AP: LAB-RELATED AP EXAM ESSAYS

LAB 1. OSMOSIS AND DIFFUSION

A laboratory assistant prepared solutions of 0.8 M, 0.6 M, 0.4 M, and 0.2 M sucrose, but forgot to label them. After realizing the error, the assistant randomly labeled the flasks containing these four unknown solutions as flask A, flask B, flask C, & flask D.

Design an experiment, based on the principles of diffusion and osmosis, that the assistant could use to determine which of the flasks contains each of the four unknown solutions.

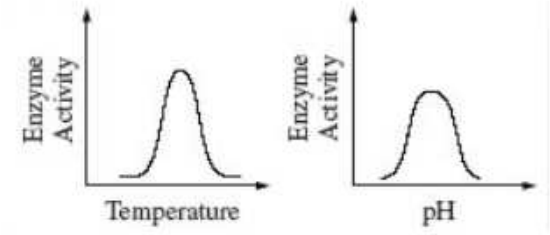
Include in your answer:

a. a description of how you would set up and perform the experiment;
b. the results you would expect from your experiment; and
c. an explanation of those results based on the principles involved.

Be sure to clearly state the principles addressed in your discussion.

LAB 2. ENZYME CATALYSIS

The effects of pH and temperature were studied for an enzyme-catalyzed reaction. The following results were obtained.



a. How do (1) temperature and (2) pH affect the activity of this enzyme? In your answer, include a **discussion** of the relationship between the structure and the function of this enzyme, as well as a **discussion** of how structure and function of enzymes are affected by temperature and pH.

b. **Describe** a controlled experiment that could have produced the data shown for either temperature or pH. Be sure to state the hypothesis that was tested here.

LAB 3. MITOSIS & MEIOSIS

1. Discuss the process of cell division in animals. Include a description of mitosis and cytokinesis, and of the other phases of the cell cycle. Do not include meiosis.

2. Meiosis reduces chromosome number and rearranges genetic information.
   a. **Explain** how the reduction and rearrangement are accomplished in meiosis.

   b. Several human disorders occur as a result of defects in the meiotic process. **Identify** ONE such chromosomal abnormality; what effects does it have on the phenotype of people with the disorder? **Describe** how this abnormality could result from a defect in meiosis.

   c. Production of offspring by parthenogenesis or cloning bypasses the typical meiotic process. **Describe** either parthenogenesis or cloning and compare the genomes of the offspring with those of the parents.

LAB 4. PHOTOSYNTHESIS

1. A controlled experiment was conducted to analyze the effects of darkness and boiling on the photosynthetic rate of incubated chloroplast suspensions. The dye reduction technique was used. Each chloroplast suspension was mixed with DPIP, an electron acceptor that changes from blue to clear when it is reduced. Each sample was placed individually in a spectrophotometer and the percent transmittance was recorded. The three samples used were prepared as follows.

   - Sample 1 — chloroplast suspension + DPIP
   - Sample 2 — chloroplast suspension surrounded by foil to provide a dark environment + DPIP
   - Sample 3 — chloroplast suspension that has been boiled + DPIP

Time (min)	Light, Unboiled % transmittance Sample 1	Dark, Unboiled % transmittance Sample 2	Light, Boiled % transmittance Sample 3
0	28.8	29.2	28.8
5	48.7	30.1	29.2
10	57.8	31.2	29.4
15	62.5	32.4	28.7
20	66.7	31.8	28.5

   a. Construct and label a graph showing the results for the three samples.

   b. Identify and explain the control or controls for this experiment.

   c. The differences in the curves of the graphed data indicate that there were differences in the number of electrons produced in the three samples during the experiment. Discuss how electrons are generated in photosynthesis and why the three samples gave different transmittance results.

