FINAL EXAMINATION

1. Exons are...
   a. genes for proteins that will be excreted from a cell.
   b. groups of genes in bacteria that are controlled together.
   c. extremely important genes.
   d. separated by introns in many eukaryotic genes.
   e. removed from an mRNA before the mRNA is exported to the cytoplasm.

2. In one strain of E. coli, a mutation in the gene that codes for the repressor of the lac operon alters the lactose-binding site of the repressor and thus prevents lactose from binding to the protein. In all other ways, the repressor stays the same. Which of the following statements represents a reasonable expectation?
   a. The strain will never make β-galactosidase.
   b. The strain will always make β-galactosidase.
   c. The strain will make β-galactosidase only in the presence of lactose.
   d. The strain will make β-galactosidase only in the absence of lactose.
   e. The strain will make huge amounts of repressor instead of β-galactosidase.

3. In bacteria, genes for related functions are often found in “operons.” What is the significance of this observation?
   a. Only genes in operons can ever be used as templates for mRNA synthesis.
   b. Genes in operons are constitutively transcribed (transcribed all the time).
   c. All operons are controlled by one repressor protein.
   d. All genes in all operons are transcribed only in the presence of lactose.
   e. Two or more genes in one operon are transcribed at the same time and under the same conditions.

4. Many proteins in eukaryotes have a “leader sequence,” a short chain of amino acids that allows them to be inserted into the endoplasmic reticulum. These proteins could wind up...
   a. inside a lysosome.
   b. as an intrinsic protein in the plasma membrane.
   c. outside the cell.
   d. inside the vacuole (assuming a plant or fungal cell).
   e. any of the above.
5. In the presence of an inhibitor of microtubule formation, dividing cells will tend to be found in what phase of the cell cycle?

   a. prophase or prometaphase  
   b. S phase  
   c. anaphase  
   d. G1 phase  
   e. An inhibitor of microtubule formation will not affect the cell cycle of dividing cells, so cells will be found in all phases.

6. What phase of mitosis best describes the cell diagrammed below?

   a. Prophase  
   b. Prometaphase  
   c. Metaphase  
   d. Anaphase  
   e. Telophase

7. Gametes are best described as...

   a. haploid cells that fuse to form a zygote.  
   b. haploid cells that are always produced by meiosis.  
   c. diploid cells that undergo a series of mitotic divisions to form an adult organism.  
   d. haploid cells that undergo a series of mitotic divisions to form an adult organism.  
   e. male and female diploid cells that fuse at fertilization.

8. Meiosis differs from mitosis in that...

   a. the cells that are produced by mitosis are always diploid.  
   b. homologous chromosomes do not separate in meiosis.  
   c. only cells in mitosis have spindles.  
   d. meiosis occurs only in diploid cells.  
   e. chromosome replication is followed by one division in meiosis, two in mitosis.
9. The cell to the right was found in an organism that is known to have a diploid number of chromosomes equal to 6 (2n=6). Which of the following statements best describes the cell?

   a. The cell is the product of an abnormal meiosis.
   b. The cell is in prophase I of meiosis.
   c. The cell is in prophase II of meiosis.
   d. The cell is in telophase II of meiosis.
   e. The cell is in anaphase of mitosis.

10. Meiosis is an important stage in a species’ life cycle because...

   a. after going through meiosis, one cell produces a large number of gametes.
   b. the products of meiosis have a reduced number of chromosomes per nucleus.
   c. the chromosomes in the products of meiosis may have new combinations of alleles.
   d. without meiosis, it would be impossible to form a multicellular organism.
   e. both b and c are true.

11. The response of normal basal or squamous skin cells that are exposed to intense sunlight may include...

   a. the excision of damaged DNA bases and resynthesis of the DNA chain.
   b. a delay in the rate of cell division
   c. apoptosis (programmed cell death)
   d. all of the above.
   e. none of the above.

