

The information provided below may be useful in answering some questions.

The "Wobble" Rules of Codon-Anticodon Pairing	
5' Nucleotide of Anticodon	3' Nucleotide of Codon
C	G
A	U
U	A or G
G	C or U
I	U, C, or A
3' Nucleotide of Codon	5' Nucleotide of Anticodon
G	C, U
A	I, U
C	I, G
U	I, G, A

First position (5' end)	Second position				Third position (3' end)
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

INFORMATION ON COMPONENTS OF RIBOSOMES

I. Prokaryotes (e.g. *E. coli*)

RIBOSOME (70S)

Large Subunit (50S) --- 5S and 23S rRNAs + many proteins

Small Subunit (30S) --- 16S rRNA + many proteins

II. Eukaryotes (e.g. human)

RIBOSOME (80S)

Large Subunit (60S) --- 5S, 5.8S, and 28S rRNAs + many proteins

Small Subunit (40S) --- 18S rRNA + many proteins

The next seven questions pertain to the human gene called BRCA1, which influences susceptibility to breast and ovarian cancer.

1) Which of the following enzymes is most directly responsible for the endogenous synthesis of the primary RNA transcript from the BRCA1 gene?

- A) DNA polymerase α
- B) DNA N-glycosylase
- C) RNA polymerase II
- D) RNA polymerase III
- E) Poly A polymerase

2) The BRCA1 gene is very large, spanning roughly 100,000 base pairs of DNA. However, the mRNA from this gene is only 7,800 bases long. This difference is best explained by:

- A) the gene encodes a polycistronic mRNA
- B) the size of the mRNA is reduced by site-specific recombination
- C) unneeded regions of the RNA at the 5'- and 3'-ends are removed by endonucleases
- D) the primary transcript is spliced to remove many large introns
- E) only a small region of the gene is transcribed.

3) The BRCA1 gene is expressed in breast and ovarian cells; this expression is regulated by steroid hormones such as estrogen and progesterone. When activated (bound with estrogen), the estrogen receptor binds to which of the following sequences of the BRCA1 gene?

- A) consensus sequences at -35 and -10, relative to the transcription initiation site
- B) operator sequences near the promoter
- C) sequences at the 5'-ends of introns
- D) ribosome recognition site of the mRNA
- E) enhancer sequences located at some distance from the promoter

4) The DNA sequence of the BRCA1 gene that is recognized by the estrogen-estrogen receptor complex is most likely to be:

- A) an estrogen responsive element
- B) an iron responsive element
- C) a histone acetyl transferase
- D) a CAP (catabolite gene activator protein)-binding site
- E) an operator

5) Which of the following will be used during the translation of the BRCA1 gene product (protein) in human breast cells?

- A) polycistronic mRNA
- B) N-formylmethionine tRNA
- C) a tRNA with a 5'-UUA anticodon
- D) 16S ribosomal RNA
- E) 5'-cap nucleotide on the mRNA

6) A portion of the sequence of the normal BRCA1 gene is given below. In one of the families studied, a transition mutation had occurred within the BRCA1 gene at the position shown by the asterisk. What was the information effect of this mutation?

*

DNA sequence	5'...AACACCCAGGAGCC...	non-template strand
	3'...TTGTGGGTCCCTCGG...	template strand
Protein sequence	...Asn-Thr-????????????...	

- A) frameshift mutation
 - B) missense mutation
 - C) nonsense mutation
 - D) silent mutation
 - E) not enough information to tell
- 7) The normal BRCA1 gene product is involved in which of the following pathways?
- A) Transcription
 - B) Translation
 - C) Recombination repair
 - D) Nucleotide excision repair
 - E) Base excision repair
- 8) Specific transcription factors (e.g. steroid hormone receptors) stimulate the transcription of certain genes over and above the general (basal) transcription factors (e.g. TFII-A, B, ...D, etc.). Which of the following activities have been observed in the transcriptional regulatory domain of these specific transcription factors?
- A) recruitment of TFII-D to the TATA box
 - B) recruitment of co-activators that induce sliding of nucleosomes;
 - C) recruitment of enzymes that covalently modify histone proteins;
 - D) all of the above
 - E) none of the above
- 9) A mutation in a regulatory region of DNA can result in
- A) a missense mutation that produces a non-functional protein
 - B) increased or decreased expression of a gene
 - C) the production of an enzyme with decreased activity
 - D) an insertion event that produces a non-functional protein
 - E) an RNA splicing mutation
- 10) If *E. coli* bacteria are grown in the **absence** of both glucose and lactose, which of the following events will occur?
- A) The *lac* repressor will bind to the operator sequence
 - B) The CAP (catabolite gene activator protein) will activate transcription
 - C) RNA polymerase holoenzyme will bind to the *lac* promoter
 - D) The *lac* operon will be transcriptionally active
 - E) The CAP (catabolite gene activator protein) will synthesize cAMP

