**PART I – MULTIPLE ANSWER QUESTIONS**
**(2 pts each – circle the best answer)**

1. Genetics is the study of which of the following?

    a. replication and recombination
    b. diploid and haploid
    c. transcription and translation
    d. heredity and variation
    e. mutation and recession

2. The central dogma of molecular genetics refers to which of the following statements:

    a. independent segregation of homologous chromosomes during mitosis
    b. independent segregation of homologous chromosomes during meiosis
    c. phenotype expression is a result of gene expression
    d. use of restricted enzymes to create a recombinant DNA molecule
    e. none of the above

3. Recombinant DNA technology is a concept that refers to….

    a. the technology associated with the use of DNA CHIPS to measure gene expression under different conditions.
    b. the technology associated with the use of DNA molecules produced by in vitro ligation of heterologous DNA fragments.
    c. technology associated with the use of softwares to analyze hundreds of DNA sequences at a time.
    d. The technology associated with selecting bacterial strains with specific genotypes.
    e. 2 of these answers are correct.

4. Which of the following is not a product/benefit of recombinant technology?

    a. insulin producing bacteria
    b. virus resistant potatoes
    c. fluorescing zebra fish
    d. 2 among a, b, c are correct
    e. a, b, and c are all products of recombinant technology

5. Which of the following would not be considered in the fields of genomics, proteomics and bioinformatics?

    a. the study of protein interactions
    b. the study of gene evolution
    c. the study of gene function
    d. the study of gene sequences
    e. Each can be considered to fall within one of these fields

6. In general, a "model organism" used in genetics studies is one in which there is large body of genetic knowledge that has been compiled over decades of genetic research. In addition, model organisms have available their DNA sequence and collections of _____ that make detailed genetic analysis possible and efficient.

    a. complete metamorphic systems
    b. incomplete metamorphic systems
    c. epigenetic developmental systems
    d. strains with specific mutations
    e. museum specimens

7. A conditional mutation is one that allows a mutant gene product to function normally under the _____ condition, but to function abnormally under the _____ condition. Such mutations are especially useful for the study of _____ mutations.

    a. restrictive; permissive; dominant
    b. permissive; restrictive; dominant
    c. dominant; recessive; semidominant
    d. recessive; dominant; codominant
    e. permissive; restrictive; lethal

8. The difference between a genetic screening experiment and a selection experiment is that a screening experiment involves _____, whereas a selection experiment creates conditions that _____ irrelevant organisms.

    a. temperature extremes; eliminate
    b. visual examination; eliminate
    c. chemical removal; activate
    d. chemical removal; eliminate
    e. temperature extremes;  activate

9. Nutritional mutations can be defined as…

    a. those mutations that do not allow an organism to grow on minimal medium, but do allow the organism to grow on complete medium.
    b. those mutations that do not allow an organism to grow on complete medium, but do allow the organism to grow on minimal medium.
    c. those mutations that do not allow an organism to grow on medium with drugs, but do allow the organism to grow on medium without drugs.
    d. Those mutations belonging to the group called prototrophs
    e. Those mutations that change the composition of the medium

10. Which of the following best describes a mutation involving a transition:

    a. a substitution of an amino acid for a conservative amino acid
    b. a substitution causing a frameshift
    c. a base insertion
    d. a replacement of a purine with another purine
    e. a replacement of pyrimidine with a purine

11. Dr. Spock of the USS enterprise is interested in isolating revertant prototrophic bacteria for subsequent experiments investigating the metabolism of adenine on Planet Vulcan. Which of the following experiments will possibly allow him to isolate these bacteria?

    a. Grow adenine auxotrophic bacteria in adenine containing liquid medium and then plate the suspension on minimal medium.
    b. Grow adenine auxotrophic bacteria in adenine-less liquid medium and then plate the suspension on adenine-less medium.
    c. Both a and b are possible
    d. Spock will never be able to do this!
    e. Expose the bacteria to the intergalactic UV rays and hope for the best!

