Norwegian University of Science and Technology
Department of Biology

EXAMINATION IN BI1001 – CELL AND MOLECULAR BIOLOGY

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Date of examination: May 21st 2015

Time: 6 hours

Credits: 15

Permitted aids: none

Language: English

No. of enclosures: 8

Grades to be announced on: June 19th 2015

All questions count as equal. The multiple-choice test (5) counts as equal as one of the main questions (1,2,3,4). Note that single questions might be weighted differently (indicated in %).

Please start answering each question (1,2,3,4) on a new sheet of paper!

Exercise 1

a) DNA is a polymer. Which monomers is it composed of? What characterizes these monomers? Describe the chemical structure that links the monomers together. (30%)

b) Discuss the main steps in DNA replication. Describe the central molecular events and mention the most central proteins involved in each of these processes: replication start, elongation, finalizing steps. (70%)

Exercise 2

a) Describe how the glycolysis enables the cell to harvest chemical energy by oxidizing glucose. How does the cell respond if the oxygen level is low and what are the regulatory mechanisms behind this? (33%)

b) Explain how chemiosmosis is used by cells to produce ATP. What are the structural similarities and differences between this process in mitochondria and chloroplasts? (33%)

c) Describe how NADPH and ATP generated during photosynthesis are used to produce carbohydrates in plant cells. What happens if the CO_2 concentration in the leaf becomes low and the relative O_2 concentration increases? (33%)

Exercise 3

a) Two labrador retriever dogs are mated. Both are black and heterozygous for the black (B) and brown (b) alleles at the gene for coat colour (i.e. both parents are Bb). Use Mendel's first law and a Punnett square to explain what ratio of black and brown puppies we expect from this mating. (35%)

b) In labrador retrievers another gene determines whether the coat will have pigment or not: EE and Ee individuals have coat colour pigment (i.e. they are black or brown depending on their alleles at the B-gene), whereas ee individuals do not and are yellow. Assume that a black BbEe individual is mated to a yellow Bbee individual. Use Mendel's first and second laws and a Punnett square to explain what ratio of black, brown and yellow puppies we expect from this mating. (35%)

c) Explain the difference between epistasis and pleiotropy. (30%)

Exercise 4

a) How does binding of the *trp* corepressor to its repressor alter repressor function and transcription? What about binding of the *lac* inducer to its repressor? (33 %)

b) What are some potential difficulties in using plasmid vectors and bacterial host cells to produce large quantities of proteins from cloned eukaryotic genes? (33 %)

c) What are the three ways that transposable elements are thought to contribute to genome evolution? (33%)

Exercise 5 – 25 Multiple Choice Questions, 5 pages

This is a multiple choice exercise. Tick off correct answers directly in the exercises. Exercise 5 is teared off from the set of questions. Note: Only one answer per question. Correct answer gives one point, while two or several answers, or incorrect answer, give 0 points.

1	Which of these classes of biological molecules consist of both small molecules and macromolecular polymers? A) lipids B) carbohydrates C) proteins D) nucleic acids E) lipids, carbohydrates, proteins, and nucleic acids all consist of only macromolecular polymers	**A**	**B**	**C**	**D**	**E**
2	What aspects of protein structure are stabilized or assisted by hydrogen bonds? A) primary structure B) secondary structure C) tertiary structure D) quaternary structure E) secondary, tertiary, and quaternary structures, but not primary structure	**A**	**B**	**C**	**D**	**E**
3	Which bonds are created during the formation of the primary structure of a protein? A) peptide bonds B) hydrogen bonds C) disulfide bonds D) phosphodiester bonds E) peptide bonds, hydrogen bonds, and disulfide bonds	**A**	**B**	**C**	**D**	**E**
4	Where does glycolysis take place in eukaryotic cells? A) mitochondrial matrix B) mitochondrial outer membrane C) mitochondrial inner membrane D) mitochondrial intermembrane space E) cytosol	**A**	**B**	**C**	**D**	**E**
5	Which of the following is the best explanation for the fact that most transduction pathways have multiple steps? A) Most of the steps were already in place because they are steps in other pathways. B) Multiple steps in a pathway require the least amount of ATP. C) Multiple steps provide for greater possible amplification of a signal. D) Each individual step can remove excess phosphate groups from the	**A**	**B**	**C**	**D**	**E**

