Identifying the Genetic Material

Read the passage below, then answer the questions that follow.

In 1928, bacteriologist Frederick Griffith tried to prepare a vaccine against the pneumonia-causing bacterium *Streptococcus pneumoniae*. A **vaccine** is a substance that is prepared from killed or weakened microorganisms and is introduced into the body to protect the body against future infections by the microorganisms.

Griffith worked with two strains of *S. pneumoniae*. The first strain was enclosed in a capsule made of polysaccharides. The capsule protected the bacterium from the body's defense systems; this helped make the microorganism **virulent**, or able to cause disease. The second strain of *S. pneumoniae* lacked the polysaccharide capsule and did not cause disease.

Griffith knew that mice infected with S bacteria grew sick and died, while mice infected with R bacteria were not harmed. To determine if the capsule on the S bacteria was causing the mice to die, Griffith injected the mice with dead S bacteria. The mice remained healthy. Griffith then prepared a vaccine of weakened S bacteria by raising their temperature until the bacteria were "heat-killed", meaning they could no longer reproduce.

When Griffith injected the mice with the heat-killed S bacteria, the mice still lived. He then mixed the harmless live R bacteria with the harmless heat-killed S bacteria. Mice injected with this mixture died. When Griffith examined the blood of the dead mice, he found that the live R bacteria had acquired polysaccharide capsules. Somehow, the harmless R bacteria underwent a change and became live virulent S bacteria. This phenomenon is now called **transformation**, a change in phenotype caused when bacterial cells take up foreign genetic material.

1. What effect does a vaccine have on the body?

   _____

   _____

2. What effect does a capsule made of polysaccharides have on a bacterium contained within the capsule?

   _____

   _____

3. What does the key term *virulent* mean?

   _____

   _____

4. What effect did an injection of dead S bacteria have on the mice Griffith studied?

   _____

   _____

5. What effect did an injection of heat-killed S bacteria have on the mice Griffith studied?

   _____

   _____

6. What effect did an injection of live R bacteria mixed with heat-killed S bacteria have on the mice?

_____

_____

7. What did Griffith discover when he examined the blood of the dead mice?

_____

_____

8. In order to determine whether the capsule on the S bacteria was causing mice to die, Griffith injected mice with
    a. Dead S bacteria
    b. Weakened S bacteria
    c. Heat-killed R bacteria
    d. Both (a) and (b)

The Structure of DNA

Read the passage below, then answer the questions that follow.

Watson and Crick determined that DNA is a molecule that is a **double helix** - two strands twisted around each other, like a winding staircase. Each strand is made of linked nucleotides. **Nucleotides** are the subunits that make up DNA. Each nucleotide is made of three parts: a phosphate group, a five-carbon sugar molecule, and a nitrogen base. The five-carbon sugar in DNA nucleotides is called **deoxyribose**, from which DNA gets its full name, deoxyribonucleic acid.

1. What does the key term *double helix* mean?

   _____

   _____

2. What is the purpose of the phrase "like a winding staircase" in the first sentence?

   _____

   _____

3. Name another object that provides a visual model of a double helix.

   _____

   _____

4. In many words, the prefix *sub-*means "forming part of a whole." For example, a subset is part of a set. Why then, are nucleotides called subunits of DNA?

   _____

   _____

5. What are the three subunits that make up a nucleotide?

   _____

   _____

6. What do the letters *DNA* stand for?

   _____

   _____

7. DNA is to nucleotide as nucleotide is to
   a. Deoxyribose
   b. Double helix
   c. Nucleic acid
   d. Both (a) and (b)

The Replication of DNA

Read the passage below, then answer the questions that follow.

The process of making a copy of DNA is called **DNA replication**. It occurs during the synthesis(S) phase of the cell cycle, before a cell divides. The process can be broken down into three steps

Step 1: Before replication can begin, the double helix must unwind. This is accomplished by enzymes called **DNA helicases**, which open up the double helix by breaking the hydrogen bonds that link the complimentary nitrogen bases. Once the two strands of DNA are separated, additional enzymes and other proteins attach to each strand, holding them apart and preventing them from twisting back into their double-helical shape. The two areas on either end of the DNA where the double helix separates are called **replication forks** because of their Y shape.

