AP Biology

Lab Review

Lab 2
Enzyme Catalysis
1. Key Concepts
2. Design of the Experiment
3. Analysis of Results
4. Lab Quiz
What AP labs have we done?

- **Big Idea 1: Evolution**
  - Investigation 1 – Artificial Selection
  - Investigation 2 – Hardy-Weinberg Modeling
  - Investigation 3 – Using BLAST to show evolutionary relationships

- **Big Idea 2: Cellular Processes**
  - Investigation 4 – Diffusion and Osmosis
  - Investigation 5 – Photosynthesis
  - Investigation 6 – Cellular Respiration

- **Big Idea 3: Genetics and Information Transfer**
  - Investigation 7 – Cell Division, Mitosis and Meiosis
  - Investigations 8 & 9 – Biotechnology: Bacteria Transformation and Electrophoresis
What AP labs have we done?

- Big Idea 4: Interactions
  - Investigation 10 – Energy Transfer
  - Investigation 11 – Transpiration
  - Investigation 12 – Animal Behavior
  - Investigation 13 – Enzyme Catalysis
Investigation 1: Artificial Selection

- **Description**
  - Grow a parent generation of plants
  - Selectively breed for chosen traits
  - Grow the second generation and quantify the results.
Investigation 1 – Artificial Selection

- **Key Terms/Concepts:**
  - Phenotype
  - Artificial Selection (vs. Natural Selection)
  - Parent Generation, Filial (1st generation)
  - Cross-Pollination
  - Genetic Variation (or lack of)

- **Conclusions:**
  - Plant generations can be selectively cross breed to determine what traits are dominant/recessive; Artificial Selection has effects on future generations – specifically on genetic variation.
Investigation 2: H-W Modeling

random vs. non-random mating

size of population & gene pool

LARGE BREEDING POPULATION

Main distributions of population in California, 1997

An earthquake that kills three people out of a population of 10 million has little effect on the composition of the gene pool.

SMALL BREEDING POPULATION

Main distributions of population in California, before 1500

An earthquake that kills three people out of a band of 20 individuals has a significant effect on the composition of the gene pool.

random mating

Coral polyps disperse their sperm into the ocean currents. Contact with an egg in another coral is completely up to chance.

ASSORTATIVE MATING

Blister beetles are most likely to mate with partners of the same size.
Investigation 2: H-W Modeling

- **Description**
  - simulations were used to study effects of different parameters on frequency of alleles in a population
    - selection
    - heterozygous advantage
    - genetic drift
Investigation 2: H-W Modeling

- Concepts
  - Hardy-Weinberg equilibrium
    - \( p + q = 1 \)
    - \( p^2 + 2pq + q^2 = 1 \)
    - required conditions
      - large population
      - random mating
      - no mutations
      - no natural selection
      - no migration
  - gene pool
  - heterozygous advantage
  - genetic drift
    - founder effect
    - bottleneck

![Map showing percent of population with sickle-cell allele](image)
Investigation 2: H-W Modeling

- Conclusions
  - recessive alleles remain hidden in the pool of heterozygotes
    - even lethal recessive alleles are not completely removed from population
  - know how to solve H-W problems!
    - to calculate **allele frequencies**, use \( p + q = 1 \)
    - to calculate **genotype frequencies** or how many **individuals**, use, \( p^2 + 2pq + q^2 = 1 \)
Investigation 2: H-W Modeling

ESSAY 1989

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?
Investigation 3: BLAST Lab

- **Purpose:** Using bioinformatics tool (BLAST) to research and show evolutionary relationships between organisms.

