MARCO LEARNING

Introduction to AP BIOLOGY Free Responses

with
Tiffany Jones
& Josh Kaspar

Welcome – Who Are You?

Mrs. Tiffany Jones

- 11 years of AP Biology
- Georgia
- AP Reader
- B.S. in Biology
- Ed.S. in Instructional Tech

Welcome – Who Are You?

Mr. Joshua Kaspar

- 10 Years of AP Biology
- Florida
- B.A. in Science Education – Biology
- Undefeated at Street Fighter II on SNES

AP Biology students are penguins because they are Dressed for Success!

You are now an AP Bio Penguin!

Exam Format

Time: 90 minutes

- Section I: Multiple Choice
- 60 Questions
- 50% of Exam Weighting

Time: 90 minutes

- Section II: Free Response
- 6 Questions (2 long, 4 short)
- 50% of Exam Weighting

Based on the 2020 Practice Exam Scoring Guidelines

You need approximately 54 of the available 120 points for a 3 on the exam

Exam Format

Long FRQ Topics Breakdown

#	Topic	Points
1	Interpret & Evaluate Experimental Results	8-10
2	Interpret & Evaluate Experimental Results with Graphing	8-10

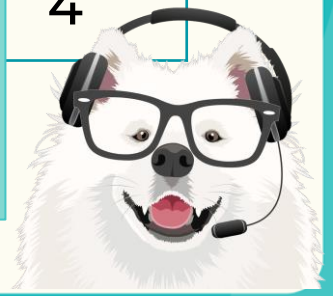
Long FRQ Total: 18 points

Exam Format

Short FRQ Topics Breakdown

#	Topic	Points
3	Scientific Investigation	4
4	Conceptual Analysis	4
5	Analyze Model or Visual Representation	4
6	Analyze Data	4

Short FRQ Total: 16 points



Tips & Tricks

FRQ Writing:

- Read the question, Read the question, Read the ...
- Label your responses (a), (b), (c) & (d)
- Write in knowledge order
- Do not restate the question
- Additional examples are not scored
- Beware of contradictions
- Use the diagrams
- Define your terms

Tips & Tricks

FRQ Writing:

- Graphs: correct type, scale, and labels
- Write clearly and legibly
- Cross out – a single line is enough
- Pen, Pencil, Crayon, Marker – keep ONE color
- Watch out for a writing utensil that bleeds

Tips & Tricks

FRQ Timing:

- Approximate:
  25 min per long & 10 min per short
- Recommendation:
  20 min per long & 8 min per short

- Checkboxes
- Time on Page
- Order of Knowledge/Ability
- WATCH YOUR QUESTION NUMBER!

FRQ #1

Interpret & Evaluate Experimental Results

- Part A (1-2 pts): Describe and explain biological concepts, processes, or models
- Part B (3-4 pts): Identify experimental design procedures
- Part C (1-3 pts): Analyze data
- Part D (2-4 pts): Make and justify predictions

2022 FRQ #1

The binding of an extracellular ligand to a G protein-coupled receptor in the plasma membrane of a cell triggers intracellular signaling (Figure 1, A). After ligand binding, GTP replaces the GDP that is bound to Gsα, a subunit of the G protein (Figure 1, B). This causes Gsα to activate other cellular proteins, including adenylyl cyclase that converