

BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI

First Semester 2010-2011 BIO C111 General Biology

Date: Dec. 1, 2010

COMPREHENSIVE EXAMINATION (Part-A)

Max. Marks: 40

Type: Closed-book

Max. Time: 1 hour

- The exam is divided into Part-A (Closed-book type) and Part-B (Open-book type). You are now having Part-A of the question paper.
- Answer this part of the exam in the space provided.
- You have a maximum of 1 hour to answer Part-A, but you can turn in the paper any time after 30 min. to the invigilator to collect Part-B.

For questions 1 through 6, write the alphabet corresponding to the right choice in the box given: [3]

1. You have a piece of DNA that includes the following sequence:

5'-ATAGGCATTCGATCCGGATAGCAT-3'

3'-TATCCGTAAGCTAGGCCTATCGTA-5'

Which of the following RNA molecules could be transcribed from this piece of DNA?

(a) 5'-UAUCCGUAAGCUAGGCCUAUGCUA-3'

(b) 5'-AUAGGCAUUCGAUCCGGAUAGCAU-3'

(c) 5'-UACGAUAGGCCUAGCUUACGGAUA-3'

(d) none of the above

2. Orchids are epiphytes because they

(a) Benefit by living on other plants which in turn benefit their hosts

(b) Benefit by living on other plants causing moderate, but not lethal, harm to their hosts

(c) Benefit by living on other plants without harming their hosts

(d) Live on plants which benefit other hosts but not the orchids themselves

3. You have a segment of DNA that contains the following sequence:

5'-GGACTAGACAAATAGGGACCTAGAGATTCGAAA-3'

3'-CCTGATCTGTTATCCCTGGATCTCTAAGGCTTT-5'

If you know that the RNA transcribed from this segment contains the following sequence:

5'-GGACUAGACAAUAGGGACCUAGAGAUUCCGAAA-3'

Which of the following choices best describes how transcription occurs?

(a) The top strand is the template strand; RNA pol. moves along this strand from 5' to 3'.

(b) The top strand is the template strand; RNA pol. moves along this strand from 3' to 5'.

(c) The bottom strand is the template strand; RNA pol. moves along this strand from 5' to 3'.

(d) The bottom strand is the template strand; RNA pol. moves along this strand from 3' to 5'.

4. Which of the following statements about the genetic code is correct?

(a) All codons specify more than one amino acid.

(b) The genetic code is redundant (i.e., unnecessarily excess)

(c) All amino acids are specified by more than one codon.

(d) All codons specify an amino acid.

5. Which of the following statements most correctly describes meiosis?

(a) Meiosis involves two rounds of DNA replication followed by a single cell division.

(b) Meiosis involves a single round of DNA replication followed by 4 successive cell divisions.

(c) Meiosis involves four rounds of DNA replication followed by 2 successive cell divisions.

- (d) Meiosis involves a single round of DNA replication followed by 2 successive cell divisions.
6. Which of the following reasons was essential for Mendel to disprove the theory of blended inheritance? ce?
- (a) The traits that Mendel examined all involved genes that did not display linkage.
- (b) The traits that Mendel examined all involved the reproductive structures of the pea plant.
- (c) Mendel pioneered techniques permitting the fusion of male and female gametes from the same plant to produce a zygote.
- (d) The traits that Mendel examined involved an allele that was dominant and an allele that was recessive.
7. Match each organism in the first column with its corresponding trophic level shown in the second column. Write the corresponding number in the space provided. Each trophic level should be used only once.

[2]

- | | |
|-----------------------|-----------------------|
| (a) Alga _____ | (1) Producer |
| (b) Mushroom _____ | (2) Tertiary consumer |
| (c) Zooplankton _____ | (3) Detritivore |
| (d) Eagle _____ | (4) Primary consumer |

8. Selected events that happen when a fat particle is used for generating energy are given below. Identify and write down the entities 'A' through 'J'. [5]

Fats ingested in food → Reach the stomach → Emulsified by **substance-A** in the digestive tract → Emulsified droplets hydrolyzed by **enzyme-B** → After processing, re-synthesized into fats → Enter into **vessel-C** within the digestive tract, that joins into **vessel-D** → Vessel-D eventually drains into **vessel-E** → Vessel-E drains into **organ-F** → The triglyceride fat particle leaves the organ via **vessel-G** → Ultimately, the fat particle reaches the skeletal muscle cell of the arm → Enters into **organelle-H** within the muscle cell → Hydrolyzed into 2-carbon fragments and converted into **compound-I** that can be used to generate a maximum of '**J**' number of ATPs.

