**Spring 2017**

**BIOL241 – Introduction to Genetics**

**and Molecular Biology**

**Midterm II (105 points)**

**3/9/2017**

*Use scantron sheet for Question A*

**Name:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Purdue ID:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Question A: (56) Question B: (3)

Question C: (5) Question D: (8)

Question E: (9) Question F: (5)

Question G: (9) Question H: (10)

**Total:**

**A) Multiple-choice questions (54 points, 2 points each; please use a bubble sheet)**.

1) The Hershey-Chase experiment demonstrated that:

1. The structure of DNA is double helix.
2. DNA is the genetic material because transforming principle was sensitive to DNase.
3. DNA is the genetic material because bacteria infected with 32P-labeled phages contained radioactivity.
4. DNA is the genetic material because bacteria infected with 35S-labeled phages contained radioactivity.
5. In the DNA of any given species, the content of A is equal to T.

2) A virus contains 10% adenine, 24% thymine, 30% guanine, and 36% cytosine. Based on this, the genetic material in this virus is likely to be:

1. Double-stranded DNA.
2. Single-stranded DNA.
3. Double-stranded RNA.
4. Single stranded RNA.
5. DNA-RNA heteroduplex.

3) The following data describes the absorbance of UV light (260nm) by two DNA species at increasing temperature. Assuming the lengths of A and B are the same, what can you conclude about the two DNA?



1. A contains more repetitive DNA than B.
2. B contains more repetitive DNA than A.
3. B contains more G-C pairing than A.
4. A contains more G-C pairing than B.
5. B is single-stranded and A is double-stranded.

**4) Based on the following reassociation kinectics curves, which of the following statements is correct?**

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1. The genome of A contains only unique DNA sequences.
2. The genome of E. coli is larger than the genome of A.
3. The genome of A has more AT content than the genome of E. coli.
4. The genome of B has more GC content than the genome of A.
5. The genome of B is larger than the genome of E. coli.

**5) The phenomena of semi-sterility is caused by:**

1. A crossover within the inverted segment between a paracentric inversion and a normal chromosome.
2. Adjacent segregation of reciprocal translocated chromosomes.
3. *Drosophila* males with P elements mated with females without P element.
4. *Drosophila* females with P elements mated with males without P element.
5. A crossover between reciprocal translocated chromosome and normal chromosome.

**6) In Maize, the Ds element cannot mobilize in the absence of Ac element because**

1. The Ds element utilizes replicative (copy-and-paste) transposition.
2. The Ds element utilizes non-replicative (cut-and-paste) transposition.
3. The Ds element does not contain a functional transposase.
4. The Ds element uses RNA intermediate during transposition.
5. The Ds element does not contain the inverted repeats near the ends of the transposon.

**7) During transposition, transposable elements insert themselves by generating staggered cuts in the target sites, resulting in:**

1. The formation of flanking direct repeats.
2. The presence of terminal inverted repeats.
3. The deletion of internal transposase gene.
4. The formation of a deletion and a circular DNA.
5. The formation of RNA intermediate.

**8) DNA wrapped around histone octomers is known as:**

* 1. 2 nm fiber.
  2. 11 nm fiber.
  3. 30 nm fiber.
  4. 300 nm fiber.
  5. 700 nm fiber.

**9) A homologous crossover between two inverted repeats on the same chromosome will generate:**

1. A chromosome with a deletion and a circular DNA.
2. Two reciprocal translocations.
3. A chromosome with an inverted segment.
4. A chromosome with a duplicated segment.
5. A chromosome with an inverted segment and a deletion.

**10) A homologous crossover between two direct repeats on a circular chromosome will generate:**

1. A linear chromosome with a deletion and a circular DNA.
2. Two circular DNA molecules.
3. A circular chromosome with an inverted segment.
4. A circular chromosome with a duplicated segment.
5. A circular chromosome with an inverted segment and a deletion.

