# Answer Key for Final Exam Practice Problems

**Cell Structure and Function Practice Questions**

1. One of the relationships that exists between ribosomes and lysosomes is that
   **a. ribosomes produce enzymes that could be stored in lysosomes.**
   b. ribosomes produce lipids that could be stored in lysosomes.
   c. lysosomes are located near ribosomes on the surface of the endoplasmic reticulum.
   d. lysosomes are produced by ribosomes and therefore contain proteins that were synthesized at the ribosomes.

2. Alcohol consumption adversely affects the digestion of proteins within liver cells, which can eventually lead to liver damage. Given this information, which organelle in liver cells is most directly affected?
   a. nucleus
   b. Golgi apparatus
   c. rough ER
   **d. lysosome**

3. Small cells function more effectively, because as cells become larger their surface area to volume ratio
   a. increases.
   **b. decreases**.
   c. stays the same.
   d. is squared.
   e. is cubed.

4. The eukaryotic organelle that is modifies proteins that have been synthesized in the rough ER is called
   a. mitochondria.
   b. vacuole.
   c. cytoskeleton.
   **d. Golgi apparatus**
   e. nucleus.

5. In eukaryotes, mitochondria are the organelles primarily involved in
   **a. the production of ATP**
   b. phospholipid assembly.
   c. export of enzymes.
   d. lipid synthesis.
   e. protein synthesis.

6. Chromosomes can be condensed into compact structures, visible with the light microscope, but usually only
   a. after the cell is dead.
   **b. during cell division.**
   c. while the DNA is being copied into RNA.
   d. while the proteins are being assembled.
   e. while the nuclear pores are open.

7. A cell biologist treats a cell so that oxygen cannot diffuse across the membrane. Which organelle will be directly affected?
   **A. mitochondria**
   b. lysosome
   c. nucleus
   d. ribosome
   e. Golgi apparatus

8) Plant cells
A) lack mitochondria and chloroplasts.
**B) have mitochondria and chloroplasts.**
C) have mitochondria but do not have chloroplasts.
D) lack mitochondria but have chloroplasts.

**Tay-Sachs disease**
The following 8 Practice questions give you the opportunity to apply what you have learned about the 4 classes of biomolecules (carbohydrates, lipids, proteins, and nucleic acids), cell organelles, and Gaucher's disease to another genetic disease that we have not studied, Tay-Sachs disease. But since all genetic diseases involve many of the same principles, cell organelles, and biomolecules that you have studied so far, you should be able to apply that knowledge to this and many other genetic diseases. The true test of comprehension and understanding is the application of those concepts to new and unfamiliar situations.

Tay-Sachs disease is an inherited disorder in humans that affects one in 3600 births in Askenazic Jews, about 100 times greater than the incidence in non-Jews. As in Gaucher's disease, affected individuals have a single faulty enzyme. The defective enzyme, gangliosidase, is found in the brain cells of Tay-Sachs patients. As a consequence, the brain cells of an affected baby are unable to breakdown gangliosides, a type of lipid. This causes gangliosides to build up causing a gradual decrease in brain cell function that ultimately results in death within a few years. Symptoms are seen within a few months of birth and include seizures, blindness, and degeneration of motor and mental performance. There is no known cure.

1. Why do Tay-Sachs patients have the defective enzyme, gangliosidase? Be as specific as you can in answering this question.

   **People with Tay-Sachs disease inherited a mutated version of the gangliosidase gene from each of their parents. The nucleotide sequence in a gene determines the amino acid sequence of the protein the gene codes for. Since the nucleotide sequence in the gangliosidase genes that they inherited is incorrect the order of amino acids in gangliosidase will be incorrect, resulting in an incorrect shape for gangliosidase, and hence the inability of the enzyme to break down gangliosides within their neurons.**

2. Name the cell organelle in which you would expect gangliosides to be broken down in normal brain cells. Explain your reasoning.

   **Gangliosides are broken down (digested) in lysosomes since this is the cell organelle responsible for digestion.**

3. Name the cell organelle that you would expect to make gangliosides. Explain your reasoning.

   **Smooth endoplasmic reticulum is the organelle that produces gangliosides. Why? Gangliosides are lipids and the smooth ER is the site of lipid synthesis.**

4. Explain why gangliosidase is unable to break down gangliosides.

   **Gangliosidase is a protein catalyst that normally breaks down gangliosides, but this enzyme is nonfunctional in people with Tay-Sachs because it has an incorrect order of amino acids. This causes the enzyme to have an incorrect shape, and therefore does not function properly.**

5. Would you expect all brain cells that are capable of making gangliosidase to have the faulty enzyme? Explain your reasoning.

   **Yes we should expect all brain cells to have the faulty enzyme. Why? All cells in the body contain the same genes; hence all brain cells would contain the faulty gangliosidase gene and would therefore produce the faulty enzyme.**

6. Where would you expect the gangliosides to accumulate within the brain cells of babies affected by Tay-Sachs? Explain your reasoning.

   **Gangliosides would be expected to accumulate within the Lysosomal membranes and plasma membranes of brain cells. Why? Gangliosides are lipids. Lipids are hydrophobic—therefore insoluble in water. Hence gangliosides will accumulate in the hydrophobic environment of the lipid bilayer of the plasma membrane and Lysosomal membrane.**

7. Explain why enzyme therapy is not successful in treating Tay-Sachs disease. Hint: Think about where you need to get the enzyme.

   **You would need to get the gangliosidase into virtually all brain cells for enzyme therapy to be effective. Since this is difficult to do, enzyme therapy would be ineffective.**

8. Explain why gene therapy is not successful in treating Tay-Sachs disease. Hint: Think about where you need to get the enzyme.

   **As in the previous question, you would need to get the gangliosidase gene into nearly all brain cells for gene therapy to be effective. This is tough to do—hence gene therapy is an ineffective therapy for this disease.**

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9. Suppose that you are a biologist out for a stroll at Dash Point State Park on the Puget Sound and notice many fish have washed up dead on the beach. Upon examination you find small red lesions in their skin. You examine the lesions under a microscope and find a single celled organism that has a cell was, green organelles and a nucleus, but no mitochondria.
   a. Is this organism eukaryotic or prokaryotic? Explain your reasoning.