	cytoplasm. E) Each step can be activated by several G proteins simultaneously.					
6	What explains the increased concentration of Ca^{++} in the ER? A) Calcium ions are actively imported from the cytoplasm into the ER. B) Calcium concentration is kept low in the cytoplasm because of its high usage level. C) Calcium cannot enter the plasma membrane through ion channels. D) Calcium levels in the blood or other body fluids are extremely low. E) The Ca ions are recycled from other molecules in the ER.	**A**	**B**	**C**	**D**	**E**
7	Which of the following describes the events of apoptosis? A) The cell dies, it is lysed, its organelles are phagocytized, and its contents are recycled. B) Its DNA and organelles become fragmented, it dies, and it is phagocytized. C) The cell dies and the presence of its fragmented contents stimulates nearby cells to divide. D) Its DNA and organelles are fragmented, the cell shrinks and forms blebs, and the cell self-digests. E) Its nucleus and organelles are lysed, and then the cell enlarges and bursts.	**A**	**B**	**C**	**D**	**E**
8	Which of the following is (are) required for motor proteins to function in the movement of chromosomes toward the poles of the mitotic spindle? A) intact centromeres B) an MTOC (microtubule organizing center) C) a kinetochore attached to the metaphase plate D) ATP as an energy source E) synthesis of cohesin	**A**	**B**	**C**	**D**	**E**
9	Which of the following is a protein maintained at constant levels throughout the cell cycle that requires cyclin to become catalytically active? A) PDGF B) MPF C) protein kinase D) cyclin E) Cdk	**A**	**B**	**C**	**D**	**E**
10	Which of the following best describes a karyotype? A) a pictorial representation of all the genes for a species	**A**	**B**	**C**	**D**	**E**

	B) a display of each of the chromosomes of a single cell C) the combination of all the maternal and paternal chromosomes of a species D) the collection of all the chromosomes in an individual organism E) a photograph of all the cells with missing or extra chromosomes					
11	How do cells at the completion of meiosis compare with cells that have replicated their DNA and are just about to begin meiosis? A) They have twice the amount of cytoplasm and half the amount of DNA. B) They have half the number of chromosomes and half the amount of DNA. C) They have the same number of chromosomes and half the amount of DNA. D) They have half the number of chromosomes and one-fourth the amount of DNA. E) They have half the amount of cytoplasm and twice the amount of DNA.	**A**	**B**	**C**	**D**	**E**
12	How does the sexual life cycle increase the genetic variation in a species? A) by allowing crossing over B) by allowing fertilization C) by increasing gene stability D) by conserving chromosomal gene order E) by decreasing mutation frequency	**A**	**B**	**C**	**D**	**E**
13	What is the function of reverse transcriptase in retroviruses? A) It hydrolyzes the host cell's DNA. B) It uses viral RNA as a template for DNA synthesis. C) It converts host cell RNA into viral DNA. D) It translates viral RNA into proteins. E) It uses viral RNA as a template for making complementary RNA strands.	**A**	**B**	**C**	**D**	**E**
14	The centimorgan (cM) is a unit named in honor of Thomas Hunt Morgan. To what is it equal? A) the physical distance between two linked genes B) 1% frequency of recombination between two genes C) 1 nanometer of distance between two genes D) the distance between a pair of homologous chromosomes E) the recombination frequency between two genes assorting independently	**A**	**B**	**C**	**D**	**E**