2. The rate of photosynthesis may vary with changes that occur in environmental temperature, wavelength of light, and light intensity. Using a photosynthetic organism of your choice, choose only ONE of the three variables (temperature, wavelength of light, or light intensity) and for this variable

   - **design** a scientific experiment to determine the effect of the variable on the rate of photosynthesis for the organism;
   - **explain** how you would measure the rate of photosynthesis in your experiment;
   - **describe** the results you would expect. **Explain** why you would expect these results.

LAB 5. CELLULAR RESPIRATION

The results below are measurements of cumulative oxygen consumption by germinating and dry seeds. Gas volume measurements were corrected for changes in temperature and pressure.

Cumulative Oxygen Consumed (mL)	Cumulative Oxygen Consumed (mL)	Cumulative Oxygen Consumed (mL)	Cumulative Oxygen Consumed (mL)	Cumulative Oxygen Consumed (mL)	Cumulative Oxygen Consumed (mL)
Time (minutes)	0	10	20	30	40
Germinating seeds 22°C	0.0	8.8	16.0	23.7	32.0
Dry Seeds (non-germinating) 22°C	0.0	0.2	0.1	0.0	0.1
Germinating Seeds 10°C	0.0	2.9	6.2	9.4	12.5
Dry Seeds (non-germinating) 10°C	0.0	0.0	0.2	0.1	0.2

a. **Plot** the results for the germinating seeds at 22°C and 10°C.

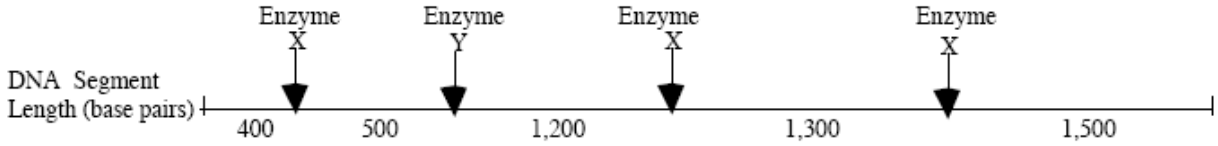
b. **Calculate** the rate of oxygen consumption for the germinating seeds at 22°C, using the time interval between 10 and 20 minutes.

c. Account for the differences in oxygen consumption observed between:
   - germinating seeds at 22°C and at 10°C
   - germinating seeds and dry seeds.

d. **Describe** the essential features of an experimental apparatus that could be used to measure oxygen consumption by a small organism. **Explain** why each of these features is necessary.

LAB 6. MOLECULAR BIOLOGY

1. The diagram below shows a segment of DNA with a total length of 4,900 base pairs. The arrows indicate reaction sites for two restriction enzymes (enzyme X and enzyme Y).



   a. Explain how the principles of gel electrophoresis allow for the separation of DNA fragments.

   b. Describe the results you would expect from electrophoretic separation of fragments from the following treatments of the DNA segment above. Assume that the digestion occurred under appropriate conditions and went to completion.
      I. DNA digested with only enzyme X
      II. DNA digested with only enzyme Y
      III. DNA digested with enzyme X and enzyme Y combined
      IV. Undigested DNA

   c. Explain both of the following:
      1. The mechanism of action of restriction enzymes
      2. The different results you would expect if a mutation occurred at the recognition site for enzyme Y.

2. The human genome illustrates both continuity and change.

   a. **Describe** the essential features of **two** of the procedures/techniques below. For each of the procedures/techniques you describe, **explain** how its application contributes to understanding genetics.
      - The use of a bacterial plasmid to clone and sequence a human gene
      - Polymerase chain reaction (PCR)
      - Restriction fragment polymorphism (RFLP analysis)

   b. All humans are nearly identical genetically in coding sequences and have many proteins that are identical in structure and function. Nevertheless, each human has a unique DNA fingerprint. **Explain** this apparent contradiction.