      **It's a eukaryotic organism since the cells of eukaryotic organisms contain a nucleus. Prokaryotes do not have a nucleus.**

   b. Which domains does this organism *not* belong to? Explain your reasoning.

      **The critter can't belong to the domains bacteria and Archaea since these domains consist only of unicellular organisms with *prokaryotic* cells.**

   c. To which biological domain does this organism belong? If the organism belongs to domain Eukarya, which kingdom does it belong to? Explain your reasoning.

      **The critter belongs to the domains Eukarya since this domain consists of organisms with Eukaryotic cells. It belongs to the kingdom Protista since this kingdom consists of unicellular eukaryotic organisms, while kingdoms fungi, animalia and plantae contain eukaryotic Multicellular organisms.**

10. a. Like the cutting of hair, when you trim your nails, you are removing dead cells that have accumulated to a huge amount one of the four classes of large biological molecules. Which one is it? Explain your reasoning.

       **Hair and nails consist of structural protein (keratin).**

    b. When you trim your nails, you are removing dead cells that have accumulated to a huge amount one of the cell organelles involved in giving shape and support to the cell. Which one is it? Explain your reasoning.

       **The Cytoskeleton is the cell organelle responsible for providing shape and support to all cells. The cytoskeleton is made of protein.**

    c. Which cell organelle is responsible for building this class of large biological molecules referred to in part a, above?

       **The cell organelle responsible for making protein is the ribosome.**

    d. Which class of large biological molecules determines if a cell will be capable of making this class of large biological molecules referred to in part a, above?

       **Genes determine the kind of protein a cell is capable of making. Genes are made of DNA, a nucleic acid. Hence, the class of compound responsible for determining if a cell can make a protein such as keratin is nucleic acids.**

    e. Almost all cells in the human body contain the exact same quantity and kind of molecules referred to in part d, above. Why then don't all cells in the body produce nails?

       **Only certain genes are used or active in specific cells. Hence, what makes one tissue different from another is determined by which genes are active—e.g. Although all the cells found in muscle tissue and liver contain exactly the same genes, different genes are active in muscle cells than are active in liver tissue.**

11. Beginning with the atom, list the hierarchy of organization of life of a Multicellular organism. Show your understanding of each level with a brief explanation.

**Atoms → molecule → organelles → cells → tissues → organs → organ-systems → organism**

**Atoms combine together to form molecules. The four basic kinds of biomolecules (carbohydrates, proteins, lipids, and nucleic acids) combine to form cells. Cells contain genes, organelles and a plasma membrane surrounding the interior of the cell. The cell is the smallest unit of life. In multicellular life forms, cells of similar types are combined into tissues (e.g. nervous tissue) that perform a similar function. Various tissue types combine to make a structural unit called an organ (e.g. heart, brain, liver, etc.), several organs that collectively perform a similar function are called an organ system (digestive system, respiratory system, etc.). All organ systems functioning cooperatively make up an organism.**

**Natural Selection, Classification and Scientific Method Practice Questions**

12. What is evolution? What is natural selection? Briefly describe how evolution occurs.

**Evolution is the theory that explains the origin of the diverse forms of life as a result of changes in the genetic makeup in a population or species over many generations.**
**If two or more populations of a species become geographically or reproductively separated/isolated from each other they will change from each other over time as natural selection selects for the organisms that are best suited for the environment in which they live. Mistakes or mutations happen each time cells reproduce their DNA—e.g. in sex cells such as egg and sperm cells. These mutations occur in each of the populations, but since mutations are random and the populations are reproductively isolated, the populations may evolve (change) in different directions and possibly evolve to form two or more different species. Natural selection is the process that determines which changes or adaptations are best suited for the environment. If the environments of the populations are different from each other, the environment will select for the organisms that are best suited for that particular environment. Those that are best suited for the environment will reproduce in larger numbers than those that are less suited, thus resulting in future generations having the genes that are best suited for a particular environment—that's natural selection, the driving force of evolution!**

13. Let's say that you are a family physician, and you have noticed that during the last few days many more patients have complained of stomach cramps and intestinal "flu" than you would expect for this time of year. You take samples from these patients and isolate a single-celled organism that has DNA, but no visible membrane-bound bodies within its cytoplasm.
    a. To which biological domain does this organism probably belong? Explain your reasoning.

    **Since the organism lacks a nucleus and other membrane-bound organelles it must be prokaryotic. Two domains have prokaryotic cells: Bacteria and Archaea. Since organisms in domain Archaea are extremophiles (prokaryotes that live in environments with very high or low temperatures), the organism must belong to domain Bacteria.**

    b. To which biological domains does this organism probably *not* belong? Explain your reasoning for each domain.

    **It can't belong to Archaea (see above), nor to domain Eukarya—organisms in domain Eukarya have eukaryotic cells, cells a nucleus and other membrane-bound organelles.**

    c. To treat these patients, will you prescribe drugs effective against prokaryotic or eukaryotic organisms? Defend your decision to one of your patients.

    **Treat these patients with a drug that's effective against prokaryotic organisms (bacteria).**

14. Which of the following best describes a hypothesis?
    **A. A statement that can be tested with an experiment**
    B. An educated guess that cannot be tested
    C. A prediction that has been proven every time tested
    D. A statement that describes a theory

15. What is the difference between an experimental group and a control group?
    **A. The experimental group receives the independent variable**
    B. The experimental group receives the placebo
    C. The control group receives the dependent variable
    D. The control group receives the independent variable

*Use the information below to answer the next 4 questions*
Jane Green Thumb tests to see the effects of fertilizer on her indoor fern plants. One group of plants she gives water and the other group of plants she gives water and fertilizer.