**11) During *E. coli* DNA replication, which of the following factors is involved with the proofreading process?**

1. DNase I.
2. Single-stranded DNA binding protein.
3. The 5’-3’ exonuclease activity of DNA polymerase I.
4. The 3’-5’ exonuclease activity of DNA polymerase III.
5. Helicase.

**12) The autonomous replicating sequences are**

1. Localized to the chromosome ends to assist telomerase functions.
2. Recognized by origin recognition complex.
3. Located at the centromeres to assist spindle fibers capturing kinectochores.
4. Transposon-like micro-satellites.
5. Required for conjugations between bacteria.

**13) Regarding the splicing of autocatalytic group II introns, which of the following statements is correct?**

1. The process requires a exogenous guanosine as a cofactor
2. The process requires spliceosomes.
3. The process forms lariats.
4. The introns usually begin with GU.
5. The introns are usually found in eukaryotic mRNAs.

**14) Regarding the splicing of *Drosophila* *sex-lethal* (*sxl*), which of the following statements is incorrect?**

1. The splicing of *sxl* mRNA requires spliceosomes.
2. The splicing of *sxl* mRNA results in the formation of lariats.
3. The splicing of *sxl* mRNA is autocatalytic.
4. The introns in *sxl* mRNA end with AG.
5. The introns in *sxl* mRNA begin with GU.

**15-16) In a mixed copolymer experiment using polynucleotide phosphorylase, synthetic message was created with 3/4A:1/4G. These messages yielded proteins with the following amino acid compositions.**

Lysine 36/64 (56%)

Glutamic acid 12/64 (19%)

Arginine 12/64 (19%)

Glycine 4/64 (6%)

**15) The frequency of the occurrence of AGA sequence in the RNA polymer is expected to be:**

1. 36/64.
2. 27/64.
3. 12/64.
4. 9/64.
5. 4/64.

**16) Based on these results, AAA codes for**

1. Lysine.
2. Glutamic acid.
3. Arginine.
4. Glycine.

**17) The formation of lariat is best described as:**

1. A 5’-3’ linkage.
2. A 5’-5’ linkage.
3. A 3’-3’ linkage.
4. A 5’-2’ linkage.
5. A 3’-2’ linkage.

**18) Shine-Dalgarno sequence is recognized by:**

1. f-met charged initiator tRNA.
2. TBP of TFIID.
3. 16S rRNA of the small ribosomal subunit.
4. Telomerase.
5. U1 snoRNP.

**19) Regarding histones, which of the following statements is incorrect?**

1. They complex with 147bps of DNA to form nucleosomes.
2. They contain a high level of positively charged amino acids.
3. In DNase protection assays, DNA bound to histones are resistant to DNase digest.
4. Histones are typically found in eukaryotic cells.
5. The functional unit of histones in chromosomal organization is a tetramer.

**20) When a λ phage infects bacteria, the decision to enter lytic or lysogenic cycle is influenced by the level of protease in the host cells. Which of the following proteins acts as the sensor of the cellular protease level?**

1. Cro.
2. RecA.
3. CI (λ repressor).
4. CII.
5. CIII.

**21) In bacteria carrying a λ prophage, DNA damage induced by UV irradiation will:**

1. Mutate OR1, which decreases the binding by λ repressors.
2. Activate RecA, which cleaves the hinge region of λ repressors.
3. Activate RecA, which cleaves the DNA-binding domain of cro.
4. Stabilize CII, which increases the expression of λ repressors.
5. Change the binding specificity of Cro.

**22) An operon, controlled by a regulatory molecule R, deals with the synthesis of enzymes capable of metabolizing a compound Z. In the presence of Z, active enzymes are made, whereas no enzyme is made in the absence of Z. When R is inactivated by loss-of-function mutations, no enzyme is made. Based on this, the regulation of this operon is:**

1. Positive, constitutive.
2. Positive, inducible.
3. Positive, repressible.
4. Negative, inducible.
5. Negative, repressible.

