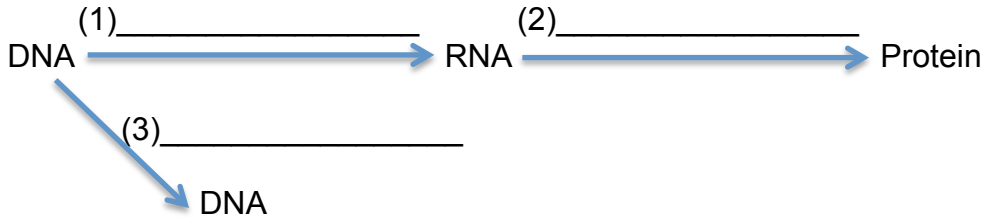
BIOS10191, Fall 2017, Midterm Exam (Practice)

1. The DNA sequence: 5' GGC AAC GTC ATC GGC AAA TTA TAC
3' CCG TTG CAG TAG CCG TTT AAT ATG

is used as a template for an RNA polymerase that makes an RNA that starts as 5' AACG (underlined in sequence). Write out the complete RNA that would be made from this RNA polymerase.

Answer: _____

2. Here is a roadmap for information transfer in cells. Fill in each space with the word that best describes the process.



3. For PCR and other DNA synthesis, DNA is only made in the 5' to 3' direction. Which of the four primers listed here will work to make a complete double stranded DNA molecule from this single strand of DNA? (Circle all correct)

5' GGACTGTTCCCGGGGTGGTGCCCATCCTGGTC 3'

A. GGACTG
B. GACCAG
C. CTGGTC
D. CAGTCC

4. What technique did Rosalind Franklin use to create the images leading to the discovery of DNA structure?

A. Restriction Enzyme Analysis
B. Electrophoresis
C. X-Ray crystallography.
D. Scanning Electron Microscopy
E. Transmission Electron Microscopy

5. Most enzymes are macromolecules composed of:

A) nucleotides. B) sugars.
C) amino acids. D) nucleic acids.
E) amino acids and sugars.

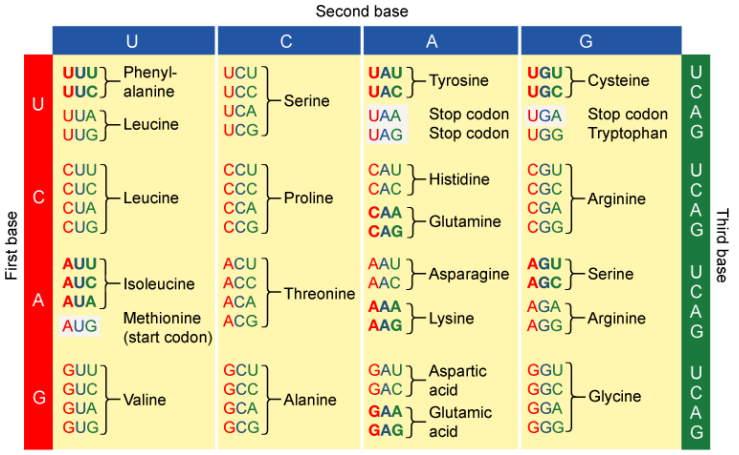
6. In the RNA sequence given below, the underlined AUG codon is the start codon of a protein. What will be the fourth amino acid in the protein?

RNA sequence: UCAUGCUGGACGGCGACGUAAACUGAGCCUAA

_____

7. How many amino acids will be contained in the completed protein?

_____



8. Huntington's Disease (HD) is a devastating family disease. In families in which one parent has been afflicted every generation, every child:

A) has a 100% chance of inheriting the faulty gene.
B) has a 50% chance of inheriting the faulty gene.
C) has a 25% chance of inheriting the faulty gene.
D) will be disease free, yet still transmit the disease to their offspring.

