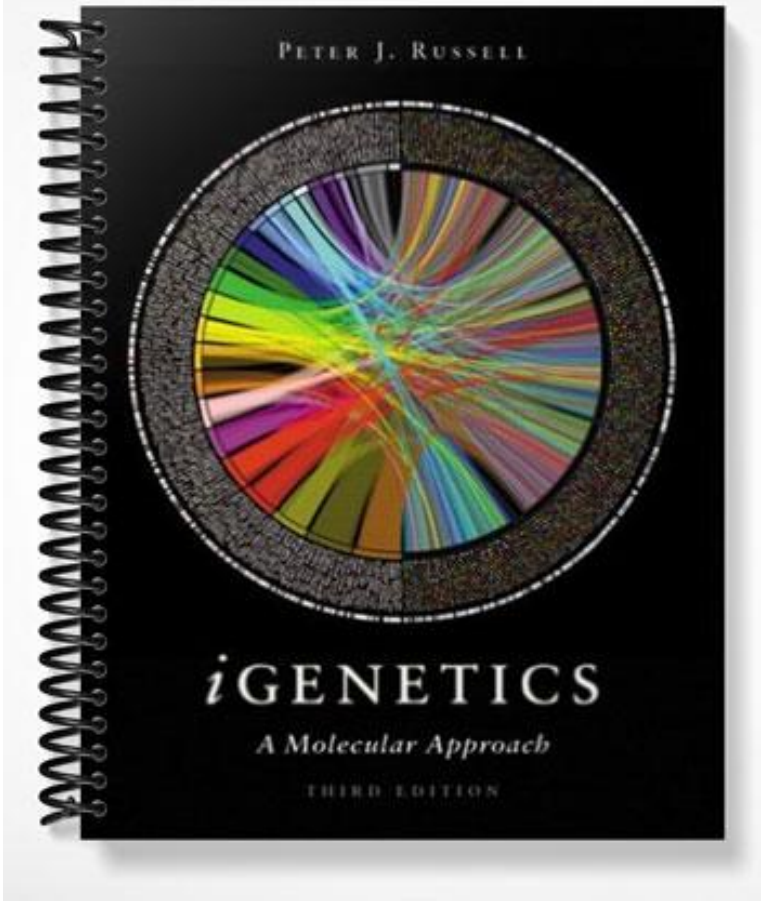
TEST BANK


Peter J. Russell
iGENETICS
A Molecular Approach
THIRD EDITION

Test Bank to Accompany

iGenetics: A Molecular Approach

Third Edition

by

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Benjamin Cummings

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Contents

Chapter 1 Genetics: An Introduction

MATCHING QUESTIONS

Please select the best match for each term.

1) A system for searching several linked databases
Skill: Factual recall

2) A tool to compare nucleotide or protein sequences
Skill: Factual recall

3) A website that provides links to research articles
Skill: Factual recall

4) A database of human genes and disorders
Skill: Factual recall

5) A database of genetic sequences
Skill: Factual recall

A) PubMed

B) OMIM

C) GenBank

D) BLAST

E) Entrez

Answers: 1) E 2) D 3) A 4) B 5) C

Please select the best match for each term.

6) Developed the polymerase chain reaction
Skill: Factual recall

7) Constructed the first recombinant DNA molecule
Skill: Factual recall

8) Cloned the first recombinant DNA molecule
Skill: Factual recall

9) Conducted breeding experiments with the pea plant
Skill: Factual recall

10) Discovered transposable elements
Skill: Factual recall

A) Boyer and Cohen

B) Barbara McClintock

C) Paul Berg

D) Gregor Mendel

E) Kary Mullis

Answers: 6) E 7) C 8) A 9) D 10) B

MULTIPLE–CHOICE QUESTIONS

11) The field of genetics includes
A) the study of heredity.
B) the molecular nature of the genetic material.
C) the ways in which genes control life functions.
D) the distribution and behavior of genes in populations.
E) All of these

Answer: E
Skill: Factual recall

12) Quantitative genetics is
A) the quantitative study of the activity of a gene.
B) the study of the genetic diversity within a large group of individuals of the same species.
C) the study of the genetic diversity within members of a number of related species.
D) the study of traits that are determined by a number of genes simultaneously.
E) the study of the number of characteristics found in an organism.

Answer: D
Skill: Factual recall

13) Bacteria and Archaea are
A) eukaryotic.
B) prokaryotic.
C) archaeotic.
D) anucleotic.
E) proteozoic.

Answer: B
Skill: Factual recall

14) Transposons are
A) proteins that are stable.
B) proteins that are unstable.
C) DNA segments that are stable.
D) DNA segments that are unstable.
E) DNA segments that code for proteins.

Answer: D
Skill: Factual recall

15) Genes influence all aspects of life because they
A) are structural elements of the cell.
B) regulate movement of proteins.
C) produce RNA and protein needed for different processes.
D) localize to the nucleus.
E) are needed for DNA synthesis.

Answer: C
Skill: Factual recall

16) An ideal organism for a geneticist to use as a study organism would possess which of the following characteristics?
A) A relatively short life cycle
B) A large degree of genetic variation among individuals
C) Matings that produce large numbers of offspring
D) A well–characterized genetic background, karyotype, etc.
E) All of these are desirable characteristics

Answer: E
Skill: Factual recall

17) The organism that Mendel used for his experiments was
A) *E. coli.*
B) the fruit fly.
C) maize.
D) yeast.
E) the pea plant.

