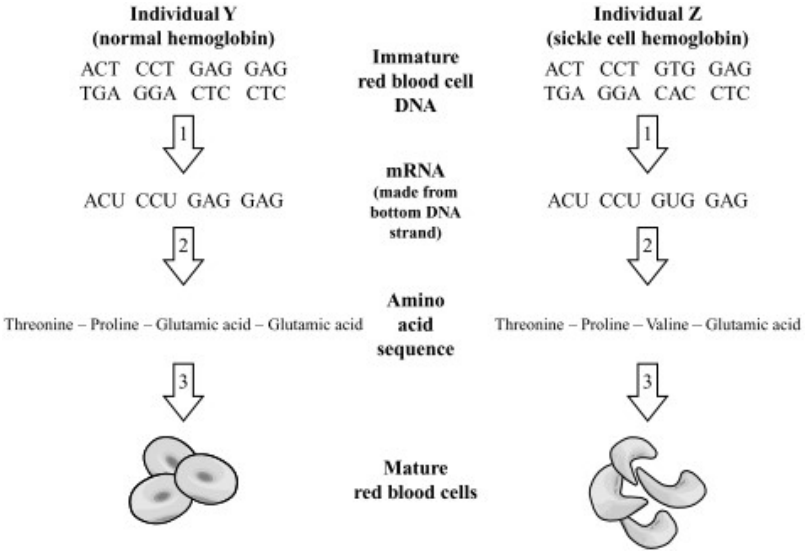
NAME: _____ DATE: _____ SECTION: _____

MCAS PREP PACKET – GENETICS

Sickle cell anemia is an autosomal recessive genetic disorder that affects thousands of people in the United States and millions worldwide. Sickle cell anemia commonly occurs in groups whose ancestors came from Africa, as well as South America, Cuba, Central America, Saudi Arabia, India, and the Mediterranean. Sickle cell anemia is caused by a change in the hemoglobin protein in red blood cells. Sickle cell anemia results in paleness, fatigue, shortness of breath, and increased heart rate due to a deficiency in the oxygen-carrying component of the blood. When oxygen levels are low in an affected individual, the red blood cells become deformed into a curved, sickle shape. People with sickle cell anemia can experience swelling, pain, infection, and organ damage. All individuals have two alleles for the gene that codes for the hemoglobin protein (Hb). Individuals with two Hb A alleles have normal, round red blood cells. Heterozygous individuals, with one Hb A allele and one Hb S allele, do not experience symptoms of the disease, but they may produce some sickle-shaped red blood cells. Individuals with two Hb S alleles have sickle cell anemia. The diagrams to the right represent some of the steps in the formation of hemoglobin in two individuals, Y and Z. In these diagrams, only a small part of the hemoglobin gene sequence is represented. Individual Y has two Hb A alleles and therefore produces normal red blood cells. Individual Z has two Hb S alleles and therefore produces sickle-shaped red blood cells.



1. Which of the following statements best describes why the change in only one DNA base of the hemoglobin gene results in a different protein product of the gene?
   A. The change prevents mRNA from being made.
   B. The change alters the amino acid sequence of the protein.
   C. The change causes the blood cells to divide in an uncontrolled way.
   D. The change creates a second strand of mRNA for each RNA molecule.

2. Which of the following statements **best** compares individual Y and individual Z in terms of genotype and phenotype?
   A. The individuals have the same genotype and the same phenotype.
   B. The individuals have the same genotype but different phenotypes.
   C. The individuals have different genotypes but the same phenotype.
   D. The individuals have different genotypes and different phenotypes.

3. Which of the following statements **best** summarizes a change that is represented by the arrows labeled “3” in the diagrams?
   A. A nucleus is formed in each cell.
   B. Each cell divides to form two daughter cells.
   C. A chain of amino acids is folded to form a protein in each cell.
   D. Proteins are transported through the plasma membrane of each cell.

4. A pedigree is a diagram that traces the inheritance of a trait through a family. Which of the following patterns is typical in a pedigree for an autosomal dominant trait?
   A. The trait affects only males.
   B. The trait appears in every generation.
   C. The trait appears in only one-fourth of the individuals.
   D. The trait affects all the individuals of the second generation.