Step 2: At the replication fork, enzymes known as **DNA polymerases** move along each of the DNA strands, adding nucleotides to the exposed nitrogen bases according to the base-pairing rules. As the DNA polymerases move along, two new double helixes are formed.

Step 3: Once a DNA polymerase has begun adding nucleotides to a growing double helix, the enzyme remains attached until all of the DNA has been copied and it is signaled to detach. This process produces two DNA molecules, each composed of a new and an original strand. The nucleotide sequences in both of these DNA molecules are identical to each other and to the original DNA strand.

1. What is replication?

   _____

   _____

2. When does replication occur?

   _____

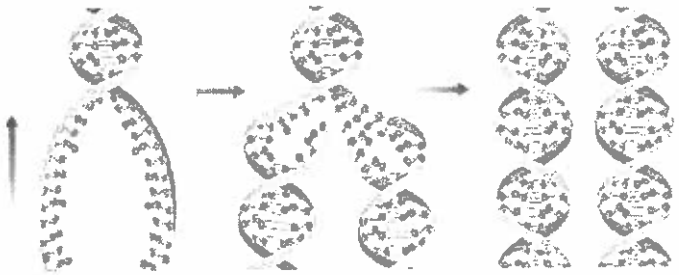
   _____

3. What must occur before replication can begin?

   _____

   _____

4. The figure below shows DNA replicating. In the space provided, describe what is occurring at each section of the figure **in your own words**.



Part a:

_____

_____

Part b:

_____

_____

Part c:

_____

_____

5. DNA helicases and DNA polymerases are alike in that both are types of
   a. Nucleotides
   b. Nitrogen bases
   c. Enzymes
   d. Both (a) and (b)

From Genes to Proteins

Read the passage below, then answer the questions that follow.

Like DNA, **ribonucleic acid (RNA)** is a nucleic acid - a molecule made of nucleotides linked together. RNA differs from DNA in three ways. First, RNA consists of a single strand of nucleotides instead of the two strands found in DNA. Second, RNA nucleotides contain the five-carbon sugar ribose rather than the sugar deoxyribose found in DNA nucleotides. And third, RNA has a nitrogen base called **uracil** - abbreviated as U - instead of the base thymine (T) found in DNA. No thymine (T) bases are found in RNA. Like thymine, uracil is complementary to adenine whenever RNA base-pairs with another nucleic acid.

1. In the spaces provided, write **D** if the statement is true of DNA. Write **R** if the statement is true of RNA. Write **B** if the statement is true of both DNA and RNA.
    a. _____ consists of a single strand of nucleotides
    b. _____ made of nucleotides linked together
    c. _____ contains deoxyribose
    d. _____ has the nitrogen base uracil
    e. _____ contains ribose
    f. _____ is a nucleic acid
    g. _____ consists of a double strand of nucleotides
    h. _____ contains a base that pairs with adenine

2. RNA is to U as DNA is to
    a. C
    b. G
    c. T
    d. A

Gene Regulation and Structure

Read the passage below, then answer the questions that follow.

A change in the DNA of a gene is called a mutation. The effects of a mutation vary, depending on whether it occurs in a gamete or in a body cell. Mutations in gametes can be passed on to offspring of the affected individual, but mutations in body cells affect only the individual in which they occur.

Mutations that move an entire gene to a new location are called *gene rearrangements*. Changes in a gene's position often disrupt the gene's function because the gene is exposed to new regulatory controls in its new location. This is something like moving to France and not being able to speak French.

Mutations that change a gene are called *gene alterations*. Gene alterations usually result in the placement of the wrong amino acid during protein assembly. This error can disrupt the protein's function. In a **point mutation**, a single nucleotide changes. In an *insertion* mutation, a sizable length of DNA is inserted into a gene. Insertions often result when mobile segments of DNA, called transposons, move randomly from one position to another on chromosomes. In a *deletion* mutation, segments of a gene are lost, often during meiosis.

1. What is a mutation?

   _____

   _____

2. A certain mutation is passed to offspring of the affected individual. What does this indicate about the type of cell in which the mutation originally occurred?

   _____

   _____

3. What is the difference between a gene rearrangement and a gene alteration?

   _____

   _____

4. What is an insertion?

   _____

   _____

5. Why can a deletion have potentially catastrophic results?

   _____

   _____

   _____

6. A mutation in a body cell is similar to a mutation in a gamete in that both involve
   a. Offspring of the affected individual
   b. A change in the DNA of a gene
   c. Addition of nucleotides
   d. Deletion of nucleotides

The Theory of Evolution by Natural Selection

Read the passage below, then answer the questions that follow.