Answer: E
Skill: Factual recall

18) A map unit (μ) is
A) the position of a gene on the chromosome.
B) the unit of genetic distance on a chromosome.
C) the unit of physical distance on a chromosome.
D) equivalent to a nucleotide.
E) equal to the number of recombinant progeny.

Answer: B
Skill: Factual recall

19) Which of the following is a nematode worm that has been used as a model organism in genetics?
A) *Drosophila melanogaster*
B) *Mus musculus*
C) *Arabidopsis thaliana*
D) *Caenorhabditis elegans*
E) *Homo sapiens*

Answer: D
Skill: Factual recall

20) In eukaryotic cells, _____ are energy–producing organelles that contain DNA.
A) nuclei
B) lysosomes
C) chromosomes
D) nucleoli
E) mitochondria

Answer: E
Skill: Factual recall

21) The principles of heredity were first established through breeding experiments carried out in _____ by Gregor Mendel.
A) the late 1700s
B) the 1950s
C) the 1860s
D) the early 1900s
E) the mid–1600s

Answer: C
Skill: Factual recall

22) *Tetrahymena* is a
A) fungus.
B) protozoa.
C) green alga.
D) weed.
E) bacteria.

Answer: B
Skill: Factual recall

23) Eukaryotic chromosomes consist of
A) DNA alone.
B) DNA complexed with protein.
C) DNA complexed with RNA.
D) DNA complexed with fatty acids.
E) DNA complexed with protein and RNA.

Answer: B
Skill: Factual recall

24) Translation of RNA into proteins occurs
A) in the nucleus.
B) in the endoplasmic reticulum.
C) in the cytoplasm.
D) in both the nucleus and the cytoplasm.
E) in both the nucleus and the endoplasmic reticulum.

Answer: C
Skill: Factual recall

25) The branch of genetics concerned with analyzing the structure and function of genes is
A) molecular genetics.
B) plant genetics.
C) transmission genetics.
D) population genetics.
E) applied genetics.

Answer: A
Skill: Factual recall

TRUE–FALSE QUESTIONS

26) Genetics is central to biology because genes and their functions form the basis of all life processes.

Answer: TRUE
Skill: Factual recall

27) There is a sharp divide between basic and applied research.

Answer: FALSE
Explanation: Basic and applied research employ the same information and similar techniques to answer questions.
Skill: Factual recall

28) The smooth endoplasmic reticulum has ribosomes attached to it.

Answer: FALSE
Explanation: The rough endoplasmic reticulum has ribosomes attached to it.
Skill: Factual recall

29) Centrioles are also called basal bodies.

Answer: TRUE
Skill: Factual recall

30) The centrosomes are a part of the chromosome that help in chromosome movement during mitosis and meiosis.

Answer: FALSE
Explanation: The centrosomes are a region of undifferentiated cytoplasm.
Skill: Factual recall

31) Bacteria and plants both have a rigid cell wall outside the cell membrane.

Answer: TRUE
Skill: Factual recall

32) Membrane–bound nuclei are characteristic of both Archaea and eukaryotes.

Answer: FALSE
Explanation: Membrane–bound nuclei are characteristic of eukaryotes. Archaea, like Bacteria, are prokaryotes.
Skill: Factual recall

33) Genetic maps show the relative location and arrangement of genes on chromosomes.

Answer: TRUE
Skill: Factual recall

34) Archaea are prokaryotes that are often found in inhospitable conditions such as hot springs and salt marshes.

Answer: TRUE
Skill: Factual recall

35) *E. coli* is a rod–shaped bacterium found in the human intestine.

Answer: TRUE
Skill: Factual recall

SHORT ANSWER QUESTIONS AND PROBLEMS

36) What is the hypothetico–deductive method of investigation?

Answer: The hypothetico–deductive method of investigation consists of observing a phenomenon, forming hypotheses to try and explain the observations, making experimental predictions based on those hypotheses, and finally testing out the predictions by doing specific experiments.
Skill: Factual recall

37) How do mutations help us in understanding the particular functions of a gene?

Answer: Comparing mutants with normal cells gives us an idea as to which life process has been affected. This helps us locate the mutated gene in the specific biochemical pathway for that particular process.
Skill: Conceptual understanding

38) How does the knowledge of complete genomes of different organisms help us in any way?

Answer: Since the function of most genes is conserved to a large degree among different organisms, the knowledge of the genomes of different species helps us compare them, leading to a better understanding of gene functions. This in turn will lead to a better understanding of human genetic diseases and will allow us to develop better cures.

Skill: Factual recall

39) How can a genetic map be used?

Answer: Genetic maps can be used in the process of localizing genes and studying the distribution of genes on chromosomes and in the genome.

Skill: Factual recall

40) What is recombination frequency?

Answer: Recombination frequency is the percentage of recombinant progeny, that is, the percentage of the progeny in which the arrangement of alleles has switched compared to their arrangement in the parents. This is taken to be a measure of the genetic distance between genes and is used to create genetic maps.

