

I. Multiple choice: pick only one option among the predetermined options (3 points each)

1) In many species, there are two representatives of each chromosome. In such species, the characteristic number of chromosomes is called the _____ number. It is usually symbolized as _____.

- A) haploid; n
- B) haploid; 2n
- C) diploid; 2n
- D) diploid; n
- E) monoploid; n

2) Early in the twentieth century, Walter Sutton and Theodor Boveri noted that the behavior of chromosomes during meiosis is identical to the behavior of genes during gamete formation. They proposed that genes are carried on chromosomes, which led to the basis of the _____.

- A) Chromosome Theory of Inheritance
- B) Law of Segregation
- C) Law of Independent Assortment
- D) First Law of Thermodynamics
- E) Chromosomal Maintenance Theory

3) Genome editing is based on _____.

- A) acetylating specific DNA sequences with specific nucleases
- B) methylating specific DNA sequences with specific proteins
- C) targeting and manipulating specific DNA sequences with specific nucleases
- D) transcribing specific DNA sequences with specific proteins
- E) none of above

4) A restriction enzyme that uses a six (6) base recognition sequence will cut DNA, on average, every _____ bases, if all four nucleotides are present in equal proportions.

- A) 256
- B) 4096
- C) 1296
- D) 500
- E) 5000

5) A probe with the sequence 5'-A-T-G-C-C-A-G-T-3' will serve as a probe for which sequence?

- A) 3'-T-G-S-C-C-G-T-A-5'
- B) 3'-A-T-G-C-C-A-G-T-5'
- C) 3'-T-A-C-G-G-T-C-A-5'
- D) 3'-A-C-T-G-G-C-A-T-3'
- E) There is insufficient information to answer this question.

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6) Translation in bacterial and eukaryotic cells has many similarities, but there are also several key differences. Which of the following is one of those differences that is seen in eukaryotes?

- A) Translation and transcription are coupled.
- B) Eukaryotic ribosomes are smaller with fewer proteins and RNA molecules.
- C) Eukaryotes use the 5' G-cap and Poly-A-tail on their mRNAs to initiate translation.
- D) Eukaryotic mRNA contains a Shine—Dalgarno sequence that increases the efficiency of translation.
- E) Eukaryotes only require one release factor that recognizes all three stop codons.

7) A researcher is studying the synthesis of a specific amino acid found in *Neurospora*. She knows that the pathway begins with a precursor that is converted into the amino acid with two known intermediates (Substance Blue and Substance Green). She accurately predicts that this amino acid synthesis pathway is catalyzed by three enzymes, (I, II, and III). She subsequently identifies three mutants that she calls Mutant I, Mutant II, and Mutant III. With the information about the mutants below place the enzymes in the order that the enzymes act in this pathway. (Note: the numbers I, II, and III don't necessarily indicate the order in which the enzymes appear.)

Mutant I (only Enzyme I is mutated) is unable to synthesize the amino acid even if she provided the mutant with both Substance Blue and Substance Green.

Mutant II (only Enzyme II is mutated) is able to synthesize the amino acid if she provided the mutant with Substance Blue or Substance Green.

Mutant III (only Enzyme III is mutated) is able to make the amino acid if she provided the mutant with Substance Green, but not if she provided the mutant with only Substance Blue.

- A) I, II, III
- B) II, III, I
- C) III, II, I
- D) II, I, III
- E) III, I, II

8) In a population of 100 individuals, 49% are of the *NN* blood type. What percentage is expected to be *MN* assuming Hardy-Weinberg equilibrium conditions?

- A) 9%
- B) 21%
- C) 42%
- D) 51%
- E) There is insufficient information to answer this question.

9) A researcher is studying plant development. She isolates a mutant and discovers that the piece of DNA that is mutated does not code for a protein. However, this piece of DNA is complimentary to a gene known to function in early embryonic plant development. The mutant she identified most likely functions as a(n) _____.

- A) ribosomal RNA (rRNA)
- B) transfer RNA (tRNA)
- C) intron
- D) general transcription factor known to regulate many different genes
- E) microRNA (miRNA)

10) Trisomy 21, or Down syndrome, occurs when there is a normal diploid chromosomal complement but one (extra) chromosome 21. Although fertility is reduced in both sexes, females have higher fertility rates than males. Van Dyke et al. (1995) summarize data involving children born of Down syndrome individuals. Assume that children are born to a female with Down syndrome and a normal 46-chromosome male. What proportion of the offspring would be expected to have Down syndrome?

- A) One-third of the offspring would be expected to have Down syndrome.
- B) Two-thirds of the offspring would be expected to have Down syndrome.
- C) All the children would be expected to have Down syndrome.
- D) None of the offspring would be expected to have Down syndrome.
- E) One-half of the offspring would be expected to have Down syndrome.

II. Terminology (3 points each)

- 1) Allele
- 2) Dominance
- 3) Epistasis
- 4) Genetic Code
- 5) Genetic drift
- 6) Genome
- 7) Heterozygous
- 8) Maternal effect
- 9) Quantitative trait
- 10) Variation

III. Essay questions

- 1) The FBI uses only 20 short tandem repeats (STRs) as their core set of STRs for forensic analysis.
 - (a) Write a short sequence to demonstrate an STR example. (3 points)
 - (b) Please explain why STR was chosen for forensic analysis. (3 points)
 - (c) Justify why only 20 STRs are sufficient, or if you would suggest a better strategy (4 points).
- 2) A patient suffering from an unknown cancer is treated with standard chemotherapy. Describe how personalized medicine could help treat this individual. (5 points)
- 3) Describe the difference between genetically modified (GM) crops and crops that have been selectively bred for centuries. (10 points)
- 4) Huntington's disease (HD) was the first example of complete dominance in human inheritance.
 - (a) Show a pedigree to demonstrate this phenomenon (5 points).
 - (b) Describe the impact this has on inheriting the disease state (2 points)
 - (c) Explain why nature selection has little effect on the HD allele in human populations (3 points).
- 5) Describe the similarities between sequencing a protein and sequencing a genome. (5points)

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