes.
    A) True B) False
    Answer: A

13. Double-stranded DNA absorbs more light than single-stranded DNA.
    A) True B) False
    Answer: B. Single-stranded DNA absorbs more light.

14. Gene size remains the same regardless of the number of introns that are present.
    A) True B) False
    Answer: B. It is proportional to the number of introns that are present.

Open-Ended Questions

1. It is estimated that the human genome contains 3 billion nucleotide pairs, and that it contains 100,000 genes. An average gene plus intergenic sequence consists of how many nucleotides of DNA?
   Answer: $3 \times 10^9/10^5 = 3 \times 10^4 = 30$ kilobase pairs (30,000 base pairs)

2. A fragment of double-stranded DNA is found to have 100,000 nucleotide pairs.
   (a) What is the total number of nitrogen bases in this fragment?
   (b) What is the total number of phosphates in this fragment?
   Answer: (a) 200,000; (b) 200,000

3. A single tetranucleotide contains the base sequence 5´-AACG-3´.
   (a) Can you distiguish whether this is DNA or RNA?
   (b) If this were DNA, what would be the base sequence and polarity of the complementary strand?
   Answer: (a) No; (b) 3´-TTGC-5´

4. The genetic materials of an RNA virus, a DNA virus, and a wombat (an Australian mammal) were analyzed by a very disorganized laboratory technician, who lost the identification tags to the samples. Identify the source of the nucleic acid for each sample, giving a reason for each choice.

Sample	Adenine	Cytosine	Guanine	Thymine	Uracil
(a)	28.0	22.0	22.0	0.0	28.0
(b)	21.0	29.0	29.0	21.0	0.0
(c)	27.0	24.0	26.0	23.0	0.0

   Answer:
   Sample (a) is a double-stranded RNA virus: U and not T is present and A = U and G = C.
   Sample (b) is wombat DNA because T and not U is present and A = T and G = C.
   Sample (c) is a single-stranded DNA virus: T and not U is present and A ≠ T and G ≠ C.

5. Watson and Crick were able to predict the structure of DNA when they published their model of the double helix. This model was based on three types of experimental data. The observations made are given for each type of experiment. In a phrase or sentence explain how the observation was used to deduce the structure of DNA.
   (a) Using a chemical approach, phosphate-sugar linkages were established.
   (b) Using chromatography to determine the molar content of bases, Chargaff observed that in the organisms he studied, the total amounts of A and T are equal, and the total amounts of G and C are equal.
   (c) Using X-ray diffraction, Rosalind Franklin and Maurice Wilkins established the three-dimensional relationships between the atoms in DNA.
   Answer:
   (a) The polynucleotide chain is built with these linkages.
   (b) The chains are held together by the specific pairing of A to T and G to C.
   (c) The molecule is helical, with at least two chains, and the bases are inside.

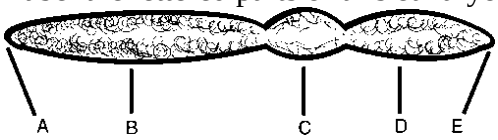
6. The genomes of prokaryotes, eukaryotes, plasmids, organelles, and viruses differ from one another in a number of parameters. Fill in the following table with the information being requested.

Genome	Free-living, Nonliving, or symbiotic?	Approx. genome size (kb)	Number of chromosomes	Approx. no. of genes	Introns: no/yes/ sometimes	Linear or circular?
Plasmid						
Phage T4						
Organelle						
E. coli						
Homo sapiens						

Answer:

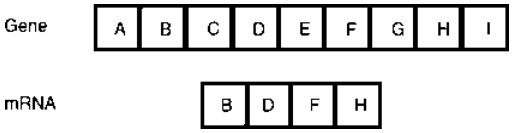
Genome	Free-living, Nonliving, or symbiotic?	Approx. genome size (kb)	Number of chromosomes	Approx. no. of genes	Introns: no/yes/ sometimes	Linear or circular?
Plasmid	*Symbiotic*	*9–100*	*1*	*2–29*	*No*	*Both*
Phage T4	*Nonliving*	*172*	*1*	*300*	*No*	*L/C*
Organelle	*Symbiotic*	*17–120*	*1*	*30–130*	*Sometimes*	*Usually C*
E. coli	*Free-living*	*4,700*	*1*	*4,000*	*No*	*C*
Homo sapiens	*Free-living*	*3,000,000*	*2*n = *46*	*40,000*	*Yes*	*L*