16. What is the control group?
    A. The plants that receive water and fertilizer
    **B. The plants that receive only water**
    C. The fertilizer
    D. The water

17. What is the experimental group?
    **A. The plants that receive water and fertilizer**
    B. The plants that receive only water
    C. The fertilizer
    D. The water

18. What is the independent variable?
    A. The plants that receive water and fertilizer
    B. The plants that receive only water
    **C. The fertilizer**
    D. The water

19. Which of the following is <u>not</u> a controlled variable?
    A. The same amount of water used in each group
    **B. The same amount of fertilizer used in each group**
    C. The same number of plants used in each group
    D. The same type of plants used in each group

20. What is the best way to share the results of an experiment with scientists?
    A. Advertise the results on TV
    B. Explain the results on the internet
    **C. Publish the results in a scientific journal**
    D. Print the results in the newspaper

21. A scientist wants to determine if a new sunscreen brand called *Burnfree* will decrease the number of sunburns. He gives one group of people *Burnfree* and the other group the regular sunscreen, though no one knows which sunscreen they received. What is the placebo?
    A. The new sunscreen called *Burnfree*
    **B. The regular sunscreen**
    C. The group of people using *Burnfree*
    D. The group of people using the regular sunscreen

22. What is a well-tested concept that explains a wide range of observations?
    A. scientific observation B. scientific inquiry **C. scientific theory** D. scientific inference

23. In a controlled experiment, a scientist is studying how long it takes parachutes of different sizes to fall to the ground. What is the manipulated (independent) variable?
    **A. the size of the parachute**
    B. the height from which the parachute is dropped
    C. the size of the object carried by the parachute
    D. the time it takes for the parachute to drop

## Biological Molecules Practice Questions

1. A general principle of large biological molecules is that monomers join to make polymers. On separate paper, make a table similar to that below, and list the four large groups of biological molecules, tell what the monomers are called, and list the major functions. Note: Lipids is one of polymers, but isn't really made of monomers. But you can still list the major molecules that make up lipids.

| Polymer Name | Monomer(s) Name(s) | Specific Examples and their Functions |
|---|---|---|
| Lipids | **Fatty acids and glycerol**<br><br>**(fat = 3 fatty acids connected to the glycerol, a three carbon compound)** | • **Fats (triglycerides): Energy storage, insulation**<br>• **Steroids: hormones (chemical messengers such as testosterone and estrogen)** |
| **Carbohydrates** | **Monosaccharides**<br><br>**(e.g. glucose, fructose)** | • **Monosaccharides: source of energy (e.g. glucose)**<br>• **Disaccharides: transport of sugars (e.g. sucrose, lactose)**<br>• **Polysaccharides:**<br>○ **storage of sugars: e.g. plants → starch; animals → glycogen**<br>○ **Structural: cellulose → Cell wall (outermost structure of plants cells) are made of cellulose.** |
| **Proteins** | **Amino Acids** | • **Enzymes—protein catalysts that speed up chemical reactions in living things**<br>• **Peptide hormones: e.g. Insulin controls blood levels of glucose in all mammals.**<br>• **Transport: hemoglobin ($O_2$), HDL's and LDL's (cholesterol)**<br>• **Structural: Hair, nails, cytoskeleton, tendons, cartilage, muscle fibers, etc.** |
| **Nucleic acids** | **Nucleotides** | • **DNA—the hereditary molecule—the substance that genes are made of. Genes control which proteins an organism can make. E.g. GCase gene, lactase gene, insulin gene, etc.**<br>• **RNA—chemical messenger of DNA. Carries DNA's message from the nucleus to ribosomes in the cytoplasm or on the rough ER to direct the synthesis of protein.**<br>• **ATP—nucleotide that is the major energy currency of all cells.** |

2. Migratory birds expend vast amounts of energy during migration. Which type of biological molecule would be most suitable for energy storage? Explain.

**Fat would be the biological molecule most suitable for migratory birds since gram for gram fats contain twice the energy (calories) as carbohydrates.**

**Mitosis and Meiosis Practice Problems**

1. The phase of mitosis in which sister chromatids are separated is called
   A. prophase. B. metaphase.
   **C. anaphase.** D. telophase.

2. The phase of mitosis in which chromosomes condense is called
   **A. prophase.** B. metaphase.
   C. anaphase. D. telophase.

3. The phase of meiosis in which the nuclear membrane is dismantled is called
   **A. prophase I.** B. anaphase I.
   C. prophase II. D. metaphase II.

4. The phase of meiosis in which sister chromatids are separated is called
   A. metaphase I. B. anaphase I.
   **C. anaphase II.** D. metaphase I

5. List four differences between mitosis and meiosis:

| Mitosis | Meiosis |
|---|---|
| • **Homologous chromo's align independently during metaphase** | • **Homologous chromo's pair during metaphase I** |
| • **Sister chromatids sep. during anaphase** | • **Homologous chromo's separate at anaphase I** |
| • **Daughter cells genetically identical to each other and to the parent cell** | • **Daughter cells genetically different from each other and to the parent cell** |
| • **Daughter cells same ploidy as parents (same number of chromosomes** | • **Daughter cells have 1/2 the number of chromosomes as parents** |

6. Most of the problems with chromosome numbers in cells are a result of
   A. alcohol. B. U.V. light
   **C. non-disjunction.** D. mitosis

7. Cite two ways that allow for genetic variation in an organism from meiosis?
   - **Cross-over between homologous pair during prophase I**
   - **Independent assortment of homologous pairs during anaphase I**

8. During interphase of the cell cycle ___.
   A. DNA recombines
   B. Sister chromatics move to opposite poles
   C. The nuclear membrane disappears
   D. RNA replicates
   **E. Sister chromatids are produced**

9. Click on the following links to get to tutorials and practice problems for the following topics.
   - Cell Cycle, Mitosis, and Cancer
   - Meiosis

## Section 12.3 Cancer: A Failure in Genetic Control

1.) The types of cells most likely to become cancer cells are the highly specialized cells that spend most of their time in the G1 phase of the cell cycle, such as nerve cells.
A) True. **B) False.**

2.) Which of the following is *not* true of cancer cells?
**A) They show a high degree of contact inhibition.**
B) They do not undergo apoptosis.
C) They release a growth factor that stimulates angiogenesis.
D) They produce enzymes.
E) Their chromosomes are abnormal.

3.) Which of the following is *not* true of tumor suppressor genes?
A) They code for proteins that inhibit the cell cycle.
B) They code for proteins that promote apoptosis.
C) They may become non-functional thus allowing tumors to develop.
**D) They activate proto-oncogenes.**
E) Mutations occurring in tumor suppressor genes can lead to "loss of function" mutations.

4.) Proto-oncogenes
A) promote apoptosis.
B) produce proteins that inhibit the cell cycle.
**C) may code for growth factors.**
D) become tumor-suppressor genes when they mutate.
E) are the result of an oncogene which has mutated

5.) Telomerase
A) is an enzyme that degrades chromosomes.
B) is found in all adult cells.
C) inhibits DNA replication.
**D) is highly active in cancer cells**.
E) is a particular DNA sequence on the ends of chromosomes.

