國立清華大學 103 學年度碩士班考試入學試題

系所班組別：生醫工程與環境科學系 甲組(分子生醫工程組)

考試科目（代碼）：普通生物學(2305)

一、問答題 (70%)

1. It is possible to extract DNA from cells and analyze it to determine the relative amounts of the four DNA bases. The DNA of a goldfish contains more T and less G than human DNA, but in both goldfish and human DNA the amount of T is equal to the amount of A. Explain why? (8%)

2.
(1) In bacterium, how dose cyclic AMP (cAMP) regulate lac operon if glucose exists? (5%)
(2) Mutations sometimes affect operons. Imagine a mutation in the regulatory gene that produces the repressor of the *lac* operon in E. coli. The altered repressor is no longer able to bind to the operator. What effect will this have on the bacterium? (5%)

3. Hypoglycemia is a condition in which blood sugar drops to abnormally low levels. What seems to be the cause of hypoglycemia? Why would it not be a good idea to try to deal with this problem by eating more sugar? (8%)

4.
(1) A mutation in a single gene may cause a major change in the body of a fruit fly, such as an extra pair of legs or wings. Yet it probably takes the combined action of hundreds or thousands of genes to produce a wing or leg. How can a change in just one gene cause such a big change in the body? (5%)
(2)What is Yamanaka's basic theory on turning regular skin cells into Pluripotent stem cells? (5%)

5. Without oxygen, cellular respiration grinds to a standstill, although glycolysis can continue to make some ATP anaerobically for a short time. When oxygen runs out, why does electron transport stop? Why do you think the citric acid cycle stops? (8%)

6.
(1) One chromosome of a homologous pair carries gene Q and R. Its homologue carries genes q and r. Show how crossing over during meiosis could produce gametes with new combinations of genes. What combinations of genes respectively occur in **parental-type** gametes and in **recombinant-type** gametes? (5%)
(2) Which of the following abnormalities (XXXX,XXY, XYYY, X, XXYY) in sex chromosome would respectively result in a predominantly **male** phenotype and a predominantly **female** phenotype? Explain why. (5%)

7. How are grills and lungs similar? How are they different? (8%)

8. Researchers have not yet come up with a cure for a common cold, but they have made some interesting observations among them: (1) There are more than 50 different known kinds of rhinoviruses, the viruses that cause colds, and (2) an average 2-year-old might catch three or four colds per year, but an 80-year-old catches a cold only once every three or four years. How do these findings relate to each other and the function of the immune system? (8%)

二、單選題 (30%; 3 points/question)

1. Rhodopsin, β-adrenergic receptors, and muscarinic acetylcholine receptors share which of the following features?
(A) Each causes an inhibitory intracellular response.
(B) Each activates a tyrosine kinase cascade.
(C) Each is composed of an αβ dimer.
(D) Each functions through a heterotrimeric G-protein.
(E) Each gates a cation channel.