Darwin realized that Malthus's hypotheses about human populations apply to all species. Every organism has the potential to produce many offspring during its lifetime. In most cases, however, only a limited number of those offspring survive to reproduce. Adding Malthus's view to what he saw on his voyage and to his own experiences in breeding domestic animals, Darwin made a key association: *Individuals that have physical or behavioral traits that better suit their environment are more likely to survive and will reproduce more successfully than those that do not have such traits.* Darwin suggested that by surviving long enough to reproduce, individuals have the opportunity to pass on their favorable characteristics to offspring. In time, these favorable characteristics will increase in a population, and the nature of the population will gradually change. Darwin called this process by which populations change in response to their environment **natural selection.**

1. Based on the first three sentences of this passage, what can the reader infer was Malthus's idea about the human population?

   _____

   _____

2. What real-life experiences of his own did Darwin reflect upon when considering Malthus's ideas about human populations?

   _____

   _____

3. According to Darwin, what causes the nature of a population to change?

   _____

   _____

Read this second passage below, then answer the questions that follow.

Scientists now know that genes are responsible for inherited traits. Therefore, certain forms of a trait become more common in a population because more individuals in the population carry the alleles for those forms. In other words, natural selection causes the frequency of certain alleles in a population to increase or decrease over time. Mutations and the recombination of alleles that occurs during sexual reproduction provide endless sources of new variations for natural selection to act upon.

4. What controls inherited traits?

5. What causes a particular trait to become more common in a population?

6. What two events cause new variations of traits in a population?

Evidence of Evolution

Read the passage below, then answer the questions that follow.

The fossil record, and thus the record of the evolution of life, is not complete. Many species have lived in environments where fossils do not form. Most fossils form when organisms and traces of organisms are rapidly buried in fine sediments deposited by water, wind, or volcanic eruptions. The environments that are most likely to cause fossil formation are wet lowlands, slow-moving streams, lakes, shallow seas, and areas near volcanoes that spew out volcanic ash. The chances that organisms living in upland forests, mountains, grasslands, or deserts will die in just the right place to be buried in sediments and fossilized are very low. Even if an organism lives in an environment where fossils can form, the chances are slim that its dead body will be buried in sediment before it decays. For example, the organism may be eaten and scattered by scavengers.