12. True or false: a mutation, for instance in the gene that codes for hemoglobin, can occur from a simple error by DNA polymerase in finding a proper complementary base during DNA replication.

   a. true   b. false
13. A pine tree cell is said to have about 5 times more DNA in its nucleus than a human cell. Which of the following statements is the most likely explanation for this observation?

a. It is difficult to measure the amount of DNA per nucleus accurately.
b. Plant development is more complicated and thus requires more genes.
c. Much DNA in a eukaryote genome does not include functional genes.
d. Plant genes are larger, because plant cells are larger.
e. Prokaryotic genomes are generally smaller than eukaryotic genomes.

14. The original purpose of the Human Genome Project was ...

a. to count all the genes in a typical human cell.
b. to measure the amount of DNA in a typical human cell.
c. to cure every human disease caused by a recessive allele.
d. to determine the base sequence of all the DNA in a typical human cell.
e. to attract mathematicians to biological research institutes.

15. In molecular biology, a “vector” is...

a. any circular piece of DNA used for transformation.
b. a special DNA, generally a plasmid or virus, used to carry a gene into a cell.
c. a type of bacteria used to produce large amounts of an foreign protein.
d. an arrow pointing into a cell.
e. an arrow pointing out of a cell.

16. *Escherichia coli* (*E. coli*) is a normal component of the bacteria in your gut. Yet in recent years, *E. coli* has been recognized as a serious pathogen, responsible for many instances of sickness in people who have eaten contaminated foods. How can these two observations best be reconciled?

a. The pathogenic *E. coli* has obtained a plasmid with a gene for a toxic protein.
b. Most of the bacteria in our gut are pathogenic: we would be much healthier if all gut bacteria could be eliminated.
c. Normal bacteria become pathogenic in the presence of the right food.
d. All of the above statements are true.
e. None of the above statements are true.
17. Penicillin kills growing bacteria by interfering with the synthesis of cell wall, which makes the cells subject to osmotic lysis. *Staphylococcus* bacteria have become more resistant to penicillin in recent years. The simplest explanation is that the resistant strains...

   a. acquired the gene for an enzyme that hydrolyzes penicillin.  
   b. became immune to osmosis. 
   c. stopped making peptidoglycan-containing cell walls. 
   d. acquired new exotoxin genes. 
   e. stopped being pathogenic.

18. Which of the following materials would be most unlikely to induce the synthesis of antibodies, if it were injected into the bloodstream of a mouse?

   a. *Staphylococcus* exotoxin  
   b. Polysaccharides purified from a plant cell wall 
   c. Antibodies purified from human blood serum  
   d. Cancer cells isolated from another mouse 
   e. Glucose purified from corn syrup

19. The addition of a serum from a person with O blood type to a suspension of type A blood cells will cause the formation of a coarse red clump. The clump can be pelleted by centrifugation. In the pellet, you should expect to find...

   a. only blood cells.                                      
   b. anti-A and anti-B antibodies only.  
   c. blood cells and anti-A antibodies. 
   d. blood cells and anti-B antibodies.  
   e. blood cells, anti-A antibodies, and anti-B antibodies.

20. Which of the following immune system cells may lyse (break the plasma membrane of) cancer cells?

   a. TH cells  
   b. TC cells  
   c. plasma cells  
   d. macrophages  
   e. neutrophils

21. Which of the following immune system cells stimulate other cells to produce and secrete antibody into the serum?

   a. TH cells  
   b. TC cells  
   c. plasma cells  
   d. macrophages  
   e. neutrophils

22. Which of the following immune system cells produce and secrete antibody into the serum?

   a. TH cells  
   b. TC cells.  
   c. plasma cells.  
   d. macrophages. 
   e. antigens.
23. Which of the following processes, involved in the differentiation of antibody producing cells, is unique as a process of differentiation in mammals?

   a. regulation of allosteric enzyme activity
   b. regulation of enzyme synthesis by an operon mechanism
   c. regulation of transcription
   d. removal of introns during RNA processing
   e. removal of DNA sequences in the middle of certain genes

24. Which of these statements is consistent with the theory of clonal selection as applied to antibody production?

   a. Each antibody-producing cell determines the specificity of the one antibody its progeny will produce before it is presented with antigen.
   b. Each antibody-producing cell determines the specificity of the one antibody its progeny will produce after it is presented with antigen.
   c. Antigen changes the shape of an antibody’s clone, inducing the antibody’s binding site to fit the antigen.
   d. Each antibody-producing cell makes many clones of antibodies.
   e. Clones of researchers have selected antibody production as the most important topic to study.