12. Read the following <u>case study</u>:

**The case of the Ages:**
A research team has identified an "important gene" that regulates the aging process in the brain. "Overall, we have now established that the Bmi1 gene is a direct regulator of cell aging in brain and retinal neurons of mammals," Dr. Gilbert Bernier, a University of Montreal scientist who led the team, said Friday. Nobody knows why aging is the prime factor to develop the onset of macular degeneration, Parkinson's and Alzheimer's. "In our case, we actually found a gene that regulates the speed of aging in the brain. If you mutate that gene, you have a hyper-accelerated aging process of the neurons in the brain" said Dr. Bernier from the University of Montreal. Bernier partnered with researchers at Lawrence Berkeley National Laboratory in California in a study that identified a mutation in mice that dramatically accelerates the process of aging in the brain and in the eye. He said the mice, from a laboratory in the Netherlands, were studied because the gene has previously been identified as important for stem cell proliferation. "We discovered these mice suffered from lens cataracts . . . which are one of the best bio-markers of aging in animals but also in humans," Bernier said. "So when we saw these cataracts in these 20-day-old animals, that's when we started to study the retina and the brain of these animals and said this gene is also very important to prevent aging."

**Based on the information provided in the case study, which of the following best explains the approach to dissect the function of this gene?**

a) forward genetics
b) reverse genetics
c) transmission genetics
e) none of the above

(5 points) Explain your choice:

_____

_____

_____

_____

_____

_____

_____

_____

13. Drosophilas make good model organisms for genetic analysis because…

a. they are easy to grow
b. have short life cycles
c. small genome
d. easily mutagenized
e. all of the above

14. Autosomal mutations….

a. are a mutation that occurs in somatic cells and germ-line cells
b. are a mutation that occurs on non sex-linked chromosomes in germ-line cells
c. are mutations that occur on the sex-linked chromosomes in germ-line cells
d. are mutations that occur on the Y-chromosome in germ-line cells
e. none of the above

15. Why are mutations invaluable in genetic analysis?

a. they are used as biomarkers
b. provide variations
c. allows to study the function of different biological processes
d. two among a, b, and c are correct
e. a, b, and c are all correct

16. Name two forms of recombination in bacteria

a. lytic and lysogenic
b. auxotrophic and prototrophic
c. conjugation and transduction
d. mixed and generalized
e. insertion and replication

17. Bacteriophages engage in two interactive cycles with bacteria. What are these cycles?

a. lytic and lysogenic
b. auxotrophic and prototrophic
c. conjugation and transduction
d. mixed and generalized
e. insertion and replication

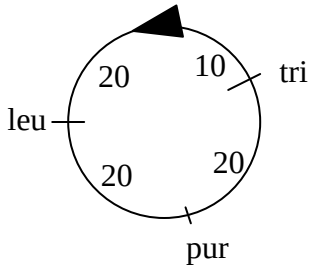
18. Transduction is a form of recombination in bacteria that involves….

a. recombination of an exogenous fragment of DNA into a bacteria
b. recombination of DNA following conjugation between an F+ and F- bacteria
c. recombination following the transfer of DNA into a bacteria from a bacteriophage
d. recombination following the transfer of DNA molecules into an F- bacteria as a result of conjugation with 2 F+ bacteria strains at the same time
e. recombination following the transfer of DNA molecules into an F- bacteria as a result of conjugation with one Hfr strain and an F+ strain at the same time

19. Which of the following events take place during conjugation in bacteria?
**Select all correct answers**

a. Direct transfer of DNA from one bacterial cell to another through cell to cell contact
b. Direct transfer of DNA from the environment to a bacterial cell via a pilus
c. A fertility factor is responsible for formation of a pilus
d. Rolling circle replication of DNA
e. Transfer of DNA from an F′ strain to an $F^-$ strain via a bacteriophage

20. The an Hfr strain of *E. coli* shown below was used as a donor for conjugation with a triple mutant ($tri^- pur^- leu^-$). If mating was interrupted after 20 mins, what will be the phenotype of the most frequent exconjugant?




a. Prototrophic
b. Auxotrophic for tri, pur and leu
c. Auxotrophic for pur and leu
d. Auxotrophic for leu only
e. Auxotrophic for pur only

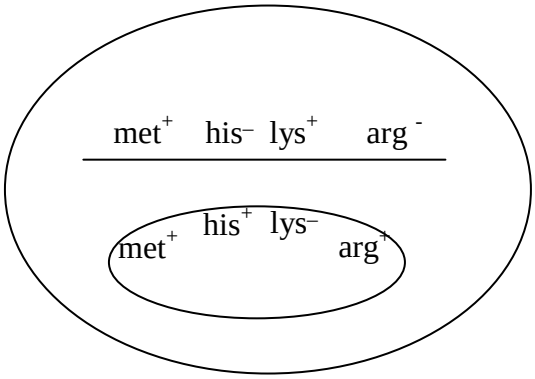
21. Which of the following describes the relationship between Hfr strains and F′ strains?

a) An Hfr strain donates DNA to an $F^-$ strain, thus converting it into an F′ strain.
b) After DNA is transferred from an Hfr to an $F^-$, the Hfr strain becomes an F′ strain.
c) When an Hfr strain is used for transduction, it is called an F′ strain.
d) Hfr strains can be converted into F′ strains through the out-looping of the F factor and some flanking bacterial DNA from the bacterial chromosome.
e) none of the above

22. Resistance to antibiotics, once obtained by a bacterium, spreads rapidly throughout a bacterial population. The most common mechanism of transfer of resistance genes is:

a) transformation.
b) zygotic induction.
c) general transduction.
d) specialized transduction.
e) conjugation.