**23-24) In a theoretical operon, A, B, and C represent the repressor gene, the operator, and the promoter, but not necessarily in that order. This operon is concerned with the synthesis of compound W. From the data provided in the accompanying table (AE=active enzyme, NE=no enzyme), please answer the following questions:**

|  |  |  |
| --- | --- | --- |
| **Genotype** | **W present** | **W absent** |
| A+B+C+ | NE | AE |
| A-B+C+ | NE | NE |
| A+B-C+ | AE | AE |
| A+B+C- | AE | AE |
| A-B+C+/ A+B-C- | AE | AE |
| A+B-C+/ A-B+C- | NE | AE |
| A+B+C-/ A-B-C+ | AE | AE |

**23) The promoter is:**

1. A.
2. B.
3. C.

**24) The repressor gene is:**

1. A.
2. B.
3. C.

**(25-27) Regarding *trp* operon in *E. coli*, predict how the following mutations will impact the transcription of *trp* structural genes:**

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**25) A deletion of the Shin-Dalgarno sequence in *trpL* will**

1. Have no effect on *trp* attenuation.
2. Allow the transcription to proceed into trp structural genes even when tryptophan level is high.
3. Cause the transcription to end after *trpL* even when tryptophan level is low.

**26) A deletion of region 4 will**

1. Have no effect on *trp* attenuation.
2. Allow the transcription to proceed into trp structural genes even when tryptophan level is high.
3. Cause the transcription to end after *trpL* even when tryptophan level is low.

**27) Aminoacyl-tRNA synthetases are responsible for attaching amino acids to tRNAs. If tryptophanyl-tRNA synthetase was partially defective at attaching tryptophan to tRNA (let’s say its activity was only 10% of that found in a normal bacterium), how would this affect attenuation of the trp operon?**

* 1. It will have no impact on attenuation.
  2. Ribosomes will stall at the leader and the structural genes will be transcribed.
  3. Ribosomes will not stall at the leader and the structural genes will not be transcribed.
  4. Ribosomes will not bind to the ribosomal binding site at the leader and the structural genes will be transcribed.
  5. Ribosomes will fall off at the leader and the structural genes will not be transcribed.

**28) In *E. coli*, the expression of *OmpF*, an aquaporin, is negatively regulated by *micF*. Which of the following statements best describes the function of *micF*?**

1. *micF* encodes a helix-turn-helix repressor, which binds to the operator site in *OmpF*.
2. *micF* encodes a transcription activator, which binds near the *OmpF* promoter.
3. *micF* is a leader mRNA, which causes an early transcription termination in *OmpF*.
4. *micF* is an antisense RNA, which inhibits the translation of *OmpF*.
5. *micF* encodes a protease, which degrades the OmpF proteins.

**B.** Red-green color blindness is a human X-linked recessive disorder. Beth has normal color vision, but her father is color-blind. Beth marries John, who also has normal color vision, but his father is also color-blind. Beth and John have a son who has Klinefelter syndrome (XXY, 47) and is color-blind. Where did the nondisjunction that gave rise to the son with Klinefelter syndrome take place (indicate the parent and the meiotic division, **3 points**)?

**C.** In the wild type of a diploid organism, the following genes (A-F) are arranged linearly along a chromosome (the circle indicates the centromere).



You have obtained a true breeding mutant, which contains recessive alleles of these genes arranged in the following order.



1. Use appropriate terminology to describe the chromosomal aberration observed in this mutant (**2 points**).
2. If a homozygous wild type is crossed with the mutant, a heterozygous F1 is formed. Explain (using a diagram) the chromosomal products seen in the F1 gametes, if a crossover takes place between B/b and C/c (**3 points**).