Skill: Factual recall

41) Are genetic maps based on the actual distance on chromosomes as measured by nucleotides?

Answer: No. Genetic maps are based on the frequency of recombination between genes. As such, they show relative distances between genes but cannot specify actual distance in terms of nucleotides.

Skill: Conceptual understanding

42) Which organelles besides the nucleus contain their own DNA?

Answer: The mitochondria in eukaryotes and the chloroplasts in plants contain DNA of their own.

Skill: Factual recall

43) The nucleus separates the chromosomes from the rest of the cell. How is the information in the DNA communicated to the cell?

Answer: The nuclear membrane has pores and is permeable to certain molecules. This allows selected materials, like RNA and proteins, to move in and out of the nucleus.

Skill: Factual recall

44) What is recombinant DNA technology?

Answer: Recombinant DNA technology encompasses procedures that allow scientists to join together DNA from two or more different organisms and make many identical copies of them (cloning).

Skill: Factual recall

45) For geneticists, why is it important that genetic variability exist in the population under study?

Answer: Genetic variation in individuals of a population is important for studying the inheritance pattern of those characteristics. If all the members of a population were identical for the trait under study, their progeny would be as well, and it would be impossible to determine how the trait was being passed on to the offspring.

Skill: Conceptual understanding

46) What characteristics does an organism have to possess to be a good genetic model?

Answer: To be a good genetic model, an organism has to have a well–known genetic history, a short life cycle, produce many offspring, be easy to handle, and have genetic variability among the individuals in a population.

Skill: Factual recall

47) Why are genetic databases so important to the study of modern genetics?

Answer: The available information about the genetics of a large number of organisms has increased dramatically in the past few years. As a result, it has become impossible to study, learn, and remember all of it. All this information needs to be stored in such a way that it may be accessed and searched easily. This is done in computer databases that have assumed enormous importance in the study of genetics.

Skill: Factual recall

48) What is the difference between PubMed and OMIM?

Answer: PubMed is a website that is used to access citations and abstracts of journal articles. OMIM is a database of human genes and genetic disorders.

Skill: Factual recall

49) What is the technique that is used to amplify DNA sequences?

Answer: The procedure employed to amplify DNA sequences is called polymerase chain reaction (PCR).

Skill: Factual recall

50) What are the differences between eukaryotes and prokaryotes?

Answer: Eukaryotes possess a nucleus that is separated from the rest of the cell by a double–layered nuclear membrane. Prokaryotes lack a nucleus. Prokaryotes also lack all membrane–bound organelles, such as mitochondria, endoplasmic reticula, and Golgi bodies. Such organelles are present in eukaryotes. Prokaryotes are generally also much smaller than eukaryotes, and are usually unicellular.

Skill: Factual recall

Chapter 2 DNA: The Genetic Material

MATCHING QUESTIONS

Please select the best match for each term.

1) Centromere
Skill: Factual recall

2) Nucleoid
Skill: Factual recall

3) Nucleotide
Skill: Factual recall

4) Chromosome
Skill: Factual recall

5) Nucleosome
Skill: Factual recall

A) The region of a prokaryotic cell where the chromosome is located

B) The basic structural unit of chromatin with "bead–on–a–string" morphology

C) A DNA molecule and associated proteins

D) The region of a eukaryotic chromosome found near the attachment point of mitotic or meiotic spindle fibers

E) The constituent monomer of DNA and RNA

Answers: 1) D 2) A 3) E 4) C 5) B

MULTIPLE–CHOICE QUESTIONS

6) Loosely aggregated DNA bound to proteins in a eukaryotic cell is called
A) chromosomes.
B) chromatin.
C) chromatid.
D) centromere.
E) nucleoid.

Answer: B
Skill: Factual recall

7) The C–value is the amount of DNA in a
A) haploid genome.
B) diploid genome.
C) bacterial genome.
D) eukaryotic genome.
E) cell's nucleus.

Answer: A
Skill: Factual recall

8) The chromosome of most prokaryotes differs from those of eukaryotes in that
   A) the prokaryotic chromosome is linear, while the eukaryotic chromosome is circular.
   B) the prokaryotic chromosome is circular, while the eukaryotic chromosome is linear.
   C) the prokaryotic chromosome does not replicate before mitosis, while the eukaryotic chromosome does.
   D) the prokaryotic chromosome does not contain genes, while the eukaryotic chromosome does.
   E) the prokaryotic chromosome is not necessary for the organism's survival, while the eukaryotic chromosome is.

Answer: B
Skill: Factual recall

9) A Barr body is an example of
   A) constitutive euchromatin.
   B) facultative euchromatin.
   C) facultative heterochromatin.
   D) a nucleosome.
   E) constitutive heterochromatin.

Answer: C
Skill: Factual recall

10) The definition of transformation is
   A) the shift of genetic information from DNA to protein.
   B) the genetic alteration of an organism.
   C) the uptake of genetic information by a cell from the environment.
   D) Both B and C
   E) None of these

Answer: D
Skill: Factual recall

11) In Griffith's experiment involving the transformation of *Streptococcus pneumoniae*,
   A) the *R* strain was virulent.
   B) the *S* strain was virulent.
   C) both the *R* and *S* strains were virulent.
   D) the *R* strain had a protein capsule.
   E) the *S* strain had a protein capsule.