25. True or false: class switching, the change of an antibody from IgM to (for instance) IgG or IgA, also changes the binding site and thus the specificity of the antibody for its antigen.

   a. true       b. false      c. Huh?

26. Retroviruses are difficult for the immune system to eliminate from the body, because...

   a. they have no coat proteins for antibodies to recognize.
   b. they have no genes.
   c. by the time antibodies are produced, their genes are integrated into host DNA.
   d. they eat antibodies.
   e. None of the above. Retroviruses are not difficult to eliminate from the body.

27. In addition to its general characteristics as a retrovirus, HIV is particularly difficult for the immune system to eliminate from the body, because its binding to________means that it infects T\textsubscript{H} cells and macrophages.

   a. antibodies
   b. CD\textsubscript{4} receptors
   c. gp120
   d. MHC I
   e. MHC II
The diagram at the right represents a bacterial cell as it might have been drawn in lecture. Questions 31-37 refer directly or indirectly to this diagram.

31. The function of the organelle marked “R” (too thin to be seen, but immediately inside the organelle marked “S”) is...
   a. exclusion of toxic compounds.
   b. preventing enzymes from leaking from the cell.
   c. detection of substances in the growth medium.
   d. a platform for enzymes.
   e. all of the above.

32. Under most growth conditions, if organelle “S” were not present, the cell would...
   a. divide.
   b. shrink.
   c. plasmolyze.
   d. lyse (break open).
   e. none of the above.

33. The best name for the organelle marked “T” is...
   a. nucleus.       b. vacuole.        c. thylakoid.        d. nucleoid.       e. nucleolus.

34. The best name for the organelle marked “U” is...
   a. chromosome.     b. genome.     c. polysome.     d. lysosome.     e. spliceosome.

35. Which of the following is necessary for translation to occur?
   a. rRNA         b. elongation factor        c. amino acyl-tRNA      d. a water molecule
   e. All of the above are necessary.
36. A biochemist is studying the synthesis of a vitamin in the bacterium *E. coli*. She believes that compounds A, B, and C are intermediates in the biochemical pathway leading to the vitamin. She has located three mutants of *E. coli*, each of which can grow on medium containing the vitamin but not on minimal medium.

Mutant 1 can grow on compound B, but not A or C.
Mutant 2 can grow on compound A, B, or C.
Mutant 3 can grow on compound B or C, but not A.

What is the order of compounds in this pathway?


37. The lac operon (which includes the promoter and operator) is found on which type of molecule?

a. DNA  b. tRNA  c. mRNA  d. nRNA  e. rRNA

The cell below represents a plant cell as it might have been drawn in lecture. Questions 38-45 refer directly or indirectly to this diagram.

38. If this cell were found in the leaf of an oak tree, it would obtain ATP from...

a. respiration only.
b. photosynthesis only.
c. respiration or photosynthesis, depending on environmental conditions.
d. none of the above.

39. In the dark, most of the ATP is formed in which organelle?


40. Which organelle is responsible for photosynthesis?

41. The equation below represents the overall reaction of photosynthesis:

\[ 6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 \]

Which of these answers correctly identifies the reduced forms of carbon and oxygen?

a. CO\(_2\) and H\(_2\)O  
b. C\(_6\)H\(_{12}\)O\(_6\) and H\(_2\)O  
c. CO\(_2\) and O\(_2\)  
d. C\(_6\)H\(_{12}\)O\(_6\) and O\(_2\)  
e. None of the above: neither of the carbon compounds is more reduced than the other.