7. Label the lettered parts of this eukaryotic chromosome:



Answer: A and E = telomere; B = "q," or long arm; C = centromere; D = "p," or short arm

8. Label the lettered parts of this eukaryotic gene:



Answer: A = regulatory region; B, D, F, H = exons; C, E, G = introns; I = termination signal

9. Two phenotypes (type 1 and type 2) of an exotic virus-like life-form were collected on Mars. The Martian virus was composed of **silly putty, thumb tacks,** and **fuzzy dice.** An experiment was carried out to determine which component was the genetic material of this life-form. The fuzzy dice, silly putty, and thumb tacks were separated for each variant and mixed together in three different combinations to form infective viral-like particles. The phenotypes of these particles' progeny were determined. The experiment is diagrammed below.

Phenotype	Fuzzy dice	Thumb tacks	Silly putty
Type 1	FD-1	TT-1	SP-1
Type 2	FD-2	TT-2	SP-2

	Mixtures		
	FD-1 + TT-2 + SP-2	FD-2 + TT-1 + SP-2	FD-2 + TT-2 + SP-1
Progeny virus	All type 2	All type 2	All type 1

(a) What is the genetic material of the Martian virus? Give a reason for your answer.
(b) You also have agents that destroy each of the components individually. Design an experiment using these agents to confirm which component is the genetic material.

Answer:
(a) Silly putty, since specificity appears to reside in this molecule. SP-1→ type 1 (even when type 2 fuzzy dice and thumb tacks are present). SP-2 → type 2 (even when type 1 fuzzy dice and thumb tacks are present).
(b) Pretreat with an agent (enzyme or chemical) that destroys FD, TT, or SP before addition to mixture. In this case we would expect to prevent virus production when SP (silly putty) is destroyed.

10. An epidemic disease affecting sheep grazing near the hot springs of Thermopolis, Wyoming, was found to be due to a new virus. This virus could be grown on sheep kidney cells cultured in vitro. The virus appeared to contain four chemically defined components, which we will call *W*, *X*, *Y*, and *Z*. Investigators wished to determine which of these components carried the genetic information of the virus.
An experiment was therefore conducted in which each of these components was radioactively labeled by growing different batches of this virus in radioactive kidney cells. Radioactive virus from each of these batches was allowed to attach to nonradioactive kidney cells. The cells were centrifuged down to remove the unattached viruses. The cells were then briefly exposed to a kitchen blender, and again centrifuged. The supernatant (containing shaved off viral parts) and the pelleted infected cells were examined for radioactivity, with the following results:

	% Radioactivity	
	Supernatant	Pelleted cells
W	100	0
X	0	100
Y	0	100
Z	0	100

(a) On the basis of these results, which of these components can*not* be carrying genetic information? Why?

Three of the components turned out to be nucleic acids, and one of these turned out to be sheep DNA. (These were sloppy investigators and somewhat sheepish about their mistake.) The base compositions were as follows:

	% A	% G	% C	% T	% U
X	21	21	32	0	26
Y	26	32	21	21	0
Z	28	22	22	28	0

(b) What can you say about the type of nucleic acid found in each of these three components?
(c) Can you guess which of these components is sheep DNA and which components belong to the virus? Why?

Answer:
(a) *W*; because it remains outside the cell
(b) *X* = RNA; *Y* = single-stranded DNA; *Z* = double-stranded DNA
(c) Only *Z* is double-stranded DNA (which sheep possess). *X* and *Y* are complementary and either $X \rightarrow Y$ by reverse transcription or $Y \rightarrow X$ by transcription.

11. Discuss the levels of chromosome organization, referring to the following terms:
Nucleotide/Histones/DNA double helix/Chromatin/Nucleosomes
Answer:
Nucleotides are the building blocks of DNA. DNA assumes the structure of a double-stranded helical molecule that wraps around a core of histone proteins. Each core of histones wrapped in DNA is a unit called a nucleosome, and nucleosomes are the building blocks of chromatin.