- 11) A primary spermatocyte is a cell that gives rise to two daughter cells called secondary spermatocytes at the end of meiosis I of spermatogenesis. The human primary spermatocyte has
- A) 92 chromosomes and 92 chromatids
 - B) 46 chromosomes and 92 chromatids
 - C) 23 chromosomes and 46 chromatids
 - D) 46 chromosomes and 46 chromatids
 - E) 23 chromosomes and 23 chromatids
- 12) The following terms refer to human nuclear material. Arrange them in order of increasing size and structural complexity:
- A) nucleoside, nucleotide, chromatin, nucleosome, genome, chromosome
 - B) nucleotide, nucleoside, chromatin, nucleosome, chromosome, genome
 - C) nucleoside, nucleosome, nucleotide, chromosome, chromatin, genome
 - D) nucleoside, nucleotide, nucleosome, chromatin, chromosome, genome
 - E) chromosome, genome, chromatin, nucleosome, nucleotide, nucleoside
- 13) For the process of incorporating deoxynucleotides in DNA replication, DNA polymerases require
- A) a short DNA primer to begin the synthesis of each new strand
 - B) a free 5'-phosphate group available for attachment of the incoming nucleotide
 - C) a free 3'-phosphate group available for attachment of the incoming nucleotide
 - D) a free 5'-OH group available for attachment of the incoming nucleotide
 - E) a free 3'-OH group available for attachment of the incoming nucleotide
- 14) Which of the following statements regarding the structure of DNA is **correct**:
- A) The bases A and T are paired by two hydrogen bonds with the phospho-deoxyribose backbone in a parallel orientation.
 - B) The bases G and C are paired by two hydrogen bonds with the phospho-deoxyribose backbone in an antiparallel orientation.
 - C) The bases G and C are paired by three hydrogen bonds with the phospho-deoxyribose backbone in an antiparallel orientation.
 - D) The bases G and C are paired by three hydrogen bonds with the phospho-deoxyribose backbone in a parallel orientation.
 - E) The bases A and T are paired by three hydrogen bonds with the phospho-deoxyribose backbone in an antiparallel orientation.
- 15) Which of the following mutagens is most likely to lead to frameshift mutations?
- A) Oxidative damage
 - B) Intercalating dyes
 - C) Ionizing radiation
 - D) Alkylating chemicals
 - E) Ultraviolet irradiation

16) Which of the following statements regarding spacer DNA is **correct**:

- A) Spacer DNA includes repetitive DNA, which accounts for less than 25% of the genome.
- B) Spacer DNA includes protein-coding regions.
- C) SINES and LINES are distinguished by the size of the repeat units.
- D) Minisatellite DNA is a type of dispersed repetitive DNA.
- E) (alpha) α -satellite DNA is located near telomeres.

17) Which of the following statements regarding prokaryotic DNA replication is **correct**?

- A) Telomerases replicate the ends of chromosomes.
- B) DNA polymerase I is the major elongation enzyme.
- C) The linked circles at the end of replication are separated by DNA ligase.
- D) DNA polymerase III removes the RNA primers.
- E) Primase synthesizes the RNA primers.

18) Which of the following statements regarding telomerase is **incorrect**?

- A) Telomerase has a portable RNA template.
- B) Telomerase has reverse transcriptase activity.
- C) Telomerase extends the 3'-end of the newly synthesized strands with many copies of a repeat sequence.
- D) Telomerase activity decreases as a cell ages.
- E) Telomerase is required for DNA replication of the ends of linear chromosomes.

19) Which of the following statements regarding stages of meiosis **correctly** describes events that occur in that stage?

- A) Metaphase I: chromosomes line up "single file" along the metaphase plate.
- B) Dictyotene stage of prophase I: primary oocytes are arrested until ovulation
- C) Interphase II: DNA replication occurs
- D) Telophase I: daughter cells are formed and contain 23 chromosomes, 23 chromatids
- E) Anaphase II: the homologs are pulled to opposite sides of the cell

20) Mendel's law of independent assortment states:

- A) the 2 alleles of a single gene are separated to different gamete cells.
- B) all 23 paternal homologs segregate to one gamete cell, while the 23 maternal homologs segregate to another gamete cell.
- C) recombination events will affect when the 2 alleles of a gene will segregate during meiosis
- D) recombination events must occur between sister chromatids of homologous chromosomes
- E) the separation of one pair of homologs into the daughter gamete cells does not affect the separation of other homologous pairs.

21) A 5 month old baby boy presents with megaloblastic anemia, failure to thrive and developmental delay due to hereditary orotic aciduria. Genetic analysis determined both of his alleles for orotate phosphoribosyltransferase (OPRT) had the same mutation. What is the most likely class of this mutant allele and its expected inheritance pattern?