A =	B =	C =
D =	E =	F =
G =	H =	I =
J =		

9. Identify each of the following and write in the space provided: [5]

- (a) A molecule used for intermediate storage of energy in photosynthesis -
- (b) The hormone that enhances uterine contractions during parturition -
- (c) The layer of the uterine wall that is shed during menstruation -
- (d) The effector cells that produce antibodies -
- (e) The pigment that is present in specialized neurons of the eye -
- (f) A membranous organelle that harbors non-membranous organelle -
- (g) The membranous organelle found abundantly in human liver cells -
- (h) Analogous structures to microtubule organizing centre in animal cells -
- (i) A group of prokaryotes with introns -
- (j) Parasitic infectious agents that completely depend on their hosts for metabolism -

10. **Based on the relationship between members of one pair, identify and write down the missing member in the other pair in each of the following cases:** [6]
- (a) Cell-mediated immune response : T cells :: : B cells
- (b) Ear : hair cells within organ of Corti :: Eye :
- (c) : blood pressure :: cerebellum : muscular coordination
- (d) Insulin : Blood Glucose :: : Blood Ca^{2+}
- (e) *Homo sapiens* : Race :: *Escherichia coli* :
- (f) Plasmid : : Protein hormone : peptide linkage

11. **For each of the following sentences, fill in the blanks with the best word or phrase selected from the list below. Not all words or phrases will be used; each word or phrase should be used only once.** [4]

The action potential is a wave of that spreads rapidly along the neuronal plasma membrane. This wave is triggered by a local change in the membrane potential to a value that is negative than the resting membrane potential. The action potential is propagated by the opening of-gated channels. During an action potential, the membrane potential changes from to The action potential travels along the neuron's to the nerve terminals, and then via the to the next neuron. Neurons chiefly receive signals at their highly branched

anions	depolarization	negative
axon	hyperpolarization	neutral
synapse	less	positive
cytoskeleton	ligand	pressure
dendrites	more	voltage

12. **Answer each of the following questions in the space provided, within a few sentences:** [15]
- (a) Which hormone is produced exclusively during pregnancy? What is its major role?

(b) What is the role of *SRY* gene in human sex determination?

(c) Do spermatogenesis and oogenesis differ with respect to the number of gametes per cell and ploidy of daughter cells? Justify.

- (d) Why antibiotics like chloramphenicol and tetracycline do not affect human cells?
- (e) What is the difference between “respiration” and “cellular respiration”?
- (f) How is *founder effect* different from *genetic bottleneck*?
- (g) How is Craig Venter’s experiment with *M. mycoides* similar to SCNT? How is it different?
- (h) Mention one ecological and one physiological advantage of using the polymer developed from *Jatropha* sp.
- (i) How do sex hormones affect the human brain? Give at least one specific example to explain.
- (j) How would DNA barcoding of birds help in their classification?

- There are five questions in total printed across four pages.
- You may attempt the questions in any order, but all parts of the same question must be answered together. If you jumble the sub-parts of a question, they may not be evaluated.

2. (A) If the sequence of the non-template strand of DNA is:

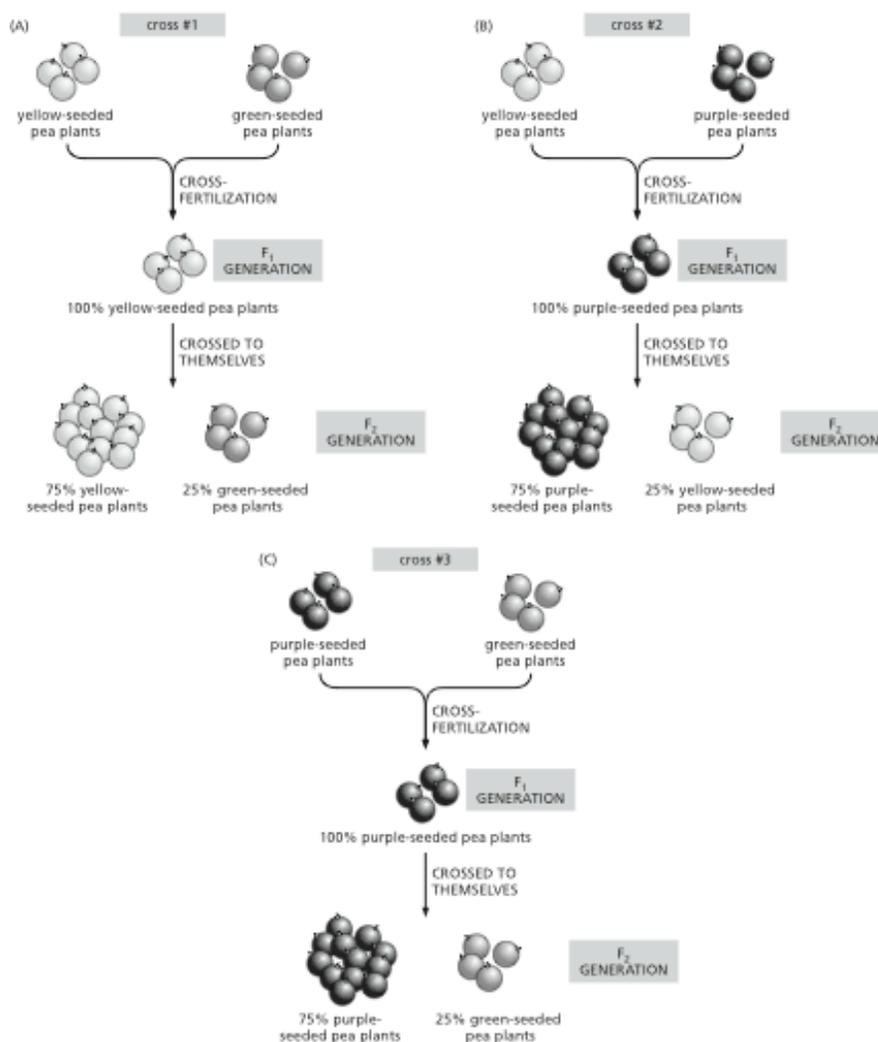
5' GGGATCGATGCCCTTAAAGAGTTTACATATTGCTGGAGGCGTTAACCCCGGA 3'