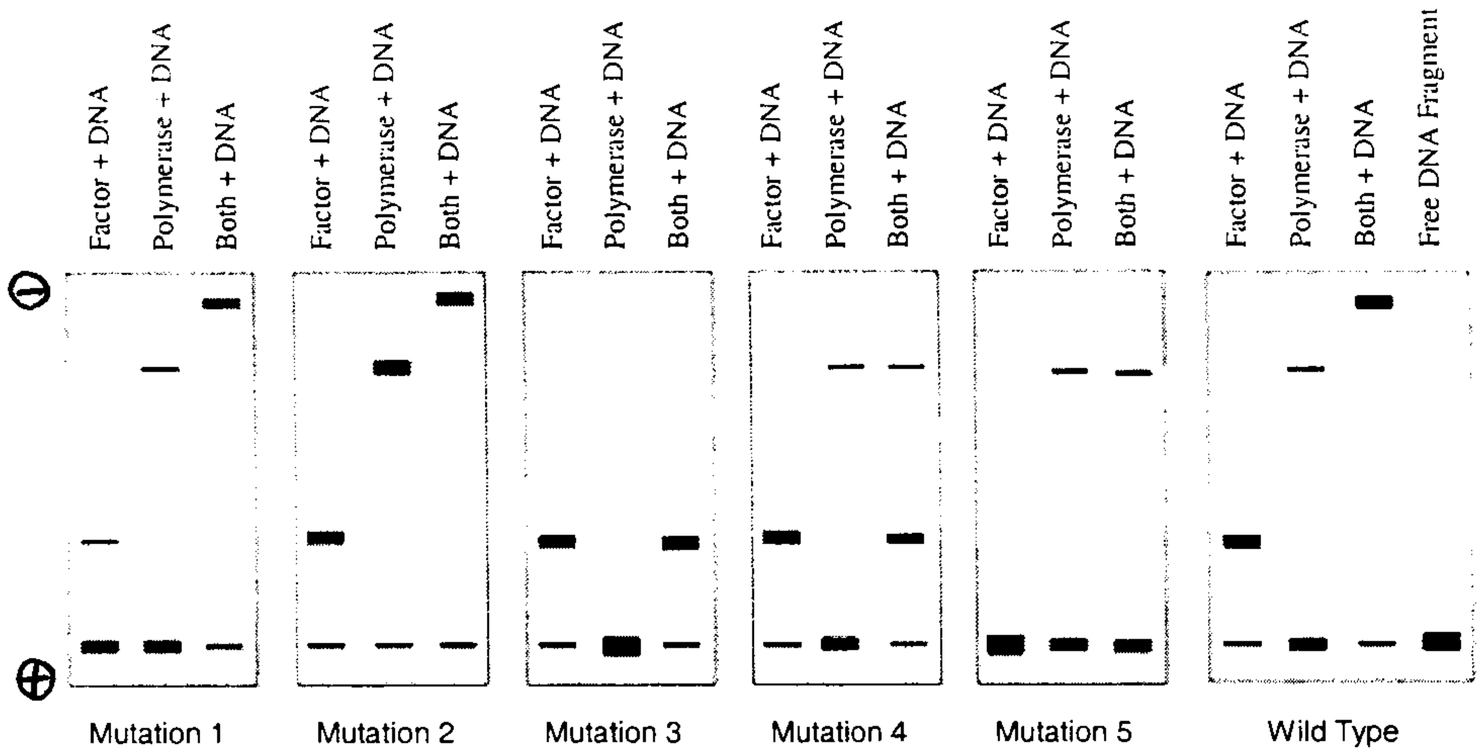
2. Retroviral oncogenes are probably aberrant forms of normal cellular genes that regulate cell proliferation. Which of the following gene products are LEAST likely to be encoded by an oncogene?
(A) GTP-binding proteins (B) DNA-binding proteins (C) Transmembrane proteins
(D) Capsid proteins (E) Tyrosine kinases

3. Which of the following best supports the endosymbiotic theory of the evolutionary origin of mitochondria?
(A) Mitochondria, chloroplasts, and prokaryotes contain electron carriers.
(B) Genes for mitochondrial pyruvate dehydrogenase subunits are found in the nuclear DNA.
(C) Mitochondrial and bacterial ribosomal functions are inhibited by the same antibiotics.
(D) The outer mitochondrial membrane contains the protein porin.
(E) Many mitochondrial proteins are imported across both inner and outer membranes after translation on cytoplasmic ribosomes is completed.

4. Which of the following will result if the level of potassium ions in a solution bathing a nerve cell is raised tenfold while the cell is at its resting state?
(A) The decrease in the normal K+ gradient will cause partial depolarization.
(B) The amplification of the normal K+ gradient will cause partial hyperpolarization.
(C) The added extracellular K+ will accelerate Na+/K+ pumping and cause partial depolarization.
(D) The added extracellular K+ will cause ligand-gated ion channels to open.
(E) The elevated K+ will promote Ca2+ channel opening and produce partial hyperpolarization.

(#5~7) Five E. coli strains have been identified, each of which has a different mutation that disrupts the normal regulation of a particular operon. For each mutant strain, the mutation has been mapped to the promoter or the operator region; however, the exact sequence changes are not known for these mutations. It is known that the normal promoter/operator consists of a single binding site for a

positively acting transcription factor located just upstream of the promoter itself. Short DNA fragments containing the promoter and the operator were subcloned from each of the five mutant strains and from the wild type, purified, and radiolabeled. These fragments were then incubated under conditions of DNA excess with either purified regulatory factor or RNA polymerase or with both polymerase and regulatory factor. The resulting protein-DNA complexes were separated by electrophoresis, and the radioactive DNA fragments were detected by exposure to x-ray film, giving the results shown below. Electrophoresis is from top to bottom; the largest complexes run slowest.