6.) To metastasize, cancer cells must enter a blood vessel or a lymphatic vessel.
**A) True.** B) False**.**

7.) Which of the following is not a suspected cause of cancer?
A) viruses
B) mutations
C) inherited genes
**D) angiogenesis**
E) oncogenes

8.) Using a "car and driver" analogy, which of the following accurately describes the role of tumor-suppressor genes and proto-oncogenes in normal cells?
A) Tumor-suppressor genes are the gas pedal, while proto-oncogenes are the brakes.
**B) Tumor-suppressor genes are the brakes while proto-oncogenes are the gas.**
C) Both tumor-suppressor genes and proto-oncogenes are like the gas, but tumor-suppressors are like turbo and proto-oncogenes are like a regular carburetor.
D) Tumor-suppressor genes are like the steering wheel, and proto-oncogenes are like the turn signals.

9.) During the early years of cancer research, there were two schools of thought regarding the causes of cancer: 1) that cancer was caused entirely by environmental factors, and 2) that cancer was caused by genetic factors. Which was correct?
A) #1 because we have identified many potential carcinogens
B) #2 because we know of many proto-oncogenes
C) #2 because we know of many tumor-suppressor genes
**D) Both were correct; most chemical carcinogens function by altering genes.**

10. _____ are mutant forms of normal genes that act dominantly to predispose a cell to a cancerous phenotype.
A.) Polymerases **B.) Oncogenes** C.) Activators D.) Tumor suppressors E.) Proto-oncogenes

11. Genes whose mutant alleles can function in a recessive manner to predispose cells to cancerous growth are referred to as:
A.) polymerases. B.) oncogenes. C.) activators. **D.) tumor suppressors**. E.) proto-oncogenes.

## Genetics Practice Problems

### Using the Probability Method

1. How many different types of gametes could be generated from individuals with the following genotypes?
A) AaBb **4** B) AaBbCc **8** C) AaBbCcDd **16**

2. How many different types of gametes could be generated from individuals with the following genotypes?
A) AABBCc **2** B) AaBBCC **2** C) AABbCC **2**

3. Given AaBbcc x AabbCc. What are the chances of producing the following genotypes?
A) AaBbCc **1/8** B) aabbcc **1/16** C) AABbCC **0**

4. Given AaBbCC x aabbCc what are the chances of producing the following genotypes?
A) AabbCC **1/8** B) aaBBCc **0** C) aabbcc **0**

5. Suppose A = Red and a = White. B = Tall and b = Short. Given the following cross AaBb x aaBb what are the chances of producing the following phenotypes?
A) Red Tall **3/8** B) Red Short **1/8** C) White Short **1/8**

### Monohybrid Crosses

6. Lithuanian lima beans have inflated pods, but you have discovered a mutant variety with flat pods (how exciting!!!). If a recessive gene determines flat pod, what phenotypes and their fractional amounts would be expected in the $F_1$ and the $F_2$ of a cross between a true breeding flat and a true breeding inflated?
**$F_1$ = 100% with Inflated pods** **$F_2$ = 75% with Inflated pods, 25% with flat pods**

7. In humans, curly hair, **C,** is dominant over straight hair, **c**. A woman who has straight hair marries a man with curly hair. Their first child has straight hair.
   a. What is the genotype of the man?
   **Heterozygous: Cc**

   b. What is the chance of this couple having a child with straight hair? **50%** Curly hair? **50%**

**Dihybid Crosses**

8. A cross between a tall plant with round seeds and a dwarf plant with round seeds produced: 121 tall plants with round seeds, 124 dwarf plants with round seeds, 42 tall plants with wrinkled seeds, and 37 dwarf plants with wrinkled seeds.
   a. What are the genotypes of the parents? **TtRr (tall with round seeds) x ttRr (dwarf with round seeds)**

   How do you know?
   - **The first parent has the dominant phenotype for each trait, hence it must be heterozygous for each trait to produce offspring that have the recessive phenotypes, dwarf and wrinkled**
   - **The 2nd parent must be homozygous recessive (tt) be be a dwarf and heterozygous to produce wrinkled offspring.**

   b. Do the phenotypes of the resulting offspring deviate from the expected phenotype ratios? Explain.
   **No, since a cross of TtRr x ttRr would be expected to produce offspring with the following phenotypic ratio:**
   **3 Tall - Round : 3 Dwarf - Round : 1 Tall - wrinkled : 1 Dwarf - wrinkled**

   **The actual phenotypic ratio is... 121Tall - Round : 124 Dwarf - Round : 42 Tall - wrinkled : 37 Dwarf - wrinkled**
   **This simplifies to... 3.3 Tall - Round : 3.4 Dwarf - Round : 1.1 Tall - wrinkled : 1 Dwarf - wrinkled**
   **which is nearly the same as the expected 3 : 2 :1 : 1 ratio. Deviations from the expected are most likely due to chance.**

9. In Scottish Terrier dogs, the allele for gray fur, **G**, is dominant, and the allele for black fur, **g**, is recessive. The allele for rough coat, **R,** is dominant, and the allele for smooth fur, **r**, is recessive.
   a. If 2 dogs heterozygous for this kind of coat (rough & gray) are bred, what are the possible types of gametes they could produce?

   **GR, Gr, gR, gr**

   b. Show the phenotypes of all possible types of offspring, as well as the probability of each phenotype occurring.
   c.

   **9 gray - rough : 3 gray - smooth : 3 black - rough : 1 black - smooth**

**Sex-Linked Crosses**

10. In humans, red-green color blindness is due to sex-linked (X-linked) allele, $\mathbf{X^b}$, and normal color vision is due to the dormant allele, $\mathbf{X^B}$. Consider the following family history: A man (Tim) and a woman (Alice), both with normal color vision, have the following three children, all of whom marry people with normal color vision: a color-blind son (Henry) who has a daughter with normal color vision (Sarah); a daughter with normal color vision (Shannon) who has one color-blind son (Paul) and two sons with normal color vision (Robert & Tom); and a daughter with normal color vision (Joan) who has six sons (Stephen, Peter, Greg, Mike, Sam, David; all with normal vision). Draw the pedigree for this family. Give probable genotypes of all individuals of the family (including spouses). Use the name given for each individual to identify them in the pedigree. Use circles to represent females and squares to represent males.