- **Key Terms:**
  - Basic Local Alignment Search Tool
  - Cladogram
  - Root
  - Derived Characteristics
Investigation 3: BLAST Lab

- **Conclusions:**
  - The more aligned a gene sample is to a known sample in the database the more closely related = would be closer together on a cladogram.
Investigation 4: Diffusion & Osmosis

- Selectively permeable membrane
- Inside bag
- Inside beaker
- Hypotonic solution
- Hypertonic solution
- Isotonic solutions
- Distilled water
- Animal cell
- Plant cell
- Cell wall
Investigation 4: Diffusion & Osmosis

**Description**

- dialysis tubing filled with starch-glucose solution in beaker filled with KI solution
- Dialysis bags in different sucrose solutions
- Different sucrose solutions to determine Molarity of tissue sample
Investigation 4: Diffusion & Osmosis

- Concepts/Key Terms
  - semi-permeable membrane
  - diffusion
  - osmosis
  - solutions
    - hypotonic
    - hypertonic
    - Isotonic
  - Water potential
    - Solute, pressure
Investigation 4: Diffusion & Osmosis

- Conclusions
  - water moves from high concentration of water/high potential (hypotonic = low solute) to low concentration of water/low potential (hypertonic = high solute)
  - solute concentration affects water potential
  - size of molecule affect movement through semi-permeable membrane
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, and 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.
Investigation 5: Photosynthesis
Investigation 5: Photosynthesis

- Description
  - determine rate of photosynthesis under different conditions
    - Carbon (sodium bicarbonate) v. no carbon
    - Removed the air from leaf disks to sink, placed in solution and counted number of disks rising
    - Production of oxygen caused the disks to float (shows rate of photosynthesis)
Investigation 5: Photosynthesis

- **Concepts**
  - photosynthesis
  - Photosystem 1
    - NADPH
  - chlorophylls & other plant pigments
    - chlorophyll a
    - chlorophyll b
    - xanthophylls
    - carotenoids
  - experimental design
    - control vs. experimental
Investigation 5: Photosynthesis

- Conclusions
  - Photosynthesis
    - Leaf disks with carbon source floated at a faster rate than leaf disks with no carbon source
  - Others?
    - Light Intensity
    - Light Color
Investigation 5: Photosynthesis

ESSAY 2004 (part 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 wrap to provide a dark environment + DPIP
Sample 3 — chloroplast suspension that has been boiled + DPIP

Data are given in the table on the next page.

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.
### Investigation 5: Photosynthesis

#### ESSAY 2004 (part 2)

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Light, Unboiled % transmittance Sample 1</th>
<th>Dark, Unboiled % transmittance Sample 2</th>
<th>Light, Boiled % transmittance Sample 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>28.8</td>
<td>29.2</td>
<td>28.8</td>
</tr>
<tr>
<td>5</td>
<td>48.7</td>
<td>30.1</td>
<td>29.2</td>
</tr>
<tr>
<td>10</td>
<td>57.8</td>
<td>31.2</td>
<td>29.4</td>
</tr>
<tr>
<td>15</td>
<td>62.5</td>
<td>32.4</td>
<td>28.7</td>
</tr>
<tr>
<td>20</td>
<td>66.7</td>
<td>31.8</td>
<td>28.5</td>
</tr>
</tbody>
</table>
Investigation 6: Cellular Respiration

- **Description**
  - Using probeware to measure rate of CO$_2$ production by seeds/crickets
    - non-germinating seeds
    - germinating seeds
    - Crickets (live)
    - effect of temperature
    - control for changes in pressure & temperature in room
Investigation 6: Cellular Respiration

- **Concepts**
  - respiration
  - experimental design
    - control vs. experimental
Lab 5: Cellular Respiration

- **Conclusions**
  - ↓ temp = ↓ respiration
  - ↑ germination = ↑ respiration

![Graph showing the effect of temperature on respiration rate during germination.](image-url)
Investigation 6: Cellular Respiration

ESSAY 1990

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.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germinating seeds 22°C</td>
<td>0.0</td>
<td>8.8</td>
<td>16.0</td>
<td>23.7</td>
<td>32.0</td>
</tr>
<tr>
<td>Dry Seeds (non-germinating) 22°C</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Germinating Seeds 10°C</td>
<td>0.0</td>
<td>2.9</td>
<td>6.2</td>
<td>9.4</td>
<td>12.5</td>
</tr>
<tr>
<td>Dry Seeds (non-germinating) 10°C</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

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:
   1. germinating seeds at 22°C and at 10°C
   2. 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.
Investigation 7: Mitosis & Meiosis