15	One possible result of chromosomal breakage is for a fragment to join a nonhomologous chromosome. What is this alteration called? A) deletion B) transversion C) inversion D) translocation E) duplication	**A**	**B**	**C**	**D**	**E**
16	Suppose that a gene on human chromosome 18 can be imprinted in a given pattern in a female parent but not in a male parent. A couple in whom each maternal meiosis is followed by imprinting of this gene have children. What can we expect as a likely outcome? A) All sons but no daughters will bear their mother's imprinting pattern. B) All daughters but no sons will bear their mother's imprinting pattern. C) All sons and daughters will have a 50% chance of receiving the mother's imprinting pattern. D) All the children will bear their mother's imprinting pattern but only daughters will then pass it down. E) Each of the children will imprint a different chromosome.	**A**	**B**	**C**	**D**	**E**
17	In an analysis of the nucleotide composition of DNA, which of the following will be found? A) A = C B) A = G and C = T C) A + C = G + T D) G + C = T + A E) C = T	**A**	**B**	**C**	**D**	**E**
18	The enzyme telomerase solves the problem of replication at the ends of linear chromosomes by which method? A) adding a single 5' cap structure that resists degradation by nucleases B) causing specific double-strand DNA breaks that result in blunt ends on both strands C) causing linear ends of the newly replicated DNA to circularize D) adding numerous short DNA sequences such as TTAGGG E) adding numerous GC pairs which resist hydrolysis and maintain chromosome integrity	**A**	**B**	**C**	**D**	**E**
19	The genetic code is essentially the same for all organisms. From this, one can logically assume which of the following? A) A gene from an organism can theoretically be expressed by any other organism.	**A**	**B**	**C**	**D**	**E**

	B) All organisms have experienced convergent evolution. C) DNA was the first genetic material. D) The same codons in different organisms translate into the different amino acids. E) Different organisms have different numbers of different types of amino acids					
20	Accuracy in the translation of mRNA into the primary structure of a polypeptide depends on specificity in the A) binding of ribosomes to mRNA. B) shape of the A and P sites of ribosomes. C) bonding of the anticodon to the codon. D) attachment of amino acids to tRNAs. E) bonding of the anticodon to the codon and the attachment of amino acids to tRNAs.	**A**	**B**	**C**	**D**	**E**
21	Why might a point mutation in DNA make a difference in the level of protein's activity? A) It might result in a chromosomal translocation. B) It might exchange one stop codon for another stop codon. C) It might exchange one serine codon for a different serine codon. D) It might substitute an amino acid in the active site. E) It might substitute the N-terminus of the polypeptide for the C-terminus.	**A**	**B**	**C**	**D**	**E**
22	If you were to observe the activity of methylated DNA, you would expect it to A) be replicating nearly continuously. B) be unwinding in preparation for protein synthesis. C) have turned off or slowed down the process of transcription. D) be very actively transcribed and translated. E) induce protein synthesis by not allowing repressors to bind to it.	**A**	**B**	**C**	**D**	**E**
23	Steroid hormones produce their effects in cells by A) activating key enzymes in metabolic pathways. B) activating translation of certain mRNAs. C) promoting the degradation of specific mRNAs. D) binding to intracellular receptors and promoting transcription of specific genes. E) promoting the formation of looped domains in certain regions of DNA.	**A**	**B**	**C**	**D**	**E**

24	Muscle cells differ from nerve cells mainly because they A) express different genes. B) contain different genes. C) use different genetic codes. D) have unique ribosomes. E) have different chromosomes.	**A**	**B**	**C**	**D**	**E**
25	How does a bacterial cell protect its own DNA from restriction enzymes? A) by adding methyl groups to adenines and cytosines B) by using DNA ligase to seal the bacterial DNA into a closed circle C) by adding histones to protect the double-stranded DNA D) by forming "sticky ends" of bacterial DNA to prevent the enzyme from attaching E) by reinforcing the bacterial DNA structure with covalent phosphodiester bonds	**A**	**B**	**C**	**D**	**E**