LAB 7. GENETICS (FLY LAB)

In fruit flies, the phenotype for eye color is determined by a certain locus. *E* indicates the dominant allele and *e* indicates the recessive allele. The cross between a male wild type fruit-fly and a female white eyed fruit-fly produced the following offspring

	Wild-Type Female	Wild-Type Female	White-eyed Female	White-Eyed Male	Brown-Eyed Female
F1	0	45	55	0	1

The wild-type and white-eyed individuals from the F1 generation were then crossed to produce the following offspring.

	Wild-Type Female	Wild-Type Female	White-eyed Female	White-Eyed Male	Brown-Eyed Female
F2	23	31	22	24	0

a. **Determine** the genotypes of the original parents (P generation) and **explain** your reasoning. You may use Punnett squares to enhance your description, but the results from the Punnett squares must be discussed in your answer.

b. Use a Chi-squared test on the F2 generation data to analyze your prediction of the parental genotypes. **Show** all your work and **explain** the importance of your final answer.

c. The brown-eyed female of the F1 generation resulted from a mutational change. **Explain** what a mutation is, and **discuss** two types of mutations that might have produced the brown-eyed female in the F1 generation.

Probability (p)	Degrees of Freedom (df)				
	1	2	3	4	5
.05	3.84	5.99	7.82	9.49	11.1

The formula for Chi-squared is:

$$X^2 = \sum \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

LAB 8. POPULATION GENETICS

Do the following with reference to the Hardy-Weinberg model.

a. **Indicate** the conditions under which allele frequencies (p and q) remain constant from one generation to the next.

b. **Calculate**, showing all work, the frequencies of the alleles and frequencies of the genotypes in a population of 100,000 rabbits of which 25,000 are white and 75,000 are agouti. (In rabbits the white color is due to a recessive allele, w, and agouti is due to a dominant allele, W.)

c. If the homozygous dominant condition were to become lethal, what would happen to the allelic and genotypic frequencies in the rabbit population after two generations?

LAB 9. TRANSPIRATION

A group of students designed an experiment to measure transpiration rates in a particular species of herbaceous plant. Plants were divided into four groups and were exposed to the following conditions.

- Group I: Room conditions (light, low humidity, 20°C, little air movement.)
- Group II: Room conditions with increased humidity.
- Group III: Room conditions with increased air movement (fan)
- Group IV: Room conditions with additional light

The cumulative water loss due to transpiration of water from each plant was measured at 10- minute intervals for 30 minutes. Water loss was expressed as milliliters of water per square centimeter of leaf surface area. The data for all plants in Group I (room conditions) were averaged. The average cumulative water loss by the plants in Group I is presented in the table below.

Average Cumulative Water Loss by the Plants in Group I	
Time (minutes)	Average Cumulative Water Loss ($mL\ H_2O/cm^2$)
10	3.5×10^{-4}
20	7.7×10^{-4}
30	10.6×10^{-4}

a. Construct and label a graph using the data for Group I. Using the same set of axes, draw and label three additional lines representing the results that you would predict for Groups II, III, and IV.

b. **Explain** how biological and physical processes are responsible for the difference between each of your predictions and the data for Group I.

c. **Explain** how the concept of water potential is used to account for the movement of water from the plant stem to the atmosphere during transpiration.

LAB 10. CIRCULATORY PHYSIOLOGY

In mammals, heart rate during periods of exercise is linked to the intensity of exercise.

a. **Discuss** the interactions of the respiratory, circulatory, and nervous systems during exercise.

b. **Design** a controlled experiment to determine the relationship between intensity of exercise and heart rate.

c. On the axes provided below, **indicate** results you expect for both the control and the experimental groups for the controlled experiment you described in part B. Remember to label the axes.