**Sorry—this one is a work in progress!**

**Misc. Genetics Practice Problems**

11. An allele is ___.
   A. one of the bases in DNA
   **B. an alternate form of a gene**
   C. another term for epistasis
   D. present only in males and is responsible for sex determination
   E. found in mitochondria but not in nuclei

12. What is the probability that on four flips of a coin, heads will occur on all four flips?
   a. ¼ b. ½ **c. 1/16** d. 1/8 e. None of the preceding are correct.

13. Starting with a cross between *AA* and *aa* in the P generation, the proportion of heterozygotes in the $F_2$ progeny will be ___.
A. 1/8 B. ¼ C. 1/3 **D. ½** E. All heterozygotes

14. Chromosomes that are matched up or paired at metaphase of meiosis I are called ___?
**a. homologous**
b. heterologous
c. complementary
d. non-disjunctive
e. sister chromatids

15. Individuals whose genotype is represented by the alleles Aa are described as
**A. heterozygous**
B. dihybrid
C. homozygous
D. homologous
E. dominant

**Multiple Alleles and Blood Groups**

16. A mother has Type ARh- blood and the father has ARh+ blood
a. What are all the possible genotypes of the offspring these two could produce?
**$I^Ai$Rr, $I^Ai$rr, $I^AI^A$Rr, $I^AI^A$rr, *ii*Rr, *ii*rr**
b. What are all the possible phenotypes of their potential offspring? **A+, A-, O+, O-**

17. Immediately after giving birth to a baby girl, the mother charges that a well-known politician (in a state neighboring Connecticut) is the child's father. The blood types involved are:

Mother: type A
Child: type O
Politician: type B

a. Could this man be the child's father?
**Yes, but only if the politician and the mother are each heterozygous:**
**$I^Ai$ *(mother) x* $I^Bi$ *(politician)***

b. Could a man with type O blood have been the child's father? **Yes, if the mother is heterozygous, $I^Ai$**

c. Could a man with type A blood have been the child's father?
**Yes, but only if the man and the mother are each heterozygous:**
**$I^Ai$ *(mother) x* $I^Ai$ *(man***

d. Could a man with type AB blood have been the child's father? **No, since the man does not have an O allele, *i***

**Incomplete Dominance**

18. In four-o,clock flowers, red flower color, **R**, is incompletely dominant over white, r. This results in the heterozygous plants being pink-flowered. If you wanted to produce four o,clock seed, all of which would yield pink-flowered plants when sown, how would you do it?

    **Red-flowering plant (RR) x White-flowering plant (rr) → 100% pink-flowering plants (Rr)**

19. **Thalassemia** is a type of human anemia rather common in Mediterranean populations, but, relatively rare in other peoples. The disease occurs in two forms minor and major; the latter is much more severe and fatal shortly after birth. People with ***Thalassemia major*** are homozygous recessive for a mutant allele involved with hemoglobin production—as a consequence they are unable to produce normal red blood cells and may die of anemia. Those suffering from ***Thalassemia minor*** are heterozygous and only mildly affected—their red blood cells carry oxygen, but not as well as in healthy people that are homozygous dominant. Those without the disease are homozygous for the normal allele. Let **T** = the normal allele, and let **t** = the allele for thalassemia. Use this information to answer the following questions dealing with thalassemia.

    a. A man with thalassemia minor **(Tt)** marries a normal/healthy woman **(TT)**. What are the possible genotypes of the gametes produced by the man **(T, t)** and the woman **(T)**? With respect to thalassemia, identify the possible genotypes and phenotypes of all of the children resulting from this union.

       **Tt x TT → ½ TT (Healthy) : ½ Tt (Thalassemia minor)**

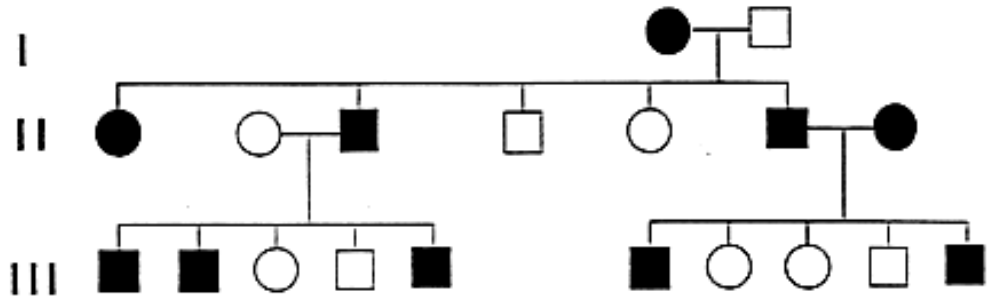
    b. A man with thalassemia minor **(Tt)** marries a woman with thalassemia minor **(Tt)**. What is the chance that their first child will be severely affected? **25%** Mildly affected? **50%** Normal? **25%** Determine the possible genotypes of the gametes produced by the man **(T, t)** and the woman **(T, t)**, and use these to show the possible genotypes of the resulting zygotes.

    c. An infant is born with thalassemia major. What possibilities would you expect to find if you checked the infant's parents for anemia? **Each parent would have to be at least a carrier, Tt, or perhaps have Thalassemia major, tt.**

**Human Pedigrees**

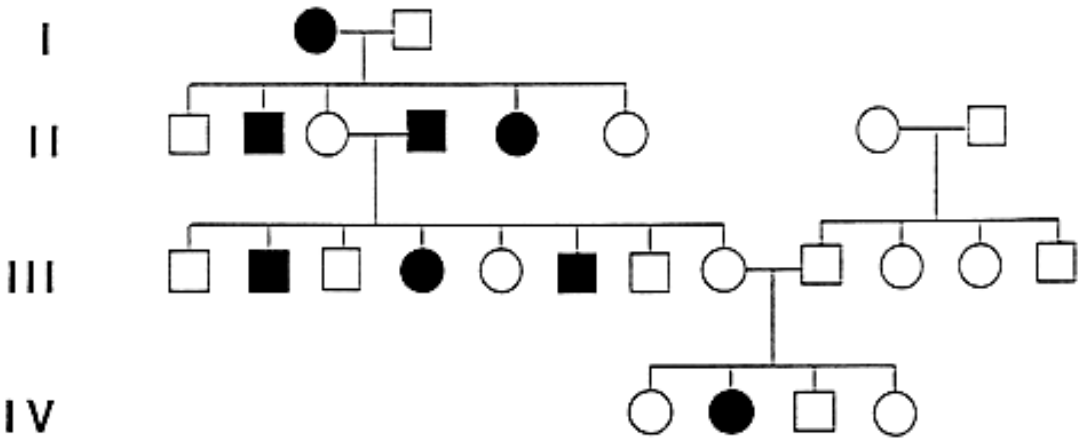
In the following four human pedigrees the individuals that are solid possess the trait mentioned. In the blank following the title of the pedigree state whether the trait is dominant or recessive. In the corresponding blanks below the pedigree complete the requested genotypes as fully as possible but do not include any genes that cannot be determined with certainty. Disregard the possibility of such things as environmental influence and mutations.