23. As shown below, a bacterium with the genotype $met^+$ $his^+$ $lys^-$ $arg^+$ has been transformed with DNA from a second bacterium that has the genotype $met^+$ $his^-$ $lys^+$ $arg^-$.




Following the transformation, scientists streaked a sample of a transformed bacterium onto several different plates that contain different nutritional supplements in order to determine the transformant's genotype. Using the results of the experiment (shown below), determine what crossovers occurred to produce the bacterium.

| minimal | minimal + methionine + histidine + lysine + arginine | minimal + histidine + lysine | minimal + histidine | minimal + lysine |
|---|---|---|---|---|

a. Cross over between the met and his genes
b. Cross over between the met and his genes and a cross over between his and lys genes
c. Cross over between the his and lys genes and a cross over between lys and arg genes
d. Cross over between the met and his genes and a cross over between lys and arg genes
e. None of the above

24. Two methods of estimating the distance between two genes are 1) the calculation of recombination frequency and 2) calculation of co-transduction frequency. However, the interpretation of the data is drastically different. For each of these two types of calculations, how does the magnitude of the number relate to the distance between the genes? Explain the cause of this relationship.

a. recombination frequency – smaller number = smaller distance;
co-tranduction frequency – higher the number = smaller the distance

b. recombination frequency – smaller number = longer distance;
co-tranduction frequency – higher the number = smaller the distance

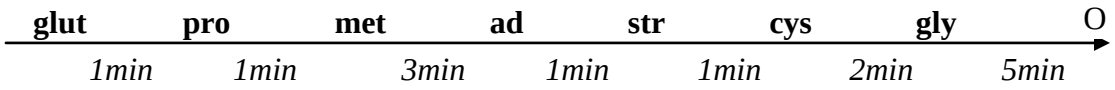
c. recombination frequency – smaller number = smaller distance;
co-tranduction frequency – higher the number = higher the distance

d. recombination frequency – higher number = smaller distance;
co-tranduction frequency – higher the number = higher the distance

e. recombination frequency – smaller number = longer distance;
co-tranduction frequency – smaller the number = smaller the distance

(5 points) Explain your choice:

25. Among the many experiments he conducted, Dr. Dumbledore wished to obtain prototrophic *E. coli* for the following nutrients: methionine (met), adenine (ad), cyteine (cys), proline (pro). In a previous experiments, his assistant Harry Potter established the following time map for the *E.coli* bacterial map:




To obtain his prototrophic strain, Dr. Dumbledore makes the following cross:
$F^+$ $met^+$ $ad^+$ $cys^+$ $pro^+$ X F- $met^-$ $ad^-$ $cys^-$ $pro^-$

**At least how many minutes will Dumbledore have to wait to obtain bacteria prototrophic for methionine, adenine, cystein, and proline?**

a) 5 minutes
b) 12 minutes
c) 13 minutes
d) 14 minutes
e) Cannot be determined in this experiment

## PART IV – PROBLEM SOLVING QUESTIONS

**26. (10 points)** In this experiment, E. coli have been plated on selective media in order to determine their genotypes. The following figures represent each of the plates, the composition of the media on which bacteria were grown and the colonies that grew on each of these plates.