Answer: B
Skill: Factual recall

12) What was the transforming principle isolated in Griffith's experiment?
   A) Protein
   B) RNA
   C) DNA
   D) Virus
   E) Polysaccharide

Answer: C
Skill: Factual recall

13) Who used radioactively labeled T2 bacteriophage to confirm the identity of the transforming principle?
A) Griffith
B) Hershey and Chase
C) Avery
D) Gierer and Schramm
E) Beadle and Tatum

Answer: B
Skill: Factual recall

14) Which part of the T2 bacteriophage entered *E. coli* cells in the experiment which confirmed the identity of the transforming principle?
A) The RNA
B) The DNA
C) The whole virus
D) The protein coat
E) No part

Answer: B
Skill: Factual recall

15) Certain _____ have RNA for their genetic material.
A) bacteria
B) viruses
C) plants
D) eukaryotes
E) prokaryotes

Answer: B
Skill: Factual recall

16) What did the X-ray diffraction patterns *initially* reveal about the DNA molecule?
A) It is of uniform diameter and has a helical structure.
B) It is a helical molecule with paired bases in the center.
C) It is double-stranded with antiparallel strands.
D) It is acidic, phosphorus-rich, and large.
E) It contains hereditary information.

Answer: A
Skill: Factual recall

17) What did Watson and Crick deduce about the three-dimensional structure of DNA?
A) There is a repeating pattern every 3.4 nm and every 0.34 nm.
B) It is a double-stranded helix.
C) It contains a lot of phosphorus.
D) It is a large molecule.
E) It consists of supercoiled chromatin.

Answer: B
Skill: Factual recall

18) Which of the following is a nonhistone protein found in chromatin?
A) H1
B) HMG
C) H2A
D) H5
E) All of these

Answer: B
Skill: Factual recall

19) Antiparallel means that
A) the two polynucleotide chains run in opposite directions.
B) each DNA molecule consists of one old and one new strand.
C) opposite strands are held together by base pairing.
D) the helix twists to the right.
E) there is complementary base–pairing.

Answer: A
Skill: Factual recall

20) Complementary base–pairing allows for
A) spontaneous mutations to occur.
B) genes to be expressed as a phenotype.
C) DNA to serve as its own template for replication.
D) replication to be semiconservative.
E) covalent bonds to form between the opposite bases.

Answer: C
Skill: Factual recall

21) Which of the following are the purine nucleotides in DNA?
A) Adenine and thymine
B) Cytosine and guanine
C) Adenine and cytosine
D) Guanine and adenine
E) Thymine and uracil

Answer: D
Skill: Factual recall

22) Topoisomerases function to
A) remove nucleotides from DNA.
B) join DNA pieces together.
C) twist DNA molecules.
D) attach DNA loops to scaffold proteins.
E) move chromosomes along spindle fibers.

Answer: C
Skill: Factual recall

23) Which form of DNA is a left–handed double helix?
A) A–DNA
B) B–DNA
C) L–DNA
D) R–DNA
E) Z–DNA

Answer: E
Skill: Factual recall

24) The displacement loop (D–loop) may be a characteristic of
A) centromeres.
B) telomeres.
C) A–DNA.
D) B–DNA.
E) Z–DNA.

Answer: B
Skill: Factual recall

25) Which nucleotide is absent in RNA?
A) Adenine
B) Guanine
C) Uracil
D) Cytosine
E) Thymine

Answer: E
Skill: Factual recall

TRUE–FALSE QUESTIONS

26) DNA and RNA both contain phosphate and ribose.

Answer: FALSE
Explanation: They both contain phosphate, but DNA contains the sugar deoxyribose rather than ribose.
Skill: Factual recall

27) Hershey and Chase used radioactive sulfur to label the genetic material of bacteriophages.

Answer: FALSE
Explanation: The radioactive sulfur labeled the protein coat.
Skill: Factual recall

28) In a strand of DNA, a hydrogen bond connects the phosphate group of one nucleotide to the sugar of the adjacent nucleotide.

Answer: FALSE
Explanation: A covalent phosphodiester bond connects the two adjacent nucleotides.
Skill: Factual recall

29) The genome of the T–even family of bacteriophage consists of single–stranded RNA.

Answer: FALSE
Explanation: It consists of double–stranded DNA.
Skill: Factual recall

30) *Borrelia burgdorferi* is a bacterium whose genome consists of one large and several small linear chromosomes.

Answer: TRUE
Skill: Factual recall

31) By weight, the amount of DNA in chromatin is less than that of histone.

Answer: FALSE
Explanation: The weights of DNA and histone in chromatin are equal.
Skill: Factual recall

32) The virus first shown to have RNA as its genetic material was tobacco mosaic virus (TMV).

Answer: TRUE
Skill: Factual recall

33) The more condensed a part of a chromosome is, the more likely it is that the genes in that region will be active.

Answer: FALSE
Explanation: The genes in a region are less likely to be active the more condensed a part of a chromosome is.
Skill: Factual recall

34) The genome of most prokaryotes consists of moderately repetitive DNA.