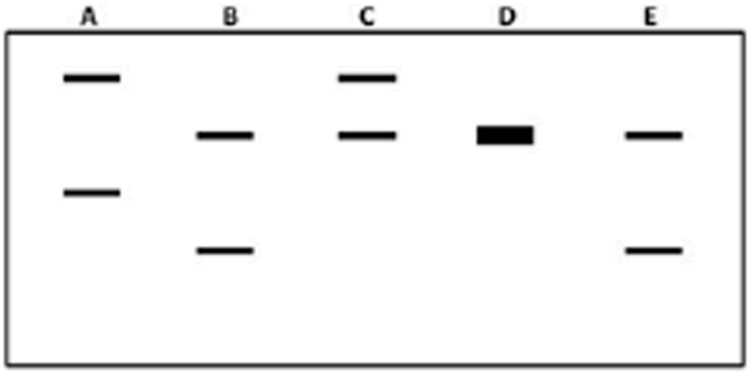
9. Lactose intolerance results when a person inherits two defective alleles of the lactase gene. Normally, this gene produces the enzyme lactase, which breaks down lactose during digestion. What would most likely happen if a person had one defective allele and the other allele was functional?

A) The person could not digest lactose at all.
B) The person could still digest lactose.
C) The person could make lactase but if would not be functional.
D) The person would make more lactase than normal.
E) The person would make no lactase but still could digest lactose.

10. Why can you say that males determine the sex of their children (choose best answer)?

A) Since males have two X chromosomes, whichever one is passed along to their offspring will determine the sex.
B) Males will either contribute an X or a Y chromosome, whereas females will always contribute an X chromosome.
C) Male chromosomes are inherited preferentially over female chromosomes.
D) Y chromosomes are dominant; X chromosomes are recessive.
E) Females possess a sex-determining chromosome but it is not included in their eggs.

11. The gel below shows the STR DNA profiles for several individuals. If sample A is from the mother and sample B is from the father, which one of the others could be from one of their biological children?



A. All (C, D, and E) B. C and E C. C
D. D E. E

12. For each of the 30 STR sites used in the CODIS registry, all individuals must have at least one repeat number and a maximum of _____ repeat numbers.

13. Using the methodology developed by Hardy and Weinberg, for a population made up of AA, Aa, aa individuals and the frequency of A allele = 40%, what is the distribution of AA, Aa and aa genotypes in population?

AA _____ Aa _____ aa _____

14. Huntington's disease is a neurodegenerative genetic disease. Prior to symptoms appearing, it is possible to determine if a person will develop the disease by:

A. determining if the person was exposed to lead or other environmental neurotoxins.
B. examining brain tissue for evidence of traumatic brain injury.
C. examining if the repeat CAG number in the disease-causing gene is greater than 40.
D. determining if one of their parents has the disease.
E. examining if the disease-causing gene is expressed in brain tissue.

15. The labels of diet sodas that contain NutraSweet (an artificial sweetener made of phenylalanine linked to aspartic acid) include a warning to people with PKU. Which of the following statement is the best explanation for this.

A. NutraSweet stimulates different taste receptors than natural sugars do and these are absent in PKU individuals.
B. The PKU individual cannot metabolize phenylalanine, so ingestion of NutraSweet will increase blood levels of phenylalanine.
C. The PKU individual cannot metabolize aspartic acid, so ingestion of NutraSweet will increase blood levels of aspartic acid.
D. In people with PKU, phenylalanine reacts with aspartic acid to form a toxic compound.
E. The PKU individual's diet should add excess phenylalanine and aspartic acid.

16. Liver cells and kidney cells do different tasks because they:
    A) start off with the same DNA, but destroy unnecessary genes.
    B) start off with the same DNA, but gain different genes from stem cells.
    C) contain completely different DNA and genes.
    D) contain the same DNA but use different genes.

17. You create a hybrid transgene containing DNA from a human and a mouse. Which of the following factors would most strongly affect when, where, and how much protein is expressed from that gene?
    A) The gene's regulatory region B) The gene's coding sequence
    C) The age of the host animal D) The number of alleles
    E) Which chromosome the gene resides on

18. Ethical concerns about stem cell therapy:
    A) are largely centered on use of embryonic stem cells.
    B) are largely centered on use of adult stem cells.
    C) are largely centered on use of induced pluripotent stem cells.
    D) are largely centered on use of in-vivo treatments.
    E) are largely centered on use of ex-vivo treatments.