1. STREAK HAIR ( Use **H** and **h** ) **Autosomal Dominant**




Generation I: 1 Hh 2 hh
Generation II: 1 Hh 2 hh 3 Hh 4 hh 5 hh 6 Hh 7 Hh
Generation III: 1 Hh 2 Hh 3 hh 4 hh 5 Hh
6 H? 7 hh 8 hh 9 hh 10 H?

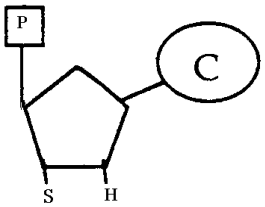
2. LEFT-HANDEDNESS ( Use **R** and **r** ) **Autosomal Recessive**




Generation I: 1 rr 2 Rr
Generation II: 1 Rr 2 rr 3 Rr 4 rr
5 rr 6 Rr 7 R? 8 R? but most likely RR!
Generation III: 1 Rr 2 rr 3 Rr 4 rr 5 Rr 6 rr
7 Rr 8 Rr 9 R? 10 R? 11 R? 12 R?
Generation IV: 1 R? 2 rr 3 R? 4 R?

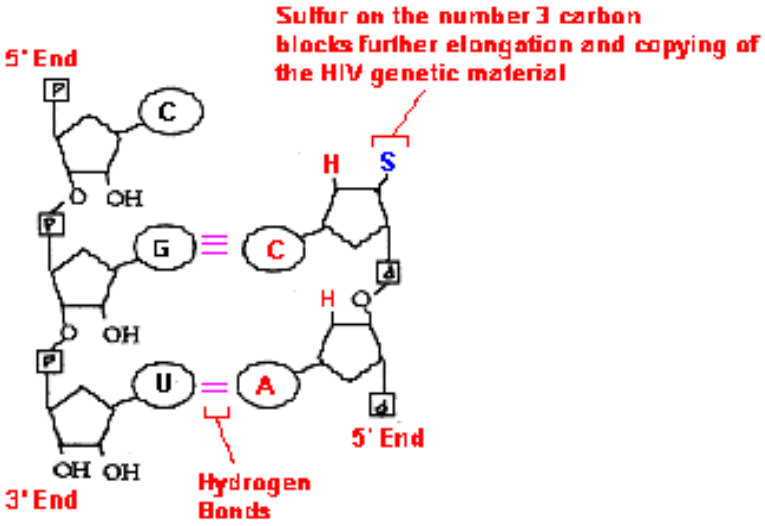
**DNA Replication Practice Questions**

1. The nucleotide 3TC diagrammed below is an anti-HIV drug that has been particularly useful in combination cocktails for AIDS therapy. It is a nucleotide that has a sulfur atom (S) in the place where normal nucleotides have an OH group. The point of this question is to figure out how this helps AIDS patients.




a. Is this a nucleotide appropriate for RNA or DNA? How do you know? Hint: Compare the sugar in 3TC, above, with the sugar in the nucleotides below.

b. Sketched here is a portion of an RNA molecule from HIV that has just infected a cell. In the correct position, sketch the nucleotide that will pair with the U nucleotide as reverse transcriptase copies this strand into a daughter DNA strand. (The reverse transcription starts at the bottom and moves towards the top.)




c. Now pretend like you are the reverse transcriptase, so continue synthesizing a new stand, placing the 3TC nucleotide in where it would go in the new strand.

**See part b, above.**

d. Use your diagram to explain how 3TC could work as a therapy for AIDS.

**See part b, above.**

## Transcription and Translation Questions

2. Here is a hypothetical gene showing the sequence of DNA nucleotides for the coding strand (i.e. coding strand is the strand that is transcribed). **This sequence includes the regions that *code for* start and stop codons in translation.**

**Coding Strand of DNA: 3' A A T G G C A T A C T C G A T A G 5'**

a. What is the order of the bases in the mRNA that would be transcribed from this gene? Indicate the 5' and 3' ends of your molecule.

**5' U U A C C G U A U G A G C U A U C 3'**

b. Consider what you have learned about the structure of DNA and RNA. List 3 ways that the structure of mRNA differs from the structure of the DNA from which it was transcribed.

i. **mRNA is single-stranded, DNA is double-stranded**

ii. **Uracil in RNA, Thymine in DNA**

iii. **Ribose is the sugar in RNA, deoxyribose in DNA**

c. Using the start codon to determine the reading frame, what is the amino acid sequence of the protein that this gene codes for? (*See your textbook for a table of mRNA codons*)

**m RNA: 5' U U A C C G U A U G A G C U A U C 3'**

**Amino Acid Sequence: Met - Ser - Tyr**

**(i.e. methionine - serine - tyrosine)**

d. What is the order of the bases of the **2nd codon**? **A G C** Name the kind of molecule where the **2nd codon** is found: **mRNA**

e. What is the order of the bases of the **2nd anticodon**? **UCG** Name the kind of molecule where the **2nd anticodon** is found. **tRNA**

3. You are investigating the cause of a disease that you suspect is inherited. You have isolated the gene that you think is responsible for the symptoms of the disease from both normal people; and people with the disease. In your lab you have the equipment needed to figure out the nucleotide sequence of the gene and any other equipment you might need.
   - Describe the steps you would do to determine if the gene you found is causing the disease. Assume the person you are explaining this to is intelligent, but has not had a biology course.