Answer: FALSE
Explanation: The genome of most prokaryotes consists of unique-sequence DNA.
Skill: Factual recall

35) In eukaryotes, the greatest relative amount of tandemly repeated DNA is associated with centromeres and telomeres.

Answer: TRUE
Skill: Factual recall

SHORT ANSWER QUESTIONS AND PROBLEMS

36) In Griffiths' transformation experiments, under what conditions did the injected mice die?

Answer: The mice died when they were injected with living, virulent bacteria, and when they were injected with living, nonvirulent bacteria mixed with heat-killed, virulent bacteria.
Skill: Factual recall

37) How could you test whether the transforming ability of a cell extract was due to DNA or RNA?

Answer: You could treat the extract with a DNase or RNase enzyme and test whether its transforming ability was intact.
Skill: Application of knowledge

38) One of the strands in a DNA double helix has the nucleotide sequence 5'-ACCTGCTACGG-3'. What is the sequence of the complementary DNA strand?

Answer: 3'-TGGACGATGCC-5'
Skill: Problem-solving

39) What is the function of dispersed repeated sequences such as SINEs and LINEs in eukaryotes?

Answer: Little is known about the function of such sequences, but one hypothesis is that they have no function at all. Another is that they are involved in regulating gene expression.

Skill: Factual recall

40) What is the C–value paradox, and what is its cause?

Answer: There is also no direct relationship between the C–value (the total amount of DNA in the haploid genome) and the structural or organizational complexity of the organism. This is due in part to the amount of repetitive–sequence DNA found in the genome of some organisms.

Skill: Conceptual understanding

41) Define Chargaff's rules of the base composition of DNA.

Answer: Chargaff's rules include the following: (1) the amount of adenine = the amount of thymine, (2) the amount of guanine = the amount of cytosine, and (3) the amount of purines = the amount of pyrimidines.

Skill: Factual recall

42) Describe the differences between heterochromatin and euchromatin in chromosomes. Are there any situations in which one can be changed into the other?

Answer: Euchromatin contains actively transcribed genes and undergoes normal cycles of condensation and decondensation in the cell cycle. Heterochromatin remains condensed and contains genes that are usually transcriptionally inactive. Euchromatin can be inactivated, as in the case of Barr bodies. It is then known as facultative heterochromatin.

Skill: Factual recall

43) What are the three necessary characteristics of the hereditary molecule in cells?

Answer: (1) It must be able to carry information, (2) it must be able to accurately pass on the information to progeny cells (replicate), and (3) it must be capable of change (evolution).

Skill: Conceptual understanding

44) Name the constituent parts of a nucleoside and a nucleotide.

Answer: A nucleoside consists of a pentose sugar covalently bonded to a nitrogenous base; a nucleotide is a nucleoside with the addition of a phosphate group.

Skill: Factual recall

45) The DNA phage ΦX174 was found to have a ratio of bases of 25A:33T:24G:18C. This departs from the usual A/T = 1 and G/C = 1 ratios. How can you explain this?

Answer: The genome of the phage consists of single–stranded, rather than double–stranded, DNA.

Skill: Conceptual understanding

46) If the human egg has 3 billion base pairs, how many nucleosomes will be present in the nucleus of a human somatic cell?

Answer: In humans, the DNA wrapped around each nucleosome is approximately 200 bp (147 bp + 53 bp linker). As such, there will be approximately $3 \times 10^9/2 \times 10^2 = 1.5 \times 10^7$ nucleosomes in a human egg nucleus. However, the egg is haploid, whereas the somatic cells are diploid. Therefore, there will be approximately $1.5 \times 10^7 \times 2 = 3 \times 10^7$ nucleosomes in the nucleus of a human somatic cell.

Skill: Problem–solving

47) Why are the amino acid sequences of eukaryotic histones so similar to one another, even among distantly related species?

Answer: Evolutionary conservation of these sequences is a strong indicator that histones perform the same basic role in organizing the DNA in the chromosomes of all eukaryotes.

Skill: Conceptual understanding

48) Describe the packing of chromatin from the 10–nm to the 30–nm fiber stage. What is the role of histones?

Answer: 10–nm chromatin fiber consists of nucleosomes–"beads" of DNA wound around eight core histone proteins–connected by strands of linker DNA. The 30–nm chromatin fiber is created by the binding of histone H1, which brings the linker DNA and the nucleosomes closer together. In the solenoid model of the 30–nm fiber, the nucleosomes are brought together into a spiraling helical structure, with about six nucleosomes per complete turn.

Skill: Conceptual understanding

49) What is the role of centromeres and telomeres?

Answer: Centromeres are the chromosomal regions where mitotic or meiotic spindle fibers attach. They are therefore responsible for the accurate segregation of chromosomes to daughter cells during replication. Telomeres are heterochromatic regions of chromosomes that are also required for replication and stability. They are usually found at the ends of the chromosome and are associated with the nuclear envelope.

Skill: Factual recall

50) If the base pairs in a DNA helix are 0.34 nm apart, and a complete (360°) turn of the helix takes 3.4 nm, how many base pairs per turn are there in a DNA molecule?

Answer: There are 10 base pairs per turn.

Skill: Problem–solving

Chapter 3 DNA Replication

MATCHING QUESTIONS

Please select the best match for each term.