19. As a possible step towards developing a new treatment for cystic fibrosis, scientists have successfully expressed the normal human CFTR protein in the lungs of rats and mice by having the animals inhale viruses containing the human CF gene. If this strategy is used to treat human patients, it would be an example of:
    A. *ex-vivo* gene delivery therapy.
    B. *in-vivo* gene delivery therapy.
    C. transcription factor therapy.
    D. stem cell gene therapy.

20. Scientists describe “Hallmarks of Cancer” as specific attributes that cells acquire as they become cancerous. Name three of these:

    1. _____
    2. _____
    3. _____

21. The typical progression of a cell to a cancerous behavior involve which of the following cellular events (check all that apply):
    □ Multiple genetic changes occur.
    □ Proteins coded by a class of genes called oncogenes become less active or inactive.
    □ Proteins coded by a class of genes called oncogenes become overactive.
    □ Proteins coded by a class of genes called tumor suppressors become less active or inactive.
    □ Proteins coded by a class of genes called tumor suppressors become overactive.

22. For an individual who has colon cancer, the cancer cells usually express an oncogenic form of k-ras while normal tissue does not. How did this happen?

A. The cancer cells came from a blood transfusion or other exchange of body fluids.
B. The copy of the oncogenic form of k-ras was created by DNA damage.
C. A k-ras mutant gene was present in the genome all along was suddenly activated
D. An oncogenic k-ras gene was acquired from eating certain foods.

23. All of the following are true of penicillin EXCEPT

A) Alexander Fleming was the first to study it scientifically.
B) it is produced by bacteria.
C) it was the first antibiotic.
D) it revolutionized medicine.
E) it works against gram-positive bacteria.

24. Penicillin kills bacterial cells but not human cells because

A) human cells do not have cell walls.
B) human cells use ribosomes to make protein.
C) human cells have cholesterol in their cell membrane.
D) bacterial cells do not have cell membranes.
E) bacterial cells do not have DNA.

25. Antibiotic resistant populations of bacterial strains are the result of:

A) fast bacterial doubling time outpaces typical drug doses.
B) increased environmental pressures.
C) binary fission.
D) manipulations in the lab to create new strains for research.
E) increased numbers of infected people.

26. Antibodies against a viral infection are produced more quickly during the second exposure to the virus because:

A. the immune system is stronger in older individuals.
B. there are fewer off targets for viral proteins.
C. memory cells produced from B cells are activated.
D. herd immunity protects all individuals in the population.
E. B cells produced from memory cells are activated.

27. The immune response during the first exposure to antigen is initiated when the antigen binds to a specific protein on the surface of:

A. the immune system's B cells.
B. the infecting pathogen (virus or bacteria).
C. the immune system's memory cells.
D. the immunization solution.

28. If you brought genetically modified lettuce (GMO lettuce) at the supermarket, you should expect that it:

A) contains the same DNA sequences, RNA sequences, and proteins that are found in non-GMO lettuce.
B) has a few different DNA sequences, but the RNA sequences and proteins are the same, as those found in non-GMO lettuce.
C) has a few different DNA and RNA sequences, but proteins are the same, as those found in non-GMO lettuce.
D) has a few different DNA sequences, RNA sequences, and proteins than non-GMO lettuce.

29. The main benefit of Golden rice, a GMO crop designed to make rice more nutritious, is:

A) it has a higher protein content, especially proteins with aromatic amino acids.
B) it has fewer simple sugars, and more complex starch, in the rice.
C) it contains vitamin A, a nutrient that is found in many other edible plants but not in non GMO rice.
D) it has a higher level of iron and other trace minerals that can be extracted from the soil.
E. the rice plant grows well in fields that were not flooded during the rainy season.

30. Plants are resistant to the herbicide Roundup if:

A) they express an enzyme capable of degrading the Roundup chemical.
B) they overexpress a transporter that removes the Roundup chemical from the cell.
C) they express an enzyme that inactivates the Roundup chemical.
D) they express a protein that sequesters the Roundup chemical.
E) they express a bacterial enzyme insensitive the Roundup herbicide.

31-34. Each of these four answers should be written in 2-5 sentences.