1. Why is the fossil record incomplete?

   _____

   _____

2. Where do fossils form?

   _____

   _____

3. In areas where fossils form, why don't all organisms that die become fossilized?

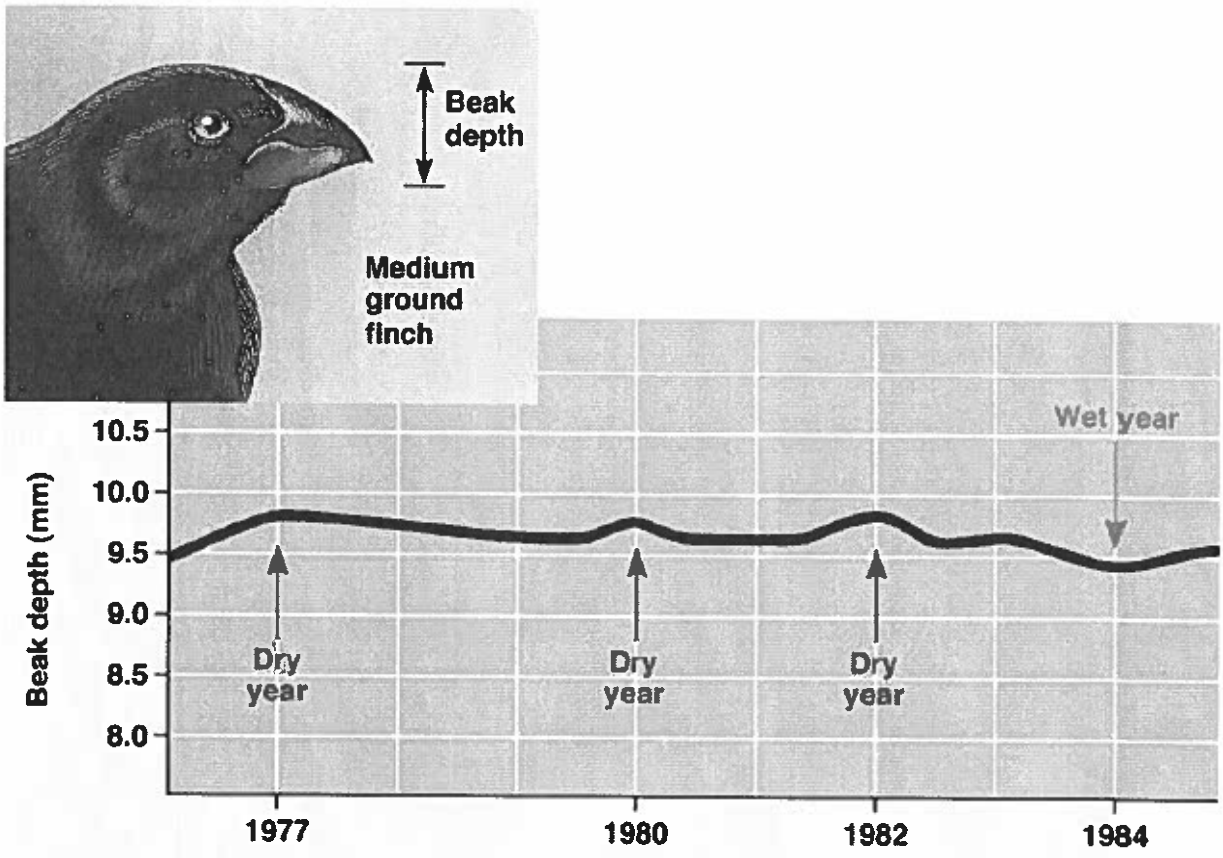
   _____

   _____

Examples of Evolution

The figure below shows beak-size variations in finches. Using the information contained in the figure, answer each question in the space provided.

BEAK-SIZE VARIATION



1. The title of a graph indicates the type of information it contains. What is the title of the graph shown? Based on this title, what type of information can an observer expect to find?

   _____

   _____

2. What information is plotted along the horizontal axis of the graph?

   _____

   _____

3. What intervals are used on the horizontal axis?

_____

_____

4. Read the label on the vertical axis of the graph. What information is plotted along this axis?

_____

_____

5. What units are used on the vertical axis?

_____

_____

6. Based on the data shown, what effect does a dry year have on beak size?

_____

_____

7. Based on the data shown, what effect does a wet year have on beak size?

_____

_____

8. During which two years was the average finch beak size nearly the same?
   a. 1976 and 1982
   b. 1977 and 1979
   c. 1979 and 1981
   d. 1980 and 1983

Categories of Biological Classification

Read the passage below, then answer the questions that follow.

Linnaeus worked out a broad system of classification for plants and animals in which an organism's form and structure are the basis for arranging specimens in a collection. He later organized the genera and species that he described into a ranked system of groups that increase in inclusiveness. The different groups into which organisms are classified have expanded since Linnaeus's time and now consist of eight levels.

Similar genera are grouped into a family. Similar families are combined into an order. Orders with common properties are united in a class. Classes with similar characteristics are assigned to a phylum. Similar phyla are collected into a kingdom. Similar kingdoms are grouped into domains. All living things are grouped into one of three domains. Two domains, Archaea and Bacteria, are each composed of a single kingdom of prokaryotes. The third domain, Eukarya, contains all four kingdoms of eukaryotes.

1. What did Linnaeus use as the basis for classifying organisms in a collection?

   _____

   _____

2. The second sentence of this passage states that Linnaeus described a "ranked system of groups that increase in inclusiveness." What does this mean?

   _____

   _____

3. How many kingdoms exist in the modern system of classification? What are they?

   _____

   _____

4. Class is to order as order is to
   a. Kingdom
   b. Species
   c. Phylum
   d. Families
   e.

How Biologists Classify Organisms

Read the passage below, then answer the questions that follow.

Most biologists analyze evolutionary relationships using cladistics. **Cladistics** is a method of analysis that reconstructs phylogenies by inferring relationships based on shared characters. Cladistics can be used to hypothesize the sequence in which different groups of organisms evolved. To do this, cladistics focuses on the nature of the characters in different groups of organisms. With respect to two different groups, a character is defined as an **ancestral character** if it evolved in a common ancestor of both groups. Thus when considering the relationship between birds and mammals, a backbone is an ancestral character. Having feathers, however, is a derived character. A **derived character** evolved in an ancestor of one group but not of the other. Feathers evolved in an ancestor of birds that was not also ancestral to mammals.