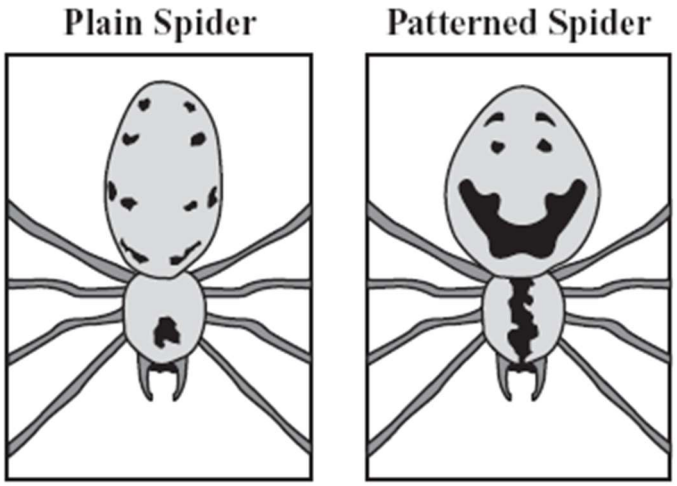
5. An inherited metabolic disorder called phenylketonuria (PKU) can result in serious problems in infancy. The chance that two parents who are heterozygous will have a child with PKU is 25 %.Which of the following terms **best** applies to the inheritance pattern for PKU?
   A. codominant
   B. dominant
   C. recessive
   D. sex-linked

6. In a eukaryotic cell, which of the following processes directly involves DNA?
   A. translation
   B. cellular respiration
   C. active transport of ions
   D. replication of chromosomes

7. In a molecule of double-stranded DNA, the amount of adenine present is always equal to the amount of
   A. cytosine.
   B. guanine.
   C. thymine.
   D. uracil.

8. In fruit flies, the gene for eye color is located on the X chromosome, and the red eye allele **(R)** is dominant to the white eye allele **(r)**. A female fly with genotype $\mathbf{X^RX^r}$ is mated with a male fly with genotype $\mathbf{X^rY}$.Which of the following statements best describes the expected outcome of the cross?
   A. The chance of an offspring having red eyes is 75 %.
   B. The chance of an offspring having white eyes is 50 %.
   C. The chance that a male offspring will have white eyes is 0 %.
   D. The chance that a female offspring will have red eyes is 100 %.

9. Hawaiian happy face spiders from the island of Maui can have different markings, as shown below. A single gene determines the markings on the spiders.



A plain spider is crossed with a patterned spider. The patterned spider is homozygous. The pattern allele is dominant to the plain allele.

What percentage of the offspring from this cross are expected to be patterned instead of plain?

A. 0%
B. 25%
C. 50%
D. 100%

10. During DNA replication, the wrong nucleotide was inserted in the DNA sequence. Which of the following terms describes this situation?

A. mutation
B. regeneration
C. transcription
D. translation

11. A partial Punnett square is shown below.

AA	AA
Aa	Aa

Which of the following statements describes the parental genotypes that would result in this Punnett square?

A. Both parents are heterozygous.
B. Both parents are homozygous dominant.
C. One parent is homozygous recessive and the other parent is heterozygous.
D. One parent is homozygous dominant and the other parent is heterozygous.

12. According to Mendel's law of segregation, which of the following statements describes what happens to the alleles of a gene pair?

A. The alleles are moved to different chromosomes.

B. The alleles are mutated in the process of mitosis.

C. The alleles are separated during fertilization.

D. The alleles are separated during gamete formation.

13. Which of the following features of DNA is **most important** in determining the phenotype of an organism?

A. the direction of the helical twist

B. the number of deoxyribose sugars

C. the sequence of nitrogenous bases

D. the strength of the hydrogen bonds

14. A portion of one strand of a DNA molecule has the sequence shown below.

ACCTGAAGG

Assuming there are no mutations in this portion of the DNA, what is the corresponding sequence on the complementary DNA strand?

A. **ACCTGAAGG**

B. **GTTCAGGAA**

C. **TGGACTTCC**

D. **UGGACUUCC**

15. Fireflies produce light inside their bodies. The enzyme luciferase is involved in the reaction that produces the light. Scientists have isolated the luciferase gene.

A scientist inserts the luciferase gene into the DNA of cells from another organism. If these cells produce light, the scientist knows that which of the following occurred?

A. The luciferase gene mutated inside the cells.

B. The luciferase gene was transcribed and translated.

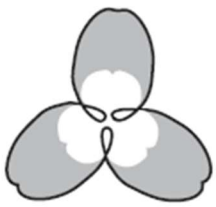
C. The luciferase gene destroyed the original genes of the cells.

D. The luciferase gene moved from the nucleus to the endoplasmic reticulum.

16. Leaves from two white clover plants, each with a different pattern, are shown below.

Plant 1
Chevron pattern

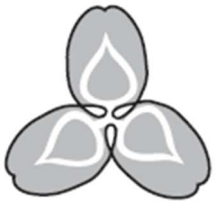
Plant 2
Oval pattern



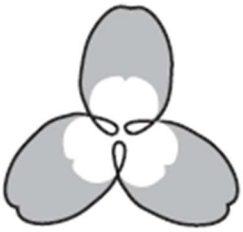
The leaf patterns are genetically determined by alleles of a single gene. Plant 1 is homozygous for the chevron allele. Plant 2 is homozygous for the oval allele. The chevron and oval alleles are codominant.