   - **Step 1: Use PCR to make many copies of the gene in question from healthy people and from people with the disease.**
   - **Step 2: Determine the base sequence of the gene from healthy people and from people with the disease.**
   - **Step 3: Compare the base sequences. If they are the same, then the gene would not be the cause of the disease. If different, then see how they differ and determine if they would code for a protein that would have a different amino acid sequence that might cause the protein to have a nonfunctional shape.**

**The following multiple choice questions problems are from the *Biology Project* at the University of Arizona. Click on the responses to learn more about each response.**

4. For the DNA strand 5'-TACGATCATAT-3' the correct complementary DNA strand is:
   **A** 3'-TACGATCATAT-5'
   **B** 3'-ATGCTAGTATA-5'
   **C** 3'-AUGCUAGUAUA-5'
   **D** 3'-GCATATACGCG-5'
   **E** 3'-TATACTAGCAT-5'

5. Three types of RNA involved in comprising the structural and functional core for protein synthesis, serving as a template for translation, and transporting amino acid, respectively, are:
   **A** mRNA, tRNA, rRNA
   **B** rRNA, tRNA, mRNA
   **C** tRNA, mRNA, rRNA
   **D** tRNA, rRNA, mRNA
   **E** rRNA, mRNA ,tRNA

6. A messenger acid is 336 nucleotides long, including the initiator and termination codons. The number of amino acids in the protein translated from this mRNA is:
   **A** 999
   **B** 630
   **C** 330
   **D** 111
   **E** 110

7. A synthetic mRNA of repeating sequence 5'-CACACACACACACACAC... is used for a cell-free protein synthesizing system like the one used by Niremberg. If we assume that protein synthesis can begin without the need for an initiator codon, what product or products would you expect to occur after protein synthesis.
   **A.** one protein, consisting of a single amino acid
   **B.** three proteins, each consisting of a different, single amino acid
   **C.** two proteins, each with an alternating sequence of two different amino acids
   **D.** one protein, with an alternating sequence of three different amino acids
   **E.** one protein, with an alternating sequence of two different amino acids

8. Under conditions where methionine must be the first amino acid, what protein would be coded for by the following mRNA?

   **5'-CCUCAUAUGCGCCAUUAUAAGUGACACACA-3'**

   **A.** pro his met arg his tyr lys cys his thr
   **B.** met arg his tyr lys cys his thr
   **C.** met arg his tyr lys
   **D.** met pro his met arg his tyr lys cys his thr
   **E.** arg his ser glu tyr tyr arg leu tyr ser

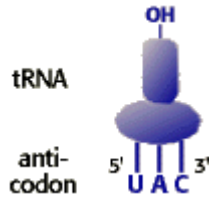
9. Which mRNA codes for the following polypeptide?

**Met-arg-ser-leu-glu**

**A.** 3'-AUGCGUAGCUUGGAGUGA-5'
**B.** 3'-AGUGAGGUUCGAUGCGUA-5'
**C.** 5'-AUGCGUAGCUUGGAGUGG-3'
**D.** 1'-AUGCGUAGCUUGGAGUGA-3'
**E.** 3'-AUGCGUAGCUUGGAGUGA-1'

10. With what mRNA codon would the tRNA in the diagram be able to form a codon-anticodon base pairing interaction?

**A.** 3'-AUG-5'
**B.** 3'-GUA-5'
**C.** 3'-CAU-5'
**D.** 3'-UAC-5'
**E.** 3'-UAG-5'




11. Which of the following tools of recombinant DNA technology is INCORRECTLY paired with its use?

**A.** restriction endonuclease - production of DNA fragments for gene cloning.
**B.** DNA ligase - enzyme that cuts DNA, creating sticky ends.
**C.** DNA polymerase - copies DNA sequences in the polymerase chain reaction.
**D.** reverse transcriptase - production of cDNA from mRNA.
**E.** electrophoresis - RLFP analysis.

12. Match the following terms to the appropriate part of the central dogma by placing an "X" in the corresponding box. There is only one answer for each term.

| Term | Replication | Transcription | Translation |
|---|---|---|---|
| Mutations Occur | X | | |
| Uses RNA Polymerase | | X | |
| Uses DNA Polymerase | X | | |
| Involves Proofreading | X | | |
| Involves RNA Primers | X | | |
| Produces RNA as the final product | | X | |
| Produces DNA | X | | |
| Produces Protein | | | X |
| Uses tRNA | | | X |
| Involves both strands of DNA | X | | |
| Involves only one strand of DNA | | X | |
| Doesn't use DNA | | | X |
| Uses amino acids | | | X |
| Involves mRNA (there are 2 answers to this one!) | | X | X |
| Involves Ribosomes | | | X |

**Biotechnology Practice Problems**

13. What are restriction enzymes? How are they used in Biotechnology?

14. Explain what PCR (polymerase chain reaction)is, how works and what it is used for.

15. What is gene therapy? How is carried out? What is the difference between somatic and germ-line gene therapy? What are the major challenges faced by gene therapy in going from an experimental science to a common medical practice?

16. Explain how you could use recombinant DNA technology to get bacteria to produce human growth hormone.

## Estimating the size of an object viewed under the microscope.

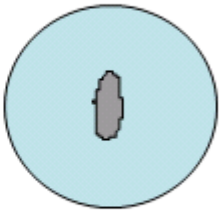
### Problem 1

- Calculate the length and width of the following microscopic object in both millimeters and micrometers. **1 mm = 1000 µm**
- Base your calculations on the following field sizes:

**Low power (40x):** 4.5 mm

**Medium power (100x):** 1.8 mm

**High power (400x):** 0.45 mm



Object viewed at medium power (100x)

**Length: ~ 1/3 field diameter**
**= (1/3)(1.8 mm)**
**= 0.6 mm = 600 µm**

**Width: ~ 1/6 field diameter**
**= (1/6)(1.8 mm)**
**= 0.3 mm = 300 µm**

*Remember:* Field size decreases by the same factor as the magnification increases!