5. One of the mutations increases the affinity of the polymerase for the promoter. Transcription of the operon is not stimulated by the regulatory factor in this mutant. Which mutant is most likely to show this effect?

   (A) Mutant 1 (B) Mutant 2 (C) Mutant 3 (D) Mutant 4 (E) Mutant 5

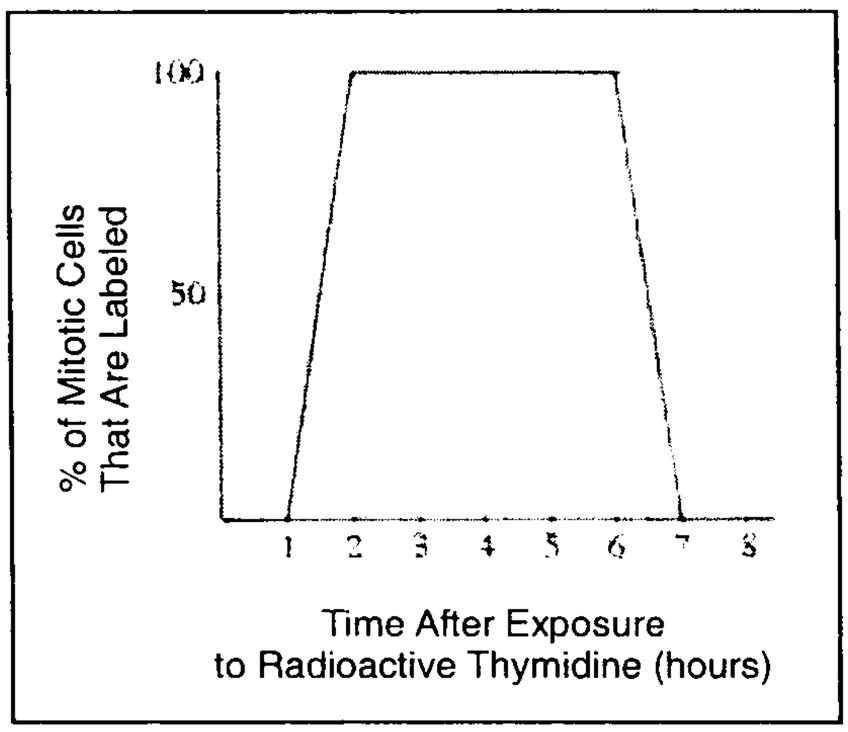
6. One of the mutations maps to the operator. Transcription of the operon is not stimulated by the regulatory factor in this mutant. Which mutant is most likely to show this effect?

   (A) Mutant 1 (B) Mutant 2 (C) Mutant 3 (D) Mutant 4 (E) Mutant 5

7. One of the mutations is known to result from a small deletion between the operator and the promoter. The polymerase and the regulatory factor are each able to bind to the mutated DNA sequence, but are unable to form the three component complex. Transcription of the operon is not stimulated by the regulatory factor in this mutant. Which mutant shows the properties that might be expected for such a change?

   (A) Mutant 1 (B) Mutant 2 (C) Mutant 3 (D) Mutant 4 (E) Mutant 5

(#8~10) The stages of the cell cycle for a cultured mammalian cell line require the following periods of time: G1 = 8 hr, S = 5 hr, G2 = 1 hr, M = 1 hr. An asynchronous culture of these cells is exposed to radioactive thymidine for five minutes and then allowed to continue to grow in nonradioactive medium. The figure below shows the percent of mitotic cells that are radioactively labeled as a function of time after exposure to the radioactive thymidine.



8. The reason it takes approximately one hour before the first radioactively labeled mitotic cells are observed is that

(A) cells must repair thymidine-induced DNA damage before entering G2

(B) the cells get out of synchrony as they proceed through the cell cycle

(C) the period of thymidine labeling is 5 minutes

(D) G2 lasts 1 hr

(E) M phase lasts 1 hr

9. What percent of labeled cells are in M phase at 2 hours after exposure to labeled thymidine?

(A) 100 (B) 33 (C) 20 (D) 6 (E) 0

10. If the length of G2 were increased by one hour, which of the following statements would be true regarding the slope of the line from the point of the first appearance of labeled mitotic cells to the first point at which all the mitotic cells were labeled?

(A) It would increase.

(B) It would decrease.

(C) It would stay the same.

(D) It would switch from a positive to a negative slope.

(E) No conclusion regarding the slope of the line can be drawn.

【END】