Synapsis: Pairing of homologous chromosomes

Homologous pair of chromosomes

Diploid parent cell (2n=4)

DNA replication

MITOSIS

First cell division

Diploid daughter cells identical to parent cell and to each other

MEIOSIS

Second cell division

Haploid daughter cells not identical to parent cell nor to each other

Haploid daughter cells

Crossing over
Investigation 7: Mitosis & Meiosis

- **Description**
  - **A:** cell stages of mitosis
    - exam slide of onion root tip
    - count number of cells in each stage to determine relative time spent in each stage
  - **B:** crossing over in meiosis
    - farther gene is from centromere the greater number of crossovers
    - observed crossing over in fungus, *Sordaria*
      - arrangement of ascospores
Investigation 7: Mitosis & Meiosis

- **Concepts**
  - **mitosis**
    - interphase
    - prophase
    - metaphase
    - anaphase
    - telophase
  - **meiosis**
    - meiosis 1
    - meiosis 2
  - **crossing over**
    - tetrad in prophase 1
Investigation 7: Mitosis & Meiosis

Conclusions

- **Mitosis**
  - longest phase = interphase
  - each subsequent phase is shorter in duration

- **Meiosis**
  - 4:4 arrangement in ascospores
    - no crossover
  - any other arrangement
    - crossover
    - 2:2:2:2 or 2:4:2
Sordaria analysis

\[
\text{% crossover} = \frac{\text{total crossover}}{\text{total offspring}}
\]

- A. No crossing over
- B. Crossing over during meiosis
Investigation 7: Mitosis & Meiosis

ESSAY 1987
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.

ESSAY 2004
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.
Investigation 8 & 9: Biotechnology

1. Ampicillin sensitive E.coli cells in log phase of growth are transferred to cold CaCl₂ solution.

2. ampR plasmids are added to experimental cells only.

3. Cells are heat-shocked at 42°C. Some of the competent cells take up the ampR plasmid and are transformed.

4. The treated cells are spread on an agar plate containing ampicillin.

5. The cells are incubated for 24 hours.

Ampicillin kills the cells that lack the ampR gene.

6. Only colonies of E.coli that have been transformed by the ampR gene will grow.
Investigation 8 & 9: Biotechnology

- **Description**
  - **Transformation**
    - insert foreign DNA in bacteria by using engineered plasmid (creating recombinant DNA)
  - **Gel electrophoresis**
    - cut DNA with restriction enzyme
    - fragments separate on gel based on size
Investigation 8: Biotechnology

- **Concepts**
  - **Transformation** –
    - Foreign DNA
    - plasmid
    - restriction enzyme
  - **gel electrophoresis**
    - DNA is negatively charged
    - smaller fragments travel faster
Investigation 8: Biotechnology

- Conclusions
  - can insert foreign DNA
  - Use the plasmid to engineer a product from bacteria
Investigation 9: Biotechnology

Conclusions

1. Make gel.
2. Obtain prepared DNA samples.
3. Load samples into gel.
4. Separate fragments by electrophoresis.
5. Stain DNA fragments and measure distances.
6. Prepare a standard curve. Determine fragment sizes.

DNA = negatively charged

correlate distance to size

smaller fragments travel faster & therefore farther
Investigation 9: Biotechnology

ESSAY 1995

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.
Investigation 8: Biotechnology

ESSAY 2002

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.
Investigation 10: Energy Transfer

Description:
- Observe the transfer of energy between a producer and a consumer and determine the efficiency of the transfer.