42. True or false: the combined products of the reaction formula in question 41 have higher free energy than the combined reactants.

a. true  b. false

43. The organelle marked “O” is surrounded by a thin structure. What is this structure composed of?

a. proteins and lipids  b. DNA and RNA  
c. carbohydrates  d. water and salts  
e. microtubules and microfilaments

The cell below represents an animal cell as it might have been drawn in lecture. Questions 46-53 refer directly or indirectly to this diagram.
46. The organelle marked “X” organizes the formation of star-shaped bodies when this cell divides. Those bodies are called...
   a. stellars.  b. spindles.  c. asters.  d. sunflowers.  e. anemones.

47. Of what material are the star-shaped bodies mentioned in question 46 made?
   a. lipids  b. DNA  c. polysaccharides  d. proteins  e. glucose

48. This cell is synthesizing antibodies and secreting them into the extracellular space. At what marked organelle is the synthesis of the antibodies taking place?

49. Through what marked organelle must the antibodies pass in order to be secreted?
   a. V  b. W  c. X  d. Y

50. This cell was stimulated to form antibodies by, among other things, a signal from a T_{H} cell. The signal induced the activation of transcription factors. Where did these transcription factors act, once they were activated?

51. In order to prepare for antibody synthesis, this cell must produce mRNA. mRNA is formed from nRNA by the removal of...
   a. introns.  b. exons.  c. protons.  d. neutrons.  e. electrons.

52. What is the source of the free energy required for the synthesis of the antibodies (at translation)?
   a. RNA  b. hydrolysis of ATP is sufficient  c. hydrolysis of ATP and GTP
   d. light photons  e. No energy is required. The reaction is spontaneous.

53. Since it is found in an adult mammal, this cell must be...
   a. haploid.  b. diploid.  c. aneuploid (unusual number of chromosomes)
54. The diagrams below show cells from an organism with diploid and haploid stages. Cells in the diploid stage have two pairs of chromosomes. Which diagram(s) shows a cell in the haploid stage.

a. both B and D  b. C only  c. D only  d. A only  e. both C and D

Questions 55-57 are based on the following information:

Sickle cell anemia is caused by the change of one nucleotide in the sequence of the hemoglobin gene. The DNA sequences of the normal and sickle cell alleles of the gene look (in part) like this:

NORMAL  ...TACCATTGGAATCTTCTC...
SICKLE   ...TACCATTGGAATCATCTC...

55. You should expect the change in one nucleotide to cause:

a. no change in the synthesis of the hemoglobin protein.
b. termination of transcription.
c. a change in the sequence of the mRNA.
d. a change in the sequence of amino acids in the hemoglobin protein
e. both c and d

56. The change in one nucleotide results in the disruption of one alpha-helix. This must mean that certain chemical bonds which are formed in normal hemoglobin are not formed in sickle cell hemoglobin. What kind of bond?

a. peptide  b. hydrogen  c. Van der Waals  d. disulfide  e. ionic
57. The sickle cell allele is codominant with the normal allele. This means that a person who is heterozygous for the sickle cell allele would...
   a. be totally normal: all blood cells would function normally.
   b. have full-blown sickle-cell anemia: all blood cells would be sickle shaped.
   c. have a mild form of the disease: blood cells would be a mixture of normal and sickle cell hemoglobin.
   d. be totally normal, because sickle cell anemia does not affect blood cells.
   e. have no blood cells.

58. Prokaryotes differ from eukaryotes in that...
   a. only eukaryotes have chromosomes.
   b. only eukaryotes have a nuclear envelope.
   c. only prokaryotes have a nuclear envelope.
   d. only prokaryotes have plastids and mitochondria.
   e. There is no difference between prokaryotes and eukaryotes in terms of cell structure.

59. The main advantage of the electron microscope derives from the fact that ...
   a. magnetic lenses can magnify images larger than glass lenses.
   b. electrons have a shorter wavelength than visible light.
   c. heavy metals stain specimens more selectively than organic dyes.
   d. high resolution is needed to see biological processes occurring in organelles.
   e. electron microscopes can use smaller, thinner specimens than light microscopes.

60. The environmental condition on Mars that most limits the existence of life is probably...
   a. high temperature    b. scarcity of liquid water    c. high CO₂ concentration
   d. lack of atmospheric O₂    e. hostile robots