- A) Loss of function mutation, recessive inheritance
- B) Loss of function mutation, dominant inheritance
- C) Gain of function mutation, recessive inheritance
- D) Gain of function mutation, dominant inheritance

22) A second baby, a 7 month old girl, is also diagnosed with hereditary orotic aciduria. Genetic analysis determined both of her alleles for orotidine 5'-phosphate decarboxylase, another enzyme involved in pyrimidine synthesis, had the same mutation. In comparing the cause of hereditary orotic aciduria in this patient with the patient in Question 21, this would be considered an example of:

- A) homologous recombination
- B) syntenic genes
- C) phenocopies
- D) locus heterogeneity
- E) allelic heterogeneity

23) Which of the following is NOT required for transcription in *E. coli*?

- A) Sigma factor
- B) RNA polymerase
- C) TFII-D
- D) DNA template
- E) ATP

24) Eukaryotic mRNAs

- A) are polycistronic
- B) constitute 10-12% of total RNA
- C) contain dihydrouracil
- D) contain 7-methyl-guanine
- E) are generally uniform in size

25) A newly made hnRNA will read:

- A) Complementary to the sense strand
- B) the same as the template strand (with U instead of T)
- C) Complementary to the anti-sense strand
- D) Complementary to the coding strand
- E) the same as the coding strand (with a polyA tail)

26) Functions of the sigma factor include:

- A) recognition of upstream promoter elements
- B) recruitment of the core polymerase subunits
- C) unwinding of the DNA
- D) A and B only
- E) All of the above

27) Which of the following would be transcribed by RNA polymerase II?

- A) β -globin gene
- B) 45S rRNA precursor gene
- C) U6 snRNA gene
- D) tRNA gene
- E) 5S rRNA gene

28) Termination of transcription by eukaryotic RNA polymerase II:

- A) is triggered by a stop codon
- B) is catalyzed by poly A polymerase
- C) takes place precisely at the polyadenylation signal
- D) is triggered by a stem-loop structure in the RNA
- E) depends on the eventual dissociation of the polymerase from the template

29) The trimming of the 5' and 3' ends of tRNA precursors to aid in formation of functional units:

- A) is an example of self splicing
- B) involves catalytic RNA
- C) involves endonuclease and ligase activities
- D) is an example of post-translational processing
- E) utilizes the DICER enzyme complex

30) A tRNA with the anticodon 5'-ICG-3' could recognize which of the following codons?

- A) 5'-GCA-3'
- B) 3'-CGA-5'
- C) 3'-CGC-5'
- D) 5'-GGC-3'
- E) 5'-CGG-3'

31) The 5' cap of eukaryotic mRNA functions to:

- A) increase the mRNA stability
- B) indicate the translation start site
- C) allow ribosome recognition
- D) signal for subcellular localization
- E) signal the beginning of an ORF

32) Which step of translation does not require direct hydrolysis of a high energy molecule (ATP, GTP)?

- A) Locking 60S ribosomal subunit in place
- B) Delivery of charged tRNA
- C) Formation of peptide bond
- D) Translocation
- E) Ribosome dissociation

33) Which type of higher order structure (analogous to the levels of structure in proteins), if any, is **absent** in tRNA?

- A) primary
- B) secondary
- C) tertiary
- D) quaternary
- E) all of the above levels of structure are present in tRNA

34) A patient presents with symptoms of scurvy (loss of collagen). What post-translational modification is lacking and what vitamin supplements would you give the patient?

- A) phosphorylation, vitamin B1
- B) palmitoylation, vitamin B5
- C) hydroxylation, vitamin C
- D) ADP-ribosylation, vitamin B3
- E) acetylation, vitamin B6

END OF EXAMINATION

Tear off this sheet and save to check your answers.

Please remember to:

- Write the letter corresponding to your **FORM** in the appropriate place on the **answer sheet**.
- SIGN AND RETURN YOUR EXAMINATION** to an instructor **before leaving the exam room**.

FORM: A

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|-----------|-----------|-----------|-----------|
| 1. _____ | 11. _____ | 21. _____ | 31. _____ |
| 2. _____ | 12. _____ | 22. _____ | 32. _____ |
| 3. _____ | 13. _____ | 23. _____ | 33. _____ |
| 4. _____ | 14. _____ | 24. _____ | 34. _____ |
| 5. _____ | 15. _____ | 25. _____ | |
| 6. _____ | 16. _____ | 26. _____ | |
| 7. _____ | 17. _____ | 27. _____ | |
| 8. _____ | 18. _____ | 28. _____ | |
| 9. _____ | 19. _____ | 29. _____ | |
| 10. _____ | 20. _____ | 30. _____ | |