1. In a particular flowering plant, two alleles for flower color are possible. One of them causes white flowers; a different allele of the same gene causes red flowers. Which of these alleles is more likely to be dominant? Why?

2. What is the purpose of the CODIS registry of STR (short tandem repeat) sequences?

3. Name a major rationale for limiting the ability of patients and their physicians to determine their medical treatments for cancer and other severe illnesses?

4 What is the major advantage associated with the medical trend towards “personalized medicine” treatment plans?

ANSWER KEY

1. 5'AACGUCAUCGGCAAAUUAUAC. The sequence is read 5'-->3' and every T is changed to U.

2. (1) Transcription, (2) Translation, (3) Replication. The process of making RNA from DNA is called transcription. Translation refers to the process of reading the genetic code in blocs of three to specify the amino acid sequence of the protein product. DNA makes copies of itself by the process of replication.

3. B. There are two things to consider. (1) The two DNA strands go in opposite directions. 92) DNA synthesis only proceeds in the 5' -> 3' direction. So the primer needs to anneal to the sequence on the 3" end of the strand shown. 5' GACCAG will anneal at this location.

4. C. Rosalind Franklin was a expert at X-ray crystallography, also called X-ray diffraction. This is a technique used for determining the atomic and molecular structure of a crystal, in which the crystalline atoms cause a beam of incident X-rays to diffract into many specific directions. The diffraction pattern reveals properties of the molecules within the crystal.

5. C. Enzymes are proteins, and proteins are polymers composed of a specific sequence of amino acids. The nucleic acids DNA and RNA contain the information for ordering amino acids of the protein. DNA and RNA are also polymers but are composed of nucleotides.

6. The AUG start codon codes for Methionine (MET) so MET will be the first amino acid of the protein. The fourth codon is GGC and from the codon table GGC codes for Glycine.

7. There are three stop codons in the genetic code. These are UAA, UGA and UAG. Protein synthesis stops when these are encounered in the mRNA. Starting with the AUG, there are seven coding codons before the stop codon UGA, so there will be seven amino acids in the completed protein.

8. B. Huntington’s disease is dominant. In most affected families, one parent does not carry the disease gene (HD+/HD+) and the afflicted parent is heterozygous (HD+/HD-). The afflicted parent will pass the HD+ gene to their offspring 50% of the time and the disease-causing gene 50% of the time. Since the disease is dominant all children who inherit the disease-causing gene will develop Huntington's disease.

9. B. Unlike Huntington’s disease, most genetic diseases are recessive. In these cases, one good copy of the gene is sufficient to make enough active gene product. Afflicted individuals are those that are homozygous for the disease-causing gene and do not have a means of making an active gene product.

10. B. Sex determination in humans is based on the XX (females) and XY (males) chromosomes. Males create two gamete types, 50% X and 50% Y. Females contribute an X chromosome to 100% of their gametes. The sex of the child then is determined by

whether the fertilized zygote received an X chromosome or a Y chromosome from the father.

11. C. STRs are inherited like genes. Parents have two copies and contribute only one to their children. So a child must possess one of the two STRs present in their biological parents.

12. 2. STRs are on chromosomes and are inherited just like a gene: parents have two copies and each parent contributes one of these to their children. For this reason the maximum number of repeat numbers for one of the STR sites is 2. The reason some individuals have only one repeat number is that they are homozygous for that STR version.

13. AA=16% (p=0.4, AA=p^2=.4 x .4), Aa=2pq=48%, and aa= (q=0.6, aa=q^2=.6 x .6). Hardy and Weinberg developed mathematical equations to determine the genetic make-up of a population. p=frequency of allele A, q=frequency of allele a. The homozygous genotype AA is calculated as p^2 (p squared), the heterozygous Aa is 2pq and homozygous aa = q^2 (q squared). You also know that p + q = 1 and p2 + 2pq +q2 = 1. These equations allow allele frequencies to be calculated from genotype frequencies and vice versa.

14. C. Huntington's disease is inherited in a dominant fashion. The discovery of the HD gene in 1993 resulted in a direct genetic test to make or confirm a diagnosis of HD. Using a blood sample, the genetic test analyzes DNA for the HD mutation by counting the number of CAG repeats in the HD gene. Individuals with HD have 40 or more repeats in one copy of the HD gene.