If plant 1 and plant 2 are crossed, the codominance of the alleles will **most likely** result in which of the following leaf patterns on the offspring plants?

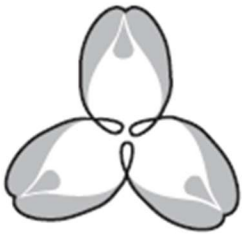
A.



B.



C.



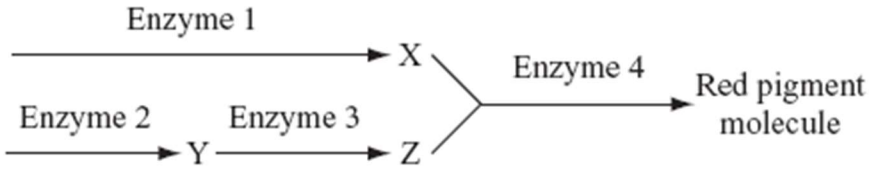
D.

17. In a certain variety of chicken, some offspring have a feather pattern that is black-and-white checkered. Chickens with this checkered feather pattern result from the cross of a black chicken with a white chicken.

Which of the following types of inheritance is **most likely** responsible for the checkered feather pattern?

A. codominant
B. dominant
C. polygenic
D. sex-linked

18. The diagram below shows the final steps of a biochemical pathway used by the bacterium *Serratia marcescens* to produce a red pigment molecule. Letters X, Y, and Z represent intermediate molecules produced in the pathway. Four enzymes are also involved in the pathway, as shown.



A mutant strain of *S. marcescens* produces molecules X and Y but does not produce the red pigment molecule or molecule Z.

Based on this result, it can be concluded that there must be a mutation in the gene coding for which enzyme?

A. enzyme 1
B. enzyme 2
C. enzyme 3
D. enzyme 4

19. Which of the following statements **best** describes a DNA molecule?

A. It is a double helix.
B. It contains the sugar ribose.
C. It is composed of amino acids.
D. It contains the nitrogenous base uracil.

20. In fruit flies, a single gene controls wing phenotype. The diagram below shows the phenotypes for long wings and vestigial wings in fruit flies.

Long wings

Vestigial wings

Two fruit flies that have long wings are crossed. Of the 95 offspring produced, 73 have long wings. The other 22 have vestigial wings.

Which of the following conclusions about the inheritance of long wings and vestigial wings is **best** supported by the results of this experiment?

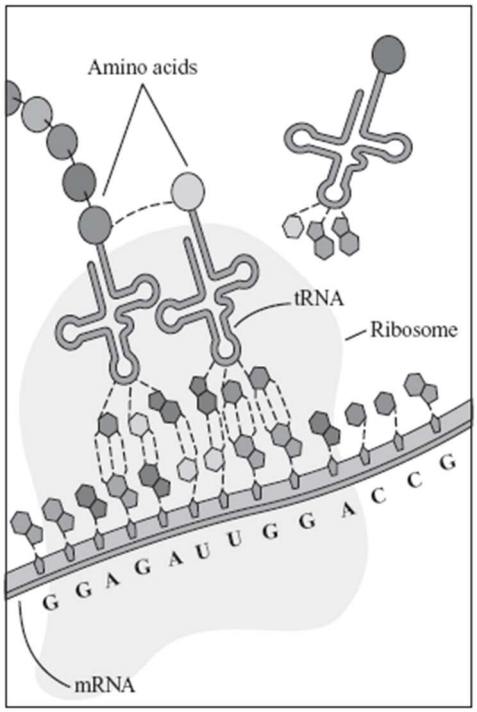
A. The alleles for long wings and vestigial wings are sex-linked.
B. The alleles for long wings and vestigial wings are codominant.
C. The allele for long wings is dominant and the allele for vestigial wings is recessive.
D. The allele for long wings is recessive and the allele for vestigial wings is dominant.

21. In sheep, the allele for white wool (**W**) is dominant, and the allele for black wool (**w**) is recessive. A farmer has mated two Suffolk sheep for a few years. These matings have resulted in six offspring, four with white wool and two with black wool. One parent has white wool and the other has black wool.

Which of the following could be the genotypes of the parent sheep?