Key Terms:
- 1st law of thermodynamics
- Biomass
- Gross vs. Net Productivity
- Producer, Consumer
Investigation 10: Energy Transfer

- Conclusions:
  - Energy Transfer between trophic levels is not efficient.
    - Not all the mass from the oatmeal was transferred to the mealworm.
    - Why? What else does the energy go towards?
Investigation 11: Transpiration

Diagram showing the process of transpiration with labeled parts such as xylem cell wall, adhesion, cohesion, xylem cell, mesophyll cells, xylem vessel, air space, water molecule, guard cell, and stoma.
Investigation 11: Transpiration

- **Description**
  - test the effects of environmental factors on rate of transpiration
    - temperature
    - humidity
    - air flow (wind)
    - light intensity (dark)
Investigation 11: Transpiration

- **Concepts**
  - transpiration
  - stomata
  - guard cells
  - xylem
    - adhesion
    - cohesion
      - H bonding
  - Cohesion-tension theory
Investigation 11: Transpiration

- Conclusions
  - ↑transpiration
    - ↑ wind
    - ↑ light
  - ↓transpiration
    - ↑ humidity
Lab 9: Transpiration

ESSAY 1991

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.

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Average Cumulative Water Loss (mL H₂O/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>3.5 x 10⁻⁴</td>
</tr>
<tr>
<td>20</td>
<td>7.7 x 10⁻⁴</td>
</tr>
<tr>
<td>30</td>
<td>10.6 x 10⁻⁴</td>
</tr>
</tbody>
</table>

1. 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.

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

3. 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.
Investigation 12: Animal Behavior

A Orientation  
B Male song  
C Following  
D Male licking  
E Copulation  
F Rejection
Investigation 12: Animal Behavior

- **Description**
  - set up an experiment to study behavior in an organism
    - Mealworm kinesis or taxis?
Investigation 12: Animal Behavior

- Concepts
  - innate vs. learned behavior
  - experimental design
    - control vs. experimental
    - hypothesis
  - choice chamber
    - temperature
    - humidity
    - light intensity
    - salinity
    - other factors
Investigation 12: Animal Behavior

- Experimental design

<table>
<thead>
<tr>
<th>EXPERIMENT</th>
<th>CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left compartment</td>
<td>Right compartment</td>
</tr>
<tr>
<td>MOISTURE</td>
<td>wet</td>
</tr>
<tr>
<td>LIGHT</td>
<td>25 Watts</td>
</tr>
<tr>
<td>FILTERPAPER</td>
<td>#1 Whatman</td>
</tr>
<tr>
<td>TEMPERATURE</td>
<td>20°C</td>
</tr>
<tr>
<td>NUMBER OF BUGS AT START</td>
<td>5</td>
</tr>
</tbody>
</table>

Sample size

- Sample size too small.
- Sample size better.
Investigation 12: Animal Behavior

**Conclusions**

- Kinesis is random movement
- Taxis is movement in response to something (light, moisture)
Investigation 12: Animal Behavior

ESSAY 1997

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.

<table>
<thead>
<tr>
<th>time of day</th>
<th>12 mid</th>
<th>4am</th>
<th>8am</th>
<th>12 noon</th>
<th>4pm</th>
<th>8pm</th>
<th>12 mid</th>
</tr>
</thead>
<tbody>
<tr>
<td>average distance between individuals</td>
<td>8.0</td>
<td>8.9</td>
<td>44.8</td>
<td>174.0</td>
<td>350.5</td>
<td>60.5</td>
<td>8.0</td>
</tr>
</tbody>
</table>

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.
Investigation 12: Animal Behavior

ESSAY 2002

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.**
Investigation 13: Enzyme Catalysis
Investigation 13: Enzyme Catalysis

- **Description**
  - measured factors affecting enzyme activity
  - $\text{H}_2\text{O}_2 \xrightarrow{\text{catalase}} \text{H}_2\text{O} + \text{O}_2$
  - measured rate of $\text{O}_2$ production
Investigation 13: Enzyme Catalysis

- Concepts/Key Terms
  - substrate
  - enzyme
    - enzyme structure
  - product
  - denaturation of protein
  - experimental design
    - rate of reactivity
      - reaction with enzyme vs. reaction without enzyme
    - optimum pH or temperature
      - test at various pH, temperature values, or salinity
Investigation 13: Enzyme Catalysis

- Conclusions
  - enzyme reaction rate is affected by:
    - pH
    - temperature
    - substrate concentration
    - enzyme concentration

![Graph showing enzyme activity vs temperature and substrate concentration]
Investigation 13: Enzyme Catalysis

ESSAY 2000

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.