15. B. Phenylketonuria (fen-ul-ke-toe-NU-re-uh), also called PKU, is a rare inherited disorder that causes an amino acid called phenylalanine to build up in the body. High phenylalanine levels cause developmental defects and other health concerns. PKU is caused by a defect in the gene that helps create the enzyme needed to break down phenylalanine. Without the enzyme necessary to process phenylalanine, a dangerous buildup can develop if someone with PKU person eats foods that are high in protein or other sources of phenylalanine. Nutrasweet is made from phenylalanine so it is included among these foods.

16. E. With very rare exceptions, all cells in the body contain exactly the same DNA. Different cell types (for example muscle cells and skin cells) have different properties because they do not express the same genes.

17. A. The gene expression profile is dependent on regulatory sequences present within the promoter region of a gene. Hybrid genes often combine a promoter from one source and the coding information from another.

18. A. The major stem cell controversy centers on the fact that the destruction of human embryos is required to harvest embryonic stem cells. Other stem cell types can be generated without this process and so trigger less ethical concern.

19. B. Gene therapy strategies can be classified into two groups: in-vivo and ex-vivo. For in vivo, which means interior, the gene is transferred to cells residing inside the patient’s body. if the patient's cells are removed from the patient, grown in the laboratory for the gene treatment process and then returned to the patient, the gene therapy is called ex vivo because the cells are treated outside the body.

20. All cancers share common traits ("hallmarks") that govern the transformation of normal cells to cancer (malignant or tumor) cells. The traits highlighted in our class are (1) Cancer cells stimulate their own growth (self-sufficiency in growth signals); (2) They resist inhibitory signals that might otherwise stop their growth (insensitivity to anti-growth signals); (3) They resist their programmed cell death (evading apoptosis); (4) They can multiply indefinitely (limitless replicative potential) (5) They stimulate the growth of blood vessels to supply nutrients to tumors (sustained angiogenesis); (6) They invade local tissue and spread to distant sites (tissue invasion and metastasis).

21. A, C, D. Mutations found in the DNA of cancer cells typically affect two general classes of genes: oncogenes and tumor suppressor genes. In “normal,” non-cancerous cells, the normal versions of the oncogene (gas pedal) and tumor suppressor genes (brakes) are regulated in ways to promote normal development and tissue maintenance. In cancer cells, oncogenes are more active thus enhancing growth potential and tumor suppressor genes are less active and thus unable to slow growth signals.

22. B. Genetic changes (mutations) occurred within a normal cell of the colon. These changes increased the rate at which the cell underwent cell division and allowed the cell to gain the other attributes (hallmarks) of cancer cells.

23. B. Penicillin was discovered in 1928 by Scottish scientist Alexander Fleming. He noted that a mold growing on the same plate as the bacteria caused: "bacterial cells became transparent and were obviously undergoing lysis … the broth in which the mold had been grown at room temperature for one to two weeks had acquired marked inhibitory, bactericidal and bacteriolytic properties to many of the more common pathogenic bacteria". Penicillin is produced by the mold, not the bacteria. This discovery is due to the inadvertant growth of a mold on a bacterial culture plate. The discovery of penicillin changed the course of medicine and has enabled physicians to treat formerly severe and life-threatening illnesses such as bacterial endocarditis, meningitis, pneumococcal pneumonia, gonorrhea and syphilis.

24. A. Bacterial cells are surrounded by a cell wall. Penicillin affects the ability of the bacteria to build a strong cell wall, ultimately causing the bacterial cell to burst open. Animal cells do not possess a cell wall, so penicillin has no effect on human cells.

25. B. Bacterial cells do not acquire resistance when exposed to an antibiotic. Rather the small number of cells within the population already possessing resistance to the antibiotic are at a competitive advantage and continue to grow while other cells are killed by the antibiotic. At a later time point, the entire population will be composed of these resistant cells.