A. **WW** and **Ww**
B. **WW** and **ww**
C. **Ww** and **Ww**
D. **Ww** and **ww**

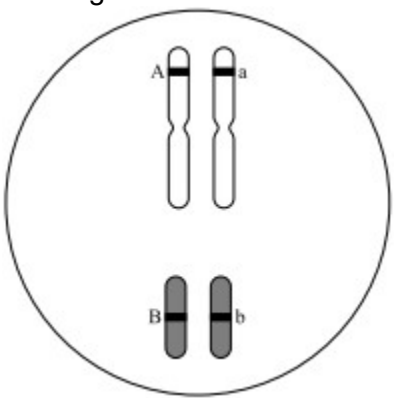
22. The diagram below represents part of a process that occurs in cells.



Which process is represented?

A. meiosis
B. osmosis
C. replication
D. translation

23. Gregor Mendel developed an understanding of heredity through his experiments with pea plants. The diagram below shows a cell with two pairs of homologous chromosomes and a genotype of **AaBb**.



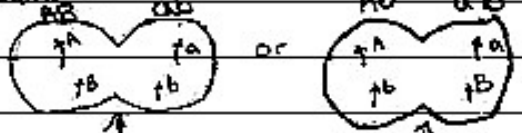
a. Identify all the possible allele combinations that could be formed if this cell undergoes meiosis.
b. Identify one of Mendel's laws that is illustrated when you write out these allele combinations. Explain this law.

SCORE POINT 4:

a. If the cell undergoes meiosis, the possible combinations of alleles in the gametes are AB, Ab, aB, and ab. These cells are haploid and only have half the number of chromosomes necessary.

b. Mendel's law of independent assortment explains why this occurs. This law states that if two genes are located on different chromosomes the alleles will split randomly with no relation between their assortment. This means that when cells are dividing their DNA into 2 half sets of chromosomes, the chromosomes containing the A allele will go into either cell and the chromosome will do the same, independent of the other chromosome.

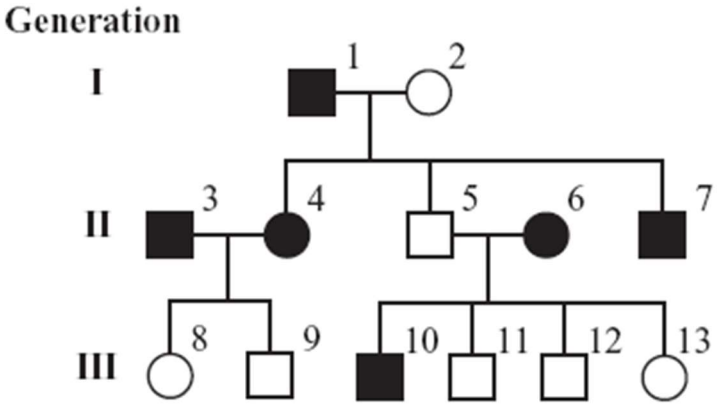
Meiosis



cell in final stages of meiosis

Chromosomes have divided themselves equally among the 2 haploids and the old cell is about to split into 2 new ones.

24. People who are tune deaf are unable to follow a rhythm. Scientists have evidence that tune deafness can be genetic. The pedigree below traces the inheritance of tune deafness in a family. Individuals in the pedigree are numbered.



Key		
	Tune deaf	Normal tune perception
Male	■	□
Female	●	○

Scientists have analyzed the inheritance patterns for tune deafness and have concluded that tune deafness is caused by an autosomal dominant allele, **T**.

a. Provide evidence from the pedigree that conclusively shows that the tune deafness allele is autosomal dominant, not autosomal recessive. Explain your reasoning.
b. Identify the genotypes of individuals 5 and 6, and then draw the Punnett square for the cross of these two individuals.
c. Compare the expected percentage of each phenotype of the offspring from the cross in part (b) with the actual percentage of each phenotype observed in the children of individuals 5 and 6.

SCORE POINT 4:

a. The tune deafness allele is autosomal dominant, not autosomal recessive. If it was recessive, individuals 3 and 4 would have to have the genotypes tt and tt. (because they are both tune deaf) They would only be able to have tune deaf children with the genotype tt. However, 3 and 4 had two normal children, 8 and 9. Therefore the tune deafness allele must be dominant, and 3 and 4 were both heterozygous. That way they could have two children with the genotype tt, normal tune perception.

b. Individual 5 is tt. Individual 6 is Tt.

	t	t ← 5
T	Tt	Tt
t ← 6	tt	tt

c. The expected percentage of the phenotypes for the offspring would be 50% tune deaf and 50% normal tune perception. The actual percentage was 25% tune deaf and 75% normal tune perception.