

LS 3202 End-semester Examination

Time: 2.5 hours

50 marks

I. Write down the letter corresponding to the correct answer for the following questions. Write the reason for your choice in a single sentence. Both the answer and the reason should be correct to get full credit for the question.

15 x 1 = 15

1. Which of the following is NOT an essential criterion for defining a cluster of genes as an operon?
  - a. Functionally related
  - b. Constitutively induced
  - c. Physically contiguous
  - d. Coordinately regulated
2. Under which of the following conditions will the Lac operon be turned on?
  - a. CAP not bound, Lac I not bound to operator
  - b. CAP not bound, Lac I bound to operator
  - c. CAP bound, Lac I not bound to operator
  - d. CAP bound, Lac I bound to repressor
3. Which of the following will be caused by the interaction of an aminoacylated tRNA with a T-box element present in the 5'UTR of an mRNA?
  - a. Formation of anti-terminator stem-loop and occlusion of SD sequence
  - b. Formation of terminator stem-loop and occlusion of SD sequence
  - c. Formation of anti-terminator stem-loop and freeing of SD sequence
  - d. Formation of terminator stem-loop and freeing of SD sequence
4. Upstream open reading frame mediated translation regulation plays an important role in maintaining translation of certain cellular genes during ER stress as cap-dependent translation is repressed by
  - a. Phosphorylation of eIF2 $\alpha$
  - b. Sequestering of eIF4E by 4E-BP
  - c. Inhibition of eIF4A activity
  - d. Cleavage of eIF4G
5. Mutation of the gene encoding a specific protein resulted in the accumulation of pri miRNAs in the cell. Which of the following proteins might be mutated?
  - a. Drosha
  - b. TRBP
  - c. Argonaute
  - d. Dicer
6. Mice lacking which dimeric transcription factor will have reduced activation of both innate and adaptive immune responses?
  - a. STAT3
  - b. NF $\kappa$ B
  - c. AP1
  - d. SMAD2
7. Which of the following processes can make a global translation regulatory system transcript specific?
  - a. Interaction of an eIF4E-BP with eIF4G
  - b. Interaction of an eIF4E-BP with a cis-acting mRNA element
  - c. Interaction of an eIF4E-BP with the poly(A) tail
  - d. Interaction of an eIF4E-BP with eIF4E

8. In *Drosophila* the *sxl* protein is expressed from *Sxl* mRNA in females because of:
  - a. Inclusion of a female specific exon
  - b. Inclusion of male specific exon
  - c. Exclusion of a female specific exon
  - d. Exclusion of a male specific exon
9. In bacteriophage  $\lambda$  which of the following promoters is the last to be activated in the process of lysogeny?
  - a. *pAQ*
  - b. *pRM*
  - c. *pRE*
  - d. *pI*
10. In presence of low cellular Fe concentration, Fe cannot bind to IRP and allows its interaction with IRE. This leads to
  - a. High Ferritin mRNA translation and low Transferrin receptor mRNA decay
  - b. Low Ferritin mRNA translation and high Transferrin receptor mRNA decay
  - c. High Ferritin mRNA translation and high Transferrin receptor mRNA decay
  - d. Low Ferritin mRNA translation and low Transferrin receptor mRNA decay
11. Which of the following stresses activate an eIF2 kinase with a tRNA synthetase-like domain?
  - a. Unfolded protein response
  - b. Viral infection
  - c. Protein deficiency
  - d. Iron deficiency
12. Which of the following experimental methods might be useful in determining Riboswitch-ligand interactions?
  - a. Yeast two-hybrid.
  - b. Regulated transcription on-off system.
  - c. Isothermal Titration calorimetry.
  - d. In-line RNA probing.
13. GAIT-mediated translation silencing is caused by
  - a. Inhibition of PABP interaction with eIF4G
  - b. Inhibition of eIF4G interaction with eIF4E
  - c. Inhibition of eIF2 $\alpha$
  - d. Inhibition of 40S recruitment by eIF3
14. The discovery of which of the following compounds proved the idea of enzyme adaptation in bacterial sugar metabolism wrong?
  - a.  $\beta$  galactosidase
  - b. ONPG
  - c. Lactose
  - d. IPTG
15. A gene was mutated by a single nucleotide substitution in the 3'UTR without causing any change in the protein coding region. However, the protein synthesis from the gene was drastically reduced. What might be the cause of this phenomenon?
  - a. A new stop codon is generated.
  - b. A new start codon is generated.
  - c. A new ribosome binding site is generated.
  - d. A new miRNA binding site is generated.

II. Answer the following questions briefly.

5 x 4 = 20

1. Why is the integrase protein Int produced during initiation of lysogeny but both Int and Xis produced during the switch from lysogeny to lysis in bacteriophage lambda? What prevents production of both Int and Xis during normal lytic development of the bacteriophage?
2. Cap-dependent translation is repressed due to phosphorylation of eIF2alpha in response to various stress conditions. Surprisingly, it is seen that translation is repressed even when only 20% of the eIF2alpha molecules are phosphorylated. Why do you think is cap-dependent translation repressed even when 80% of eIF2alpha remains unphosphorylated?
3. Favourable conditions, such as growth of bacteria in rich medium, support lytic development of bacteriophage  $\lambda$ . However, a bacterium which is being newly infected under this condition has a high chance of becoming a lysogen. Why? Why doesn't this happen in most cases and the newly infected bacteria also undergo lytic infection?
4. You are growing *E. coli* and *B. subtilis* in minimal medium. If you start adding increasing quantities of tryptophan (Trp) to the medium, which bacteria will stop Trp synthesis earlier (i.e. at a lower concentration of Trp)? Why?
5. The *Drosophila* protein Sxl acts both as transcription factor and splicing factor to regulate sex determination in *Drosophila*. What are the ways in which this single protein perform these two different functions?

III. Answer ANY THREE of the following questions

3 x 5 = 15

1. What will be the phenotypes (lysis or lysogeny) of the following inactivating mutations in the lambda phage genome and why?
  - a) *pAQ* promoter mutation.
  - b) *OR3* mutation.
  - c) Mutation in *cI* gene that abolishes cI repressor interaction with RNA polymerase.
  - d) *sib* site mutation.
  - e) *pI* promoter mutation
2. A bacterium with the genotype  $\text{AraE}^+ \text{AraI}^-$  can constitutively express an enzyme (AraE) that allowed the bacteria to use arabinose even in the absence of any external inducer. A scientist laid a bet with a friend that this is due to the presence of an internal inducer (AraI<sup>-</sup>). The friend contended that instead of an inducer there is a repressor. To test it they set up a conjugation between  $\text{AraE}^+ \text{AraI}^+$  bacteria and  $\text{AraE}^- \text{AraI}^-$  recipient bacteria and found that the recipient cells could produce AraE constitutively. Did this observation support the idea of internal inducer or internal repressor? Before deciding on either, what control experiment should be done, and how would the result of the control experiment support either hypothesis?

3. How does endoplasmic reticulum (ER) stress cause the translation of most cellular genes to stop? Two genes, BiP and ATF4 are translated even under ER stress. How are these two genes translated under this condition and why is this required for cell survival? How does cellular translation recover from ER stress?
4. Two signals, a cytokine and oxygen availability, antagonistically regulate the translation of an mRNA by inducing or inhibiting the binding of an inhibitory protein respectively. Presence of oxygen is necessary and sufficient for translation. Draw a truth table that would describe this genetic switch with translation inhibition as the output. Why do you think this truth table would be a correct description of the genetic switch for a single mRNA but not for the cell as a whole? Do you think it would be the same if the two signals regulated transcription instead of translation?