**Determine the genotypes of each of the colonies. Explain how you were able to determine the genotypes. (Explain the overall reasoning – not your reasoning for every individual colony)**

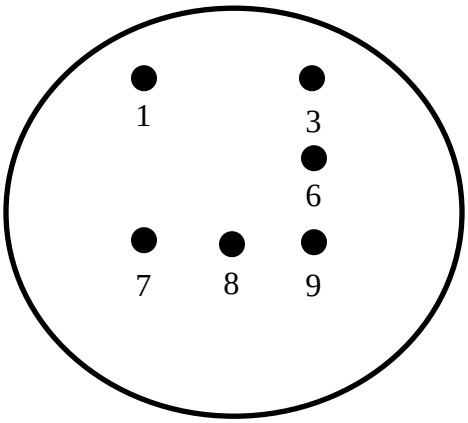



**Plate 2: minimal**

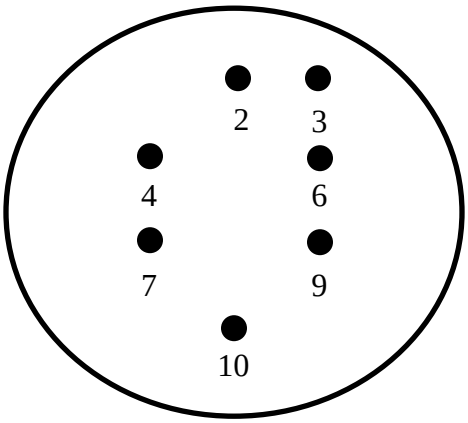



**Plate 3: minimal + methionine + Amp**

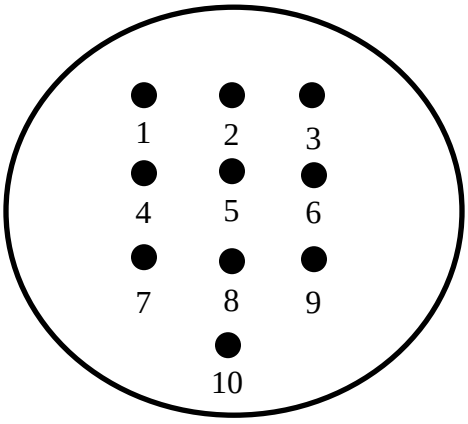



**Plate 1: minimal + methionine**

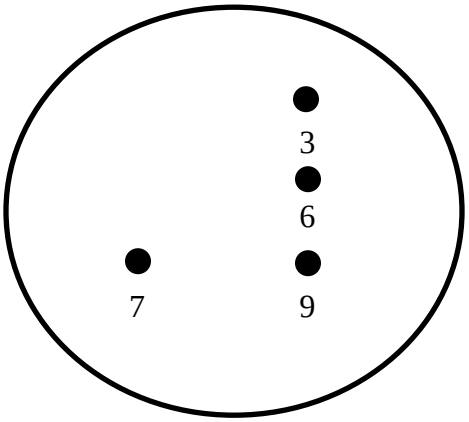



**Plate 4: minimal + Amp**

**<u>Genotypes (0.5pts each):</u>**

**Colony 1:**
**Colony 2:**
**Colony 3:**
**Colony 4:**
**Colony 5:**
**Colony 6:**
**Colony 7:**
**Colony 8:**
**Colony 9:**
**Colony 10**

**<u>Explanation (5 points):</u>**

**27**. **(10 points)** In a generalized-transduction system using P1 phage, the donor is ad+ met+ $amp^s$ and the bacterial recipient is ad- met- $amp^r$. The donor allele ad+ is initially selected after transduction, and 50 ad+ transductants are then scored for the other alleles present. Here are the results:

| **Genotype** | **Number of colonies** |
|---|---|
| met+ $amp^r$ | 13 |
| met+ $amp^s$ | 24 |
| met- $amp^r$ | 10 |
| met- $amp^s$ | 3 |

**a. What is the cotransduction frequency for ad and met? (3 points)**

**b. What is the cotransduction frequency for ad and amp? (3 points)**

**c. Determine the order of the genes and draw the gene map? (4 points)**

**28. (10 points)** An Hfr *E. coli* strain that is prototrophic for Ile (isoleucine) and Arg (arginine), and auxotrophic for Met (methionine) is crossed with F- *E.coli* strain that is auxotrophic for Ile and Arg, and prototrophic for Met. Interrupted mating studies have shown that the Ile gene enters the recipient last among these genes. You are interested in determining the order and the map distances between Ile, Arg, and Met genes on the bacterial chromosome. Therefore, following the cross, the Ile recombinants were selected on a medium containing supplements that satisfy Met and Arg. The recombinants for Ile were then tested for the presence/absence of the Arg and Met alleles. The following recombinants and their numbers were detected:

| | | | |
|---|---|---|---|
| Ile+ | Arg + | Met + | 3 |
| Ile+ | Arg + | Met - | 480 |
| Ile+ | Arg - | Met + | 64 |
| Ile+ | Arg - | Met - | 7 |

Determine the gene map **(4 pts)** and the map distances (in recombination units) **(6 pts)** between the genes.