1) Primosome
Skill: Factual recall

2) Replicon
Skill: Factual recall

3) Replisome
Skill: Factual recall

4) Telomerase
Skill: Factual recall

5) Replicator
Skill: Factual recall

A) A complex of proteins and RNA that replicates the ends of eukaryotic chromosomes

B) A complex of helicase and primase on the template DNA

C) A complex of key replication proteins at the replication fork in *E. coli* and bacteriophage DNA

D) The distance between the origin and the termination of replication where two replication forks fuse

E) A DNA sequence that contains the specific region where replication begins

Answers: 1) B 2) D 3) C 4) A 5) E

MULTIPLE-CHOICE QUESTIONS

6) During replication, the direction of synthesis of new DNA from the leading and lagging strands is
A) 5' to 3' only.
B) 3' to 5' only.
C) from left to right only.
D) both 5' to 3' and 3' to 5'.
E) different, depending on whether the cell is prokaryotic or eukaryotic.

Answer: A
Skill: Factual recall

7) DNA replication is always
A) discontinuous.
B) bidirectional.
C) conservative.
D) semiconservative.
E) dispersive.

Answer: D
Skill: Factual recall

8) In *E. coli*, replication begins at which chromosome site?
A) The replication fork
B) *ter*
C) *oriC*
D) TBP
E) All of these

Answer: C
Skill: Factual recall

9) Which of the following did Kornberg use to detect DNA synthesis?
A) Radioactively labeled *E. coli* cells
B) Fluorescently labeled *E. coli* cells
C) Radioactively labeled deoxynucleotide triphosphates
D) Fluorescently labeled deoxynucleotide triphosphates
E) Nonlabeled deoxynucleotide triphosphates

Answer: C
Skill: Factual recall

10) How many replication forks are produced when DNA denatures at an origin?
A) 0
B) 1
C) 2
D) 3
E) The number varies

Answer: C
Skill: Factual recall

11) What is a replication bubble?
A) A complex of replication enzymes on the DNA template strand
B) A DNA sequence that initiates replication
C) A tangle of denatured DNA strands near the replication fork
D) A locally denatured segment of DNA where replication originates
E) A localized site in the nucleus where chromosomes are replicating

Answer: D
Skill: Factual recall

12) Which of the following are necessary for DNA replication *in vitro*?
A) RNA, helicase, primers, DNA polymerase
B) Okazaki fragments, helicase, DNA polymerase
C) Template DNA, DNA polymerase, four dNTPs, primers, magnesium ions
D) Template DNA, four dNTPs, magnesium ions
E) DNA can't replicate *in vitro*

Answer: C
Skill: Factual recall

13) In Meselson and Stahl's experiment, what kind of DNA molecules would be found after four replication cycles?
A) Only heavy DNA (^{15}N–^{15}N)
B) Only intermediate DNA (^{15}N–^{14}N)
C) Only light DNA (^{14}N–^{14}N)
D) Both heavy (^{15}N–^{15}N) and light DNA (^{14}N–^{14}N)
E) Both heavy (^{15}N-^{15}N) and intermediate DNA (^{15}N–^{14}N)

Answer: D
Skill: Conceptual understanding

14) The two most basic steps of DNA replication are
A) primase causes primer to bind the template and ligase copies the template.
B) helicase unwinds the template and DNA polymerase binds the template.
C) leading strand is copied first and lagging strand is copied second.
D) the new strand is denatured and a template is synthesized.
E) the template is denatured and a new strand is synthesized.

Answer: E
Skill: Conceptual understanding

15) Where does the initiator protein bind DNA at the start of replication?
A) At a replication fork
B) At an origin of replication
C) At any AT–rich region
D) At a promoter region
E) At a start codon

Answer: B
Skill: Factual recall

16) As helicase unwinds the DNA molecule, what keeps the strands apart?
A) DNA polymerase
B) Reverse transcriptase
C) Replication fork
D) Single–strand binding proteins
E) Okazaki fragments

Answer: D
Skill: Factual recall

17) After removal of the RNA primers and replacement with DNA nucleotides, the single–stranded nick adjacent to Okazaki fragments is filled in through a reaction that involves which enzyme?
A) DNA primase
B) SSB protein
C) RNA polymerase
D) DNA ligase
E) DNA helicase

Answer: D
Skill: Factual recall

18) Which enzyme elongates the new DNA strand starting at an RNA primer?
A) DNA polymerase I
B) DNA polymerase III
C) RNA primase
D) DNA ligase
E) RNA polymerase

Answer: B
Skill: Factual recall

19) After a region of DNA has been replicated, _____ removes the RNA primers.
A) DNA polymerase I
B) DNA polymerase III
C) DNA helicase
D) RNA primase
E) DNA ligase

Answer: A
Skill: Factual recall

20) Which enzyme replaces RNA primers with DNA after elongation?
A) DNA polymerase I
B) DNA polymerase III
C) RNA polymerase
D) RNA primase
E) DNA ligase

Answer: A
Skill: Factual recall

21) Which kind of enzyme prevents DNA from tangling up by introducing negative supercoils as the replication fork migrates during replication?
A) Helicase
B) Ligase
C) DNA polymerase I
D) DNA polymerase III
E) Topoisomerase

Answer: E
Skill: Factual recall

22) The base–pairing error rate remains low during replication because
A) DNA repair mechanisms can fix the mispaired bases.
B) bases that are mispaired can excise themselves.
C) UV light radiation corrects any base mispairs.
D) mispaired bases cause a cell to die before replication is complete.
E) None of these; base–pairing errors are not possible

Answer: A
Skill: Factual recall

23) The enzymatic activity of a telomerase is best described as a
A) polymerase.
B) ligase.
C) topoisomerase.
D) reverse transcriptase.
E) exonuclease.