26. C. The immune system responds to a pathogen by triggering the cell division of B-cells capable of making antibodies that can combat the pathogen. Some of the cells produced during B-cell multiplication are set aside as memory cells. The memory cells also make antibodies against the pathogen, but do not multiply to create more B-cells until exposure to the pathogen at a later time.

27. A. Every B-cells produces a particular antibody on their cell surface. If the antibody is capable of binding a antigen present on a pathogen, the B-cell is activated and undergoes cell division. This creates many B-cells capable of combatting the pathogen.

28. D. GMO products contain additional genes to add new features to the crop (usually insect resistance or herbicide resistance). These genes will be transcribed into mRNA and then the mRNA translated into protein, as it is the protein gene product that ultimately provides the additional features.

29. C. Golden rice is a genetically modified, biofortified crop. Biofortification increases the nutritional value in crops. Golden rice is genetically modified in order to produce beta carotene, which is not normally produced in rice. Beta carotene is converted into Vitamin A when metabolized by the human body. We need Vitamin A for healthier skin, immune systems, and vision. However, it is controversial. It is clear that the golden rice debate is about not only golden rice but also genetically modified organisms in general. See more at: http://www.npr.org/sections/thesalt/2013/03/07/173611461/in-a-grain-of-golden-rice-a-world-of-controversy-over-gmo-foods, and https://med.nyu.edu/highschoolbioethics/genetically-modified-organisms-%E2%80%9Cgolden-rice%E2%80%9D-debate.

30. E. Plants possess an enzyme that is inactivated by the Roundup chemical. In the presence of Roundup these plants do not synthesize components needed for amino acid and so will be killed. Roundup-Ready plants have been genetically engineered to express the bacterial version of this enzyme. The bacterial protein is active in the plant and is not inactivated by the Roundup chemical.

31-34. Short answers. (The answers here in the KEY are longer than required on purpose.)

31. If we use gene allele names of R and W, with R/R=Red flowers and W/W=white flowers, most likely R is dominant to W. The reason for this is that genes code proteins and these proteins provide a specific activity to the organism. In this case, it is most likely that the gene is needed to make the red pigment in the flower petals. That would be the normal (wild type) R form. A mutant form (W) then is viewed as lacking the ability to make the red pigment, hence the petals are white. The heterozygote, R/W, still has the ability to make red pigment so R will be dominant to W.
31-NOTE #1: Don't get sidetracked by the nomenclature. Once dominance is established, genetic convention typically uses capital R as designating the dominant alleles and then lower case r, not W, as designating the recessive allele.
31-NOTE #2: While it is possible that a gene may show incomplete dominance, that is the R/r plant only makes 50% red pigment so the flower is pink, the problem specifically asks which is more likely to be dominant so you need to answer this

question. For most genes, 50% activity in the heterozygote is enough to confer the wild type outcome (red flowers in this case). That is why most mutations are recessive. For most genetic diseases, heterozygous individuals are “carriers” who do not show any trace of the disease phenotype seen in the homozygotes.

32. CODIS (Combined DNA Index System) is a national database maintained to support criminal justice using information collected from DNA samples. The DNA samples are mostly obtained from convicted offenders and forensic samples collected at crime scenes. The scientific approach it is based on is known as DNA fingerprinting, sampling up to 30 STR chromosome sites. Together, the STR dataset or DNA fingerprint will be unique for every individual (except identical twins).

33. Patients with serious illnesses like cancer may receive biased or overly optimistic information from the drug companies concerning new treatments. Sometimes there are no good alternative treatment options. As a result, expensive treatments without benefit and/or with serious side effects are considered. So while it has been common to blame insurance companies for not allowing proper care, there are good reasons for insurance companies and professional medical societies have a role to play as new drugs are developed.

34. Personalized medicine is the medical procedure that separates patients into different groups—with medical decisions, practices, interventions and/or products being tailored to the individual patient based on their predicted response or risk of disease. The term has risen in usage in recent years given the growth of new diagnostic and informatics approaches that provide understanding of the molecular basis of disease. Much of the new diagnostic information comes from analysis of the patients’ DNA and molecular details of the cell types causing the disease, This information provides strong evidence on which to stratify (group) related patients to improve treatment outcomes. (text here modified from Wikipedia).