**D.** Regarding the *lac* operon, please complete the table below **(8 points).**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Genotype | β-galactosidase  (arbitrary unit) | | Permease  (arbitrary unit) | |
| - lactose | + lactose | - lactose | + lactose |
| I+O+P+Z+Y+ | 0 | 100 | 0 | 100 |
| I-O+P+Z+Y+ | 100 | 100 | 100 | 100 |
| I+OCP+Z+Y+ | 30 | 100 | 30 | 100 |
| I+O+P+Z+Y-/F’ I+O+P+Z+Y+ | 0 | 200 | 0 | 100 |
| I-OCP+Z+Y-/F’ I+O+P+Z-Y+ |  |  |  |  |
| I+OCP-Z+Y-/F’ I-O+P+Z-Y+ |  |  |  |  |

**E.** Regarding *lac* operon, here is the level of functional β–galactosidase (*lacZ*; in arbitrary unit) produced under various conditions. Please complete the table by predicting the values (**9 points**).

|  |  |  |  |
| --- | --- | --- | --- |
| Genotype | + Glucose | + Lactose | + Glucose and lactose |
| CAP+I+P+O+Z+ | 0 | 100 | 20 |
| CAP+I-P+O+Z+ |  |  |  |
| CAP-I+P+O+Z+ |  |  |  |
| CAP-I+P+OCZ+ |  |  |  |

**F.** Wild-type T4 bacteriophages can lyse both *E. coli B* and *K12*, while strains with mutations in the *rII* locus can lyse only *E. coli B*. Three *rII* T4 mutants (x, y, and z) have been isolated because of their inability to lyse *E. coli K12*, and complementation test shows that these three mutants are allelic.

To determine the genetic distance between x and y, *E. coli B* were simultaneously infected with both *rII* mutants. The phages produced by this lysis were collected. Serial dilutions of these phages were then used to infect *E. coli B* and *E. coli K12*, and the results are shown below.

Between x and y

Bacterial strain Dilution Number of plaques

E. coli B 10-8 5

E. coli K12 10-2 15

1. Calculate the recombination frequency (RF) between x and y **(3 points)**.

To determine the genetic distance between x and z and the distance between y and z, similar experiments were performed and the results are shown below.

Between x and z

Bacterial strain Dilution Number of plaques

E. coli B 10-8 8

E. coli K12 undiluted 0

Between y and z

Bacterial strain Dilution Number of plaques

E. coli B 10-8 6

E. coli K12 undiluted 0

1. Please provide a brief explanation for these observations (Hint: describe the nature of mutation in z, **2 points**).

**G.** In the Meselson-Stahl experiment, *E. coli* were grown in the presence of 15N for several generations and then synchronously divided in the presence of 14N. Based on what you know about DNA replication, predict the position of the DNA in the density gradient at the indicated time-points (**3 points**).

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Predict the position of the DNA in the density gradient at the indicated time-points, if DNA replication occurs via the conservative mechanism (**3 points**).

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Predict the position of the DNA in the density gradient at the indicated time-points, if DNA replication occurs via the dispersive mechanism (**3 points**).

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**H.** Please compare and contrast the prokaryotic and eukaryotic transcription by drawing a typical eukaryotic gene (DNA, the pre-mRNA and mRNA derived from it) with **three exons**, and a typical prokaryotic operon (DNA and the mRNA derived from it) with **three cistrons**. Assume the prokaryotic operon uses a **Rho-dependent termination**.

In your drawing, please identify (by labeling clearly) the items listed below. If appropriate, indicate the *secondary structures* associated with a particular item. Please note that some elements are present in both eukaryotic and prokaryotic transcription units **(10 point).**

1. TATA box
2. AAUAAA
3. Introns/Exons
4. Shine-Dalgarno sequence
5. Poly-A tail
6. 7-methylguanosine cap
7. -10 box
8. Rut
9. AUG Start and Stop codons
10. +1 site
11. 5’ UTR
12. 3’ UTR
13. Coding region
14. -35 sequence