- Write the primary sequence of the peptide formed, starting with the initiating amino acid.
- How will the primary sequence be affected if the codon for tryptophan is changed to UAA?
- How many possible mRNA sequences can code for the peptide sequence indicated in part (b) above? Explain briefly. [2 + 1 + 2]

(B) Your friend has obtained some pea seeds from the Abbey of St. Thomas in Brno, where Gregor Mendel worked. He is very excited because not only did he obtain some yellow and green pea seeds from true-breeding plants (like the ones used in Mendel's famous experiment), he was also able to obtain some purple pea seeds from a true-breeding plant. He performs three types of crosses as illustrated on the right.

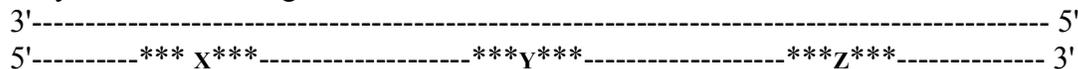
Given these results, if you were to take the purple-seeded pea plants produced in the F₁ generation in cross #2 and cross them to the purple-seeded pea plants produced in the F₁ generation of cross #3, what would be the phenotypic and genotypic ratios of the resulting progeny? Also represent every cross using the standard genotype notation, stating the alleles clearly.

[5]



(C) A trihybrid plant, having the genotype $AaBbC^1C^2$, is self-fertilized. All loci are unlinked. There is complete dominance at the A and B loci but incomplete dominance at the C locus. What fraction of progeny will be phenotypically different from the parent? Show all the steps how you arrived at the final answer. [3]

(D) Shown below is the snapshot of a DNA strand being replicated. The primers X , Y and Z are indicated by ***** in the figure.



- (a) Which of the three RNA primers would first be incorporated as part of Okazaki fragment? Explain.
 (b) Which of the three primers will be the first to be removed, and why? [3 + 2]

3. (A) A given 320 kb DNA has three sites for a restriction enzyme A at positions (from the left): 50 kb, 80 kb, and 120 kb respectively. It has one site for another restriction enzyme B at 200kb (from the left). What will be the number of bands and their sizes, if this DNA is subjected to electrophoresis after being digested using: [3]

- (a) Enzyme A
- (b) Enzyme B
- (c) Both the enzymes

(B) What is the importance of the free 3'-OH group in a deoxyribonucleotide? Which application in biotechnology utilizes the absence of the 3'-OH, and how? [3]

(C) “You can isolate PSII from a bunch of spinach [a plant whose leaves are used in salad], put it in water, turn on a light, and get oxygen!” says Vittal Yachandra from the Berkeley Lab’s Physical Biosciences Division, whose lab does pioneering research on the oxygen-evolving complex (OEC) housed within PSII. He quips, “We still don’t know how to do that on the lab bench using synthetic catalysts.”

