Mini Test 2 - Deep thought Questions for practice

1. The same chromosome can look very different depending on when in the cell cycle it is observed. Explain fully why this is so and also why the chromosome is less condensed during some parts of the cell cycle? How many DNA molecules does each chromosome contain at the beginning of mitosis? Use the following terms in your explanation: **chromatin, histone, chromatid, interphase, metaphase, mitosis, chromosome, gene expression**.

2. A 3000 bp region of the human genome encodes two intron-less genes. One of the genes encodes a protein of 700 amino acids and the other gene encodes a protein of 310 amino acids. The mRNA sequences of the two genes do not contain any of the same nucleotide sequences (i.e. they do not overlap). How is this possible? Fully explain your answer.

3. **a.** Which DNA mutation is more likely to have a detrimental effect on the protein it codes for: a 2-base pair deletion from the middle of the coding sequence of a gene, or a 12- base pair deletion from the same region of the gene? Explain why? **b.** Would the outcome be different if the deletions happened within the gene's intron? Explain why?

4. A mutant *E. coli* strain is found with a mutation affecting **some** of its tRNA(Cys). The wild type normally produces a tRNA that recognizes the codon 5' UGC 3' and is charged with the amino acid Cysteine (Cys) (its notation is tRNA(Cys)). The **mutant** tRNA is still charged with Cysteine, but the mutation is in its anticodon that now has the sequence 5'- **UCA**-3'. How will some of the proteins produced in these *E. coli* cells be different from the proteins produced in the wild type cells?

5. Researchers have identified mutations in the coding region of the *trpR* gene that lead to a change in the structure of the *trpR* repressor protein. In these mutants, the repressor protein's tryptophan binding pocket is now unable to bind free tryptophan. Explain fully what consequence, if any, this will have on the production of tryptophan in the mutant *E. coli* cells.

6. Researchers have identified mutations in the promoter region of the *lacI* gene that lead to **increased** production of the *lacI* repressor protein. In these mutants, it is more difficult for the *lac* operon to be induced. Explain why an increase in *lacI* protein makes it more difficult to induce the *lac* operon in the presence of lactose.

7. A recent research paper demonstrated that cAMP bound to CAP acts more strongly on the lac operon than on the arabinose operon. Given what you know about catabolite regulation, and the lac operon, list the order of preference of utilisation of the three sugars: arabinose, lactose and glucose. Explain.

8. **a.** What is meant by a **repressible operon**?
   b. In the case of the *trp* operon, how is repression exerted?

9. Unfertilized eggs of several animal species contain many mRNAs that should not be translated until fertilization occurs. Describe one possible molecular strategy employed by the egg to ensure timely activity of the proteins encoded by such mRNA.

10. The reading frame is an important concept in the function of a gene. What initiates the reading frame? What maintains it? Does a mutation that alters the anticodon of a tRNA alter the reading frame? How does an out-of-reading frame stop codon affect the translation of an mRNA?

11. Evolutionary change is more closely associated with changes in gene expression rather than with the evolution of new proteins with completely new functions. Describe how homeotic mutations illustrate this point.

12. HIV research has led to development of drugs that can prevent the spread of HIV virus in the host. Thinking about the replication cycle of the HIV virus, what is a likely drug target encoded by the HIV viral genome? Explain in your own words why disabling this target might stop the spread of HIV virus in the host.

13. The novel coronavirus, SARS-CoV-2, which is responsible for the disease Covid-19 is a positive strand RNA ((+)ssRNA) virus. From what you learned in BIOL1020, suggest a model of how the SARS-CoV-2 genome is replicated. The key enzyme for viral replication is unique to the virus and not found in the human host. What is the name of the enzyme, what is its enzymatic function, and how would you explain that a drug called Remdesivir (an adenosine analogue that causes premature termination of RNA synthesis) is currently the most promising drug against a range of RNA viruses, including Ebola ((-)ssRNA virus), MERS ((+)ssRNA virus) and SARS-CoV-2 ((+)ssRNA virus)?

14. Some viruses violate the central dogma of biology. Describe all the ways that different viruses are able to violate the central dogma.

15. A plant breeder breeds avocados, trying to obtain a plant with a unique combination of desirable fruit and pathogen resistance traits. After many years of breeding different wild populations of avocado, success is achieved: an avocado plant that produces fruits of excellent quality and has very strong resistance to a range of bacterial pathogens. To produce more plants like this one, should she reproduce this plant by self-fertilisation or produce more plants via asexual reproduction (using cuttings) and why? Fully explain your answer.

16. Considering the developmental origins of the germ line cells in plants and animals, what are the relative odds (plants vs. animals) of a somatic mutation in a parent being heritable? Explain your answer.

17. You would like to isolate a mutant fern capable of growing in the presence of arsenic, which is usually toxic to wild type ferns. Which specific part of a fern would you treat with a mutagen X in order to be able to identify mutant ferns within the same generation? Explain your strategy, which should be able to identify mutations right away (even if the mutation is recessive). **Hint:** Look at the life cycle of the fern.

18. The Klinefelter syndrome (disomy of the X chromosome in males) is a genetic condition caused by aneuploidy of the sex chromosomes in humans. Patients with the 47,XXY karyotype are male. Describe two genetic scenarios leading to patients with the Klinefelter syndrome.

19. For bacteria living in a rapidly changing environment, would a population of bacteria capable of conjugation be more successful than one that could not undergo conjugation? Explain why. Include in your answer a description of the process of conjugation and its advantages over other mechanisms of DNA transfer between prokaryotic organisms.

20. Even in the absence of genetic recombination, meiosis is an important source of genetic variation in sexually reproducing organisms. Use as an example a species with 2n=8, and an individual of that species that is a quadruple heterozygote for loci A, B, C, and D, with each locus on a different chromosome. Determine how many different types of gametes this individual can produce and explain how **segregation** and **independent assortment** mechanisms

produce genetic variation in the gametes produced by this individual. Use the following terms in your response: **genes; alleles; homologous chromosomes; nonhomologous chromosomes**.

21. Explain why seedless watermelons are produced from triploid mother plants. State the ploidy of the gametes of the triploid parent and explain why that is the case. (**Note:** we are **not** asking you how the triploid parent was produced in the first place.)

22. In Labrador retrievers, a gene (B) determines the black or chocolate coat colour. The black colour (B) is dominant over chocolate (b). Your neighbour owns two Labradors from the same litter, both female, one black, one chocolate. He paid $10,000 to send his chocolate Labrador female to breed with a champion chocolate Labrador sire. This "champion" is owned by a dishonest character. Your neighbour is not a witness to the mating. Last weekend the neighbour's dog gave birth to 12 puppies, 7 of which are chocolate colour and 5 are black. What is the most likely explanation for this?

23. Using Mendel's lines of peas, describe how you would use a test cross experimental design to determine the genotype of a pea plant with yellow pods. Be very specific in describing your experimental design and how you would interpret your results based on the proportion of offspring phenotypes. Make sure to include all possible offspring phenotypes in your answer and what the proportion of phenotypes tells you about the plant with yellow pods genotype.