Answer: D
Skill: Factual recall

24) Rolling circle replication of DNA is characterized by the absence of
A) the DNA polymerase.
B) a nick in the DNA template.
C) the RNA primers.
D) the replication bubble.
E) the Okazaki fragments.

Answer: D
Skill: Conceptual understanding

25) Which enzyme activity is associated with the proofreading mechanism of DNA polymerase I?
A) 5'–to–3' exonuclease activity
B) 3'–to–5' exonuclease activity
C) 5'–to–3' polymerase activity
D) Both A and B
E) All of these

Answer: B
Skill: Factual recall

TRUE–FALSE QUESTIONS

26) A new nucleotide is added to a growing strand of DNA at the 3' end.

Answer: TRUE
Skill: Factual recall

27) Only the leading strand of a DNA molecule serves as a template during replication.

Answer: FALSE
Explanation: Both the leading and lagging strands serve as templates.
Skill: Factual recall

28) At the growing end of a DNA chain, DNA polymerase catalyzes the formation of a disulfide bond between the 3'–OH group of the deoxyribose on the last nucleotide and the 5'–phosphate of the dNTP precursor.

Answer: FALSE
Explanation: DNA polymerase catalyzes the formation of a phosphodiester bond between nucleotides.
Skill: Factual recall

29) DNA primase is an RNA polymerase.

Answer: TRUE
Explanation: DNA primase catalyzes the reaction to synthesize a short RNA primer molecule.
Skill: Factual recall

30) Okazaki fragments are made from the lagging strand of the DNA double helix.

Answer: TRUE
Skill: Factual recall

31) DNA polymerase III is very inaccurate at matching bases during replication, with errors in one out of every 100 base pairs.

Answer: FALSE
Explanation: DNA polymerase III is very accurate, causing errors in only one out of every 1,000,000 base pairs.
Skill: Factual recall

32) In eukaryotic cells, histone proteins are actively synthesized during the S phase of the cell cycle.

Answer: TRUE
Skill: Factual recall

33) In eukaryotes, DNA replication begins at a single origin of replication on each chromosome.

Answer: FALSE
Explanation: Replication begins at multiple origins of replication on each chromosome.
Skill: Factual recall

34) Topoisomerase and SSB proteins are important components of the replication process in prokaryotes, but they are not found in eukaryotes.

Answer: FALSE
Explanation: These proteins also play key roles in eukaryotic DNA replication.
Skill: Factual recall

35) Mg^{2+} ions are required for optimal DNA polymerase activity.

Answer: TRUE
Explanation: DNA polymerases often require magnesium ions as cofactors.
Skill: Factual recall

SHORT ANSWER QUESTIONS AND PROBLEMS

36) What are the key replication enzymes at the replisome, and how is DNA replication on both leading and lagging strands made efficient through the conformation of the DNA at the replisome in prokaryotes?

Answer: The key replication enzymes at the replisome are helicase, primase, and DNA polymerase III. To make replication more efficient, the lagging–strand DNA is folded so that its DNA polymerase III is complexed with the DNA polymerase III on the leading strand (forming the DNA Pol III holoenzyme). The folding of the lagging–strand template also makes production of sequential Okazaki fragments more efficient by bringing the 3' end of each completed Okazaki fragments near the site where the next Okazaki fragment will start.

Skill: Conceptual understanding

37) Why is DNA replication referred to as semiconservative?

Answer: The progeny double helices consist of one parental DNA strand and one newly synthesized strand.

Skill: Conceptual understanding

38) Why is an AT–rich sequence characteristic of DNA replicators in all organisms?

Answer: AT–rich regions of DNA are relatively easy to denature to single strands. AT base pairs are held together by only two hydrogen bonds, while GC pairs are held together by three.

Skill: Conceptual understanding

39) What are the differences in replication between leading and lagging strands in terms of continuity and directionality in relation to the replication fork?

Answer: The leading strand is copied continuously from the 3' end toward the replication fork, while the lagging strand is copied in fragments away from the replication fork.

Skill: Factual recall

40) What experiment demonstrated that the 5'–to–3' exonuclease activity of DNA polymerase I was essential for cell viability?

Answer: In *E. coli*, the DNA Pol I *polAex1* mutant strain survives at 37°C but dies at 42°C. This was shown to be because the mutant DNA Pol I enzyme had normal activity at 37°C but a defective 5'–to–3' activity at 42°C. This demonstrated that the 5'–to–3' exonuclease activity of DNA Pol I was essential for cell survival.