1. How does cladistics reconstruct phylogenies?

   _____

   _____

2. What type of information is determined through cladistics?

   _____

   _____

3. How are derived characters and cladistics related?

   _____

   _____

How Populations Grow

Read the passage below, then answer the questions that follow.

Every population has features that help determine its future. One of the most important features of any population is its size. The number of individuals in a population, or **population size**, can affect the population's ability to survive. Studies have shown that very small populations are among those most likely to become extinct.

A second important feature of a population is its density. **Population density** is the number of individuals that live in a given area. If the individuals of a population are few and spaced widely apart, they may seldom encounter one another, making reproduction rare.

A third feature of a population is the way the individuals of the population are arranged in space. This feature is called **dispersion**. Three main patterns of dispersion are possible within a population. If the individuals are randomly spaced, the location of each individual is self-determined. If individuals are evenly spaced, they are located at regular intervals. In a clumped distribution, individuals are bunched together in clusters. Each of these patterns reflects the interactions between the population and its environment.

1. What are three key features of a population?

   _____

   _____

2. What do studies indicate about very small populations?

   _____

   _____

3. What is population density?

   _____

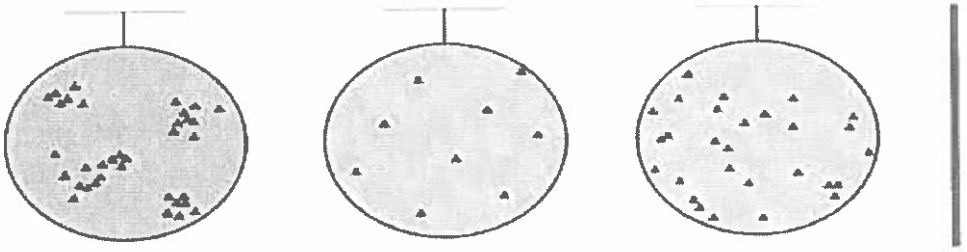
   _____

4. Describe a situation in which population density has a negative impact on the production of offspring.

   _____

   _____

The figures below show three possible patterns of dispersion in a population. Describe each pattern in the spaces provided.



a. **b.** **c.**

5. Pattern
   a:_____
   _____
6. Pattern
   b:_____
   _____
7. Pattern
   c:_____
   _____
8. The patterns of dispersion illustrated above are similar in that they all reflect interactions between
   a. The population and its environment
   b. Producers and consumers
   c. A population and its members
   d. Both (a) and (b)

How Populations Evolve

Read the passage below. Then answer the questions that follow.

In 1908, the English mathematician G.H. Hardy and the German physician Wilhelm Weinberg independently demonstrated that dominant alleles do not automatically replace recessive alleles. Using algebra and a simple application of the theories of probability, they showed that the frequency of alleles in a population and the ratio of heterozygous individuals to homozygous individuals does not change from generation to generation unless the population is acted on by other processes that favor particular alleles. Their discovery, called the **Hardy-Weinberg principle**, states that the frequencies of alleles in a population do not change unless evolutionary forces act on the population.

They Hardy-Weinberg principle holds true for any population as long as the population is large enough that its members are not likely to mate with relatives and as long as evolutionary forces are not acting. There are five principal evolutionary forces: mutation, gene flow, nonrandom mating, genetic drift, and natural selection. These evolutionary forces can cause the ratios of genotypes in a population to differ significantly from those predicted by the Hardy-jWeinberg principle.

1. What did Hardy and Weinberg independently demonstrate in 1908?

   _____

   _____

2. According to the Hardy-Weinberg principle, what causes a change in the frequencies of alleles in a population?

   _____

   _____

3. What are the five principal evolutionary forces?

   _____

   _____

4. What effect do these evolutionary forces have on the ratio of heterozygous and homozygous individuals in a population?

   _____

   _____

5. How can the population size cause a change in the frequencies of alleles in the population?

   _____

   _____

6. In forming their theories, Hardy and Weinberg used
   a. Simple algebra
   b. Theories of probability
   c. Analytic geometry

d. Both (a) and (b)