- (d) Based on what you have learned about plant photosynthesis, how do you think the OEC works?
- (e) Of what use is the OEC to the plant?
- (f) Hydrogen economy is a proposed system of using hydrogen as a fuel and is thought as an alternative to the current hydrocarbon economy. Because molecular hydrogen is not available in large quantities on earth, the search for newer and efficient methods for H_2 production is always on. How could the research by Vittal Yachandra find an application to be used in the development of hydrogen economy? [2 + 2 + 2]

(D) What will happen if we irrigate a crop plant with seawater? Justify your answer, mentioning the phenomenon involved. [3]

(E) How many ATPs and CO_2 will be produced from 50 glucose molecules present in a mature red blood cell? Justify. [3]

4. (A) Why should it be that drugs such as colchicines, that inhibit microtubule polymerization and drugs such as Taxol, that stabilize microtubules both inhibit mitosis? [3]

(B) Different cells are isolated from different tissues of the same species of eukaryotic organisms. The total DNA content of each cell is measured, with these results:

<u>Cell Sample</u>	<u>Total DNA Content</u> (in nanograms)
#1	5.1 ± 0.2
#2	2.4 ± 0.1
#3	6.7 ± 0.1
#4	9.8 ± 0.2
#5	2.7 ± 0.2

Each isolated cell was one of the following types:

- (a) Skin cell in G1 phase (b) Lung cell in G2 phase
 (c) Skin cell in S phase (d) Mature sperm cell (e) Mature egg cell

What types of cells (a-e) are there in each cell sample (#1-#5) given? Give appropriate justifications. (Hint: Consider all the data given before answering.) **[4]**

(C) During their Arctic expeditions, scientists are discovering many species of well-adapted microorganisms that live in low temperatures. These microbes are called *psychrophiles* (“cold-loving”). Suppose three new psychrophiles - A, B and C - that produce enzymes that could find used in biotech industry have been found. Species A produces the enzymes protease and lipase, species B produces protease only, and species C produces protease, lipase and cellulase. A detergent industry ‘Surfoclean’ sees these bacteria as potential sources of ‘washing enzymes’, to be used as part of detergents in washing machines.

- (i) Comparing these psychrophilic bacteria with mesophilic bacteria (those that grow between 15-40 °C):
 - (a) How would the activity profile of the metabolic enzymes differ between these two groups?
 - (b) Mention one feature of the membrane lipids that would differ between these two groups and why you think so.
- (ii) As the General Manager of ‘Surfoclean’, which of the three bacterial species of bacteria would you choose as the best source of enzyme(s) for incorporation into detergents? Why not the others? Justify.
- (iii) Using recombinant DNA techniques, how would you commercially produce these ‘Arctic-bacteria’ enzymes for use in detergents? Just outline the steps using a flowchart.
- (iv) Can you cite a popular example in molecular biology wherein the product of another extremophile bacterium has been widely used? **[3+2+2+1]**

5. **(A)** Many physiological parameters are controlled by either having a pair of hormones with opposite effects or by using a single hormone that changes the parameters in one direction only.
 - (i) Give an example of each of the two mechanisms mentioned above. Simply state the hormone(s) and the parameters they control. **[2]**
 - (ii) What is the advantage of the former mechanism compared to the latter? **[2]**

(B) Forests of Satpura contained approximately 800 tigers 40 years back. Extensive poaching has decreased their number to less than 70 and the remaining ones have begun to suffer from a disease causing muscular atrophy. What do you think is the relationship between their dwindling numbers and disease development? **[2]**

- (C) A website on disease control and prevention says the following about antibiotic resistance, “Antibiotic resistance occurs when bacteria change in some way that reduces or eliminates the effectiveness of drugs, chemicals, or other agents designed to cure or prevent infections. The bacteria survive and continue to multiply causing more harm.” As a student of biology, what errors do you find in the above text? How will you explain the concept of antibiotic resistance to a layman? [3]
- (D) Mention two ways the mother confers passive immunity to her child. Why does this passive immunity not offer long-term protection for the child? [4]
- (E) One may say that B cell is a double-edged sword. That is, it has produces both favorable and sometimes, unfavorable consequences! Justify. [3]
6. (A) How can *predators* function as agents of natural selection in prey populations? [1]
- (B) How can *prey* function as agents of natural selection in predator populations? [1]
- (C) What are the three possible fates for an organism at third trophic level if the organisms at the second trophic level are eliminated? In each case, specify how the organisms at the first trophic level be affected. [3]
- (D) A sample of bread gives a faint positive color with Nelson’s reagent for reducing sugar. After an equivalent bread sample has been masticated or chewed, the test becomes markedly positive. Explain the biochemistry behind this observation. [3]
- (E) Where stereoisomers of biomolecules are possible, only one is usually found in most organisms. For example, only L-amino acids occur in proteins. What problems would occur if, for example, the amino acids in body proteins of herbivores were in the L-isomer form, whereas those in a large number of plants they fed upon were in the D-isomer form? [2]
- (F) A wildlife biologist team wishes to clone a female member of an endangered species of bears. For each of these choices, explain whether the nucleus of the cell can be used for cloning or not. [3]
- (i) primary oocyte (ii) secondary oocyte (iii) bone marrow stem cell
-