Skill: Factual recall

41) A cross is made between yeast cells with different alleles for a set of linked genes: $pr^+q \times p^+rq^+$. The resulting tetrads show a 3:1 ratio for r^+ to r instead of the expected 2:2 ratio. Can you explain how this could have occurred?

Answer: Gene conversion by a mismatch repair mechanism could have caused this deviation from expected ratios. During pairing of homologous chromosomes in meiosis, recombination between the two inner chromatids occurred, resulting in heteroduplex (mismatched) DNA strands. Both mismatches were repaired by excision and DNA synthesis to match the parent DNA with the r^+ allele.

Skill: Analytical reasoning

42) Describe the method devised by Arthur Kornberg which first successfully achieved DNA synthesis *in vitro*, including its components and their uses.

Answer: Kornberg mixed together DNA fragments, all four dNTPs (DNA precursors), and an *E. coli* lysate to achieve DNA synthesis *in vitro*. The DNA fragments acted as a template for the synthesis of new DNA. The dNTPs were precursors of the new DNA strand, and the cell lysate contained the enzyme necessary to catalyze DNA synthesis (DNA Pol I).

Skill: Factual recall

43) The diploid set of chromosomes in *Drosophila* embryos replicates six times faster than the single *E. coli* chromosome, even though there is about 100 times more DNA in *Drosophila* than in *E. coli* and the rate of movement of the replication fork in *Drosophila* is much slower. How is this so?

Answer: Eukaryotic chromosomes duplicate rapidly because DNA replication initiates at many origins of replication throughout the genome. In *E. coli*, there is only one replicon, while in eukaryotes there are multiple, smaller replicons.

Skill: Application of knowledge

44) What are some key differences in replication between *E. coli* DNA and λ phage DNA?

Answer: Both start replication as a circular molecule, and in *E. coli*, the parental DNA strands remain in a circular form throughout the replication cycle. A replication bubble opens to form two replication forks, and replication proceeds bidirectionally. Lambda phage DNA is replicated by a rolling circle mechanism, in which a nick is made in one of the two strands of the circle, and the 5' end of the cut DNA strand is rolled out as a free "tongue"of increasing length as replication proceeds. The parental DNA circle is replicated continuously, while the linear displaced strand is replicated discontinuously. As long as the circle continues to roll, concatamers of phage DNA can be produced. This is later cut up into linear chromosomes and packaged into new phage heads.

Skill: Factual recall

45) How do the DNA polymerase repair mechanisms work?

Answer: Both DNA Pol I and DNA Pol III have 3'–to–5' exonuclease activity and can remove nucleotides from the end of a DNA chain as part of an error correction mechanism. If an incorrect base is inserted by DNA polymerase, and the error is recognized immediately, the exonuclease activity excises the erroneous nucleotide from the new strand. After excision, the DNA polymerase resumes motion in the forward direction and inserts the correct nucleotide.

Skill: Factual recall

46) How did Meselson and Stahl rule out the conservative model of DNA replication using equilibrium density gradient centrifugation?

Answer: First, they grew *E. coli* cells in a medium containing only high–density nitrogen (^{15}N). Then they allowed the cells to undergo successive rounds of replication in the presence of normal density nitrogen (^{14}N). They used equilibrium density gradient centrifugation after each round of replication to separate the DNA produced by density. If the conservative model was correct, they would have found no intermediate–density DNA after a round of replication. However, after one round of replication, they found that the entire amount of DNA had a density exactly intermediate between ^{14}N and ^{15}N. Subsequent rounds of the experiment showed that semiconservative replication was the correct model.

Skill: Conceptual understanding

47) How were the sequences that compose the replication origins in yeast discovered?

Answer: Yeast cells were grown in heavy isotope media to produce denser DNA and then shifted to media with normal, light isotopes. After a few minutes, DNA from these cells was extracted and cut into small pieces. The lighter DNA fragments (which should contain the origins of replication) were collected, fluorescently labeled, and used to hybridize a microarray of yeast sequences. Determination of the sequences to which this light, fluorescently labeled DNA hybridized led to the identification of a number of yeast replication origins.

Skill: Factual recall

48) How will DNA replication be affected if DNA polymerase I has a mutation that inactivates 5'–to–3' exonuclease activity?

Answer: The 5'–to–3' exonuclease activity of DNA polymerase I removes the RNA primers from the ends of Okazaki fragments. If this activity is missing, the primers may not be removed from the growing DNA strands.

Skill: Conceptual understanding

49) When the RNA primers are removed from the 5' ends of eukaryotic chromosomes after replication, DNA polymerase is unable to fill in the gaps. What prevents the chromosomes from getting shorter and shorter with each round of replication?

Answer: The enzyme telomerase maintains chromosome lengths by adding telomere repeats to the chromosome ends. Telomerase contains an RNA component that is complementary to the telomere repeat unit of the chromosome. After binding to the overhanging repeat, the telomerase RNA is used as a template to synthesize new chromosomal telomere repeats.

Skill: Factual recall

50) Why do tumor cells in mammals have telomerase activity?

Answer: Tumor cells are "immortal" cells, and the enzyme telomerase is required for long–term cell viability. It has been demonstrated that mutations in genes such as *TLC1* and EST1 decrease cell longevity by continuous shortening of telomere length.

Skill: Conceptual understanding