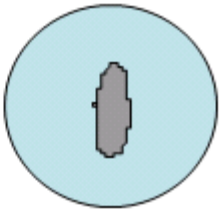
### Problem 2

- Calculate the length and width of the following microscopic object in both millimeters and micrometers. **1 mm = 1000 µm**
- Base your calculations on the following *hypothetical* field sizes:

**Low power (30x):** 4.0 mm = **4000 µm**

**Medium power (180x):** **0.67 mm = 670 µm**

**High power (300x):** **0.4 mm = 400 µm**



Object viewed at high power (300x)

**Length: ~ 1/2 field diameter**
**= (1/2)(0.4 mm)**
**= 0.2 mm = 200 µm**

**Width: ~ 1/5 field diameter**
**= (1/5)(0.4 mm)**
**= 0.08 mm = 80 µm**

### Diffusion, Osmosis and Active Transport Practice Questions

**Multiple Choice Questions**

1. Water-loving molecules such as glucose are:
   A. hydrophobic
   **B. hydrophilic**
   C. insoluble in water

2. The model of a cell membrane containing a bilayer of phospholipid molecules with interspersed protein molecules is the:
   **A. fluid mosaic model**
   B. induced fit model
   C. lock and key model

3. The cell membrane is differentially permeable. This means that:
   A. all molecules pass through the membrane at the same rate
   **B. some molecules may pass through but not others**
   C. only glucose passes through easily

4. The transport of mineral ions from soil to plant root requires energy-rich ATP. This is an example of:
   A. passive transport
   B. osmosis
   **C. active transport**

5. Diffusion is the movement of substances from:
   **A. high to low concentrations**
   B. low to high concentrations
   C. equal areas

6. The diffusion of water is called:
   A. hydrophobic
   **B. osmosis**
   C. concentration gradient

7. When a microscopic protozoan takes in a particle of food into itself, the process used is:
   **A. endocytosis**
   B. exocytosis
   C. osmosis

8. When milk is secreted by mammary glands, the process used is:
   A. endocytosis
   B. osmosis
   **C. exocytosis**

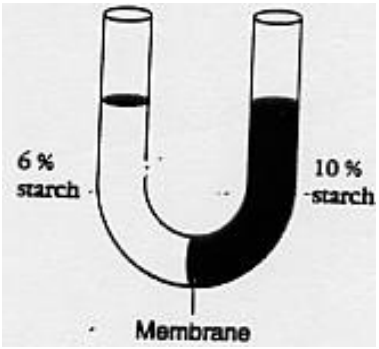
9. White blood cells engulfing foreign bacteria is an example of:
   **A. phagocytosis**
   B. exocytosis
   C. diffusion

10. Which of the following correctly describes the process of osmosis?
    **A. The passive movement of water molecules from areas of low solute concentration to high solute concentration, through a selectively permeable membrane.**
    B. The passive movement of water molecules from areas of high solute concentration to low solute concentration, through a selectively permeable membrane.
    C. The active movement of water molecules from areas of high solute concentration to low solute concentration, using a membrane pump protein.
    D. The passive movement of water molecules from areas of low solute concentration to high solute concentration, through a channel protein.

11. Inside one osmosis bag, A, is a 50% glucose solution and side bag B is a 20% glucose solution. Both bags are put into beakers containing 100% water.
    **A) Bag A will gain weight.**
    B) Bag B will gain weight.
    C) Both bags will gain weight.
    D) Both bags will lose weight.
    E) Both bags will remain the same.

12. A 0.9% NaCl solution is isotonic to red blood cells. Which of these describes the results if red blood cells are placed into a 9% solution of NaCl?
    A) They will burst.
    B) They will shrink.
    **C) There will be no net change.**
    D) They will expand but not burst.
    E) None of the above.

13. The U-shaped tube in the figure below is divided by a membrane that is impermeable to starch but permeable to water. Which of the following will occur?
    A) Water will move from the right to the left.
    **B) Water will move from the left to the right.**
    C) Starch will move from the right to the left.
    D) Starch will move from the left to the right.
    E) Nothing will happen. The membrane blocks the passage of all the molecules.




14. Red blood cells has a salt concentration of 0.9%. What will happen if it is placed into a 0.5% salt solution? The red blood cell will
    A) shrink if its membrane is permeable to both the salt and the water.
    B) shrink if its membrane is impermeable to the salt and permeable to the water.
    C) maintain its shape, ie nothing will happen.
    **D) swell and probably burst because its membrane is impermeable to salt and permeable to water.**
    E) swell and probably burst because its membrane is impermeable to water and permeable to salt.

15. The movement of materials through a transport protein without the use of energy is termed:
    A. active transport
    B. diffusion
    C. osmosis
    D. endocytosis
    **E. facilitated diffusion**

16. If the concentration of solutes outside a cell is equal to the concentration of solutes inside the cell, then the cell is _____ when compared to its surroundings?
    a.) hypertonic **b. ) isotonic** c.) hypotonic d.) endocytic

17. The diffusion of water across a semipermeable membrane is:
    a. active transport of water **b. osmosis** c. exocytosis d. Endocytosis

18. The energy responsible for active transport is associated with which of the following?
    **a. ATP** b. ADP c. AMP d. kinetic energy of the diffusing particles

19. Which of the following is not true of an plasmolyzed plant cell when placed into distilled water?
    a. the cell is hypertonic to the water
    b. the water is hypotonic to the cell
    c. the cell will gain water
    **d. the cell will lose water**

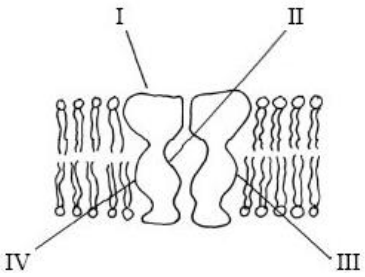
20. Red blood cells will lyse (burst) if they are in ___ solution.
    a. isotonic b. hypertonic **c. hypotonic**

21. Active transport moves materials from _____to _____concentration and requires an input of _____:
    a. low to high, water **b. low to high, energy** c. high to low, water d. high to low, energy

22. If a cell has a 10% solute concentration. What occurs to the cell in a 0% solute fluid?
    a. the cell neither gains nor loses water
    **b. the cell will lose water**
    c. the cell will gain water.
    d. none are correct

23. A substance moving through the membrane by facilitated diffusion moves through what part of the membrane?
a. phosopholipid bilayer b. cytoskeleton **c. transport protein** d. Na/K pump portion

24. The diagram below shows a channel protein in a plasma membrane. Channel proteins allow polar molecules to pass through by facilitated diffusion. Which labeled parts of the channel proteins are likely to be polar?




**A. I and II only**
B. III and IV only
C. I and III only
D. All parts