LAB 11. ANIMAL BEHAVIOR

1. A scientist working with *Bursatella leachii*, a sea slug that lives in an intertidal habitat in the coastal waters of Puerto Rico, gathered the following information about the distribution of the sea slugs within a ten-meter square plot over a 10-day period.

time of day	12 mid	4am	8am	12 noon	4pm	8pm	12 mid
average distance between individuals	8.0	8.9	44.8	174.0	350.5	60.5	8.0

a. For the data above, provide information on each of the following:

- **Summarize** the pattern.
- Identify **three** physiological or environmental variables that could cause the slugs to vary their distance from each other.
- **Explain** how each variable could bring about the observed pattern of distribution.

b. Choose **one** of the variables that you identified and **design** a controlled experiment to test your hypothetical explanation. **Describe** results that would support or refute your hypothesis.

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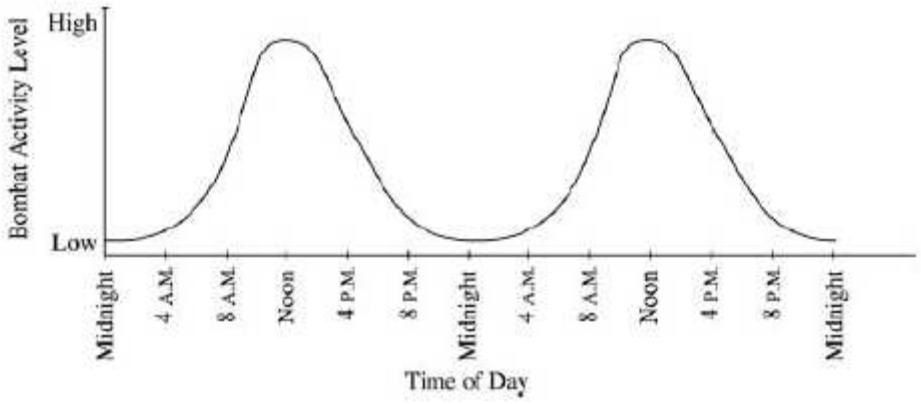
2. The activities of organisms change at regular time intervals. These changes are called biological rhythms. The graph depicts the activity cycle over a 48-hour period for a fictional group of mammals called pointy-eared bombats, found on an isolated island in the temperate zone.



a. **Describe** the cycle of activity for the bombats. **Discuss** how **three** of the following factors might affect the physiology and/or behavior of the bombats to result in this pattern of activity.
   - temperature
   - food availability
   - presence of predators
   - social behavior

b. **Propose** a hypothesis regarding the effect of light on the cycle of activity in bombats. **Describe** a controlled experiment that could be performed to test this hypothesis, and the results you would expect.

LAB 12. DISSOLVED OXYGEN

1. A biologist measured dissolved oxygen in the top 30 centimeters of a moderately eutrophic (mesotrophic) lake in the temperate zone. The day was bright and sunny and the wind was calm. The results of the observation are presented below.

Hour	$[O_2]$ mg/L
6:00 A.M.	0.9
8:00 A.M.	1.7
10:00 A.M.	3.1
12:00 noon	4.9
2:00 P.M.	6.8
4:00 P.M.	8.1
6:00 P.M.	7.9
8:00 P.M.	6.2
10:00 P.M.	4.0
12:00 midnight	2.4

   a. Using the graph paper provided, **plot** the results that were obtained. Then, using the same set of axes, draw and label an additional line/curve representing the results that you would predict had the day been heavily overcast.

   b. **Explain** the biological processes that are operating in the lake to produce the observed data. **Explain** also how these processes would account for your prediction of results for a heavily overcast day.

   c. **Describe** how the introduction of high levels of nutrients such as nitrates and phosphates into the lake would affect subsequent observations. **Explain** your predictions.

2. In most aquatic environments, primary production is affected by light available to the community of organisms.

   Using measurements of dissolved oxygen concentration to determine primary productivity, design a controlled experiment to test the hypothesis that primary productivity is affected by either the intensity of light **or** the wavelength of light. In your answer, be sure to include the following.

   - A statement of the specific hypothesis that you are testing
   - A description of your experimental design (Be sure to include a description of what data you would collect & how you would present & analyze the data using a graph.)
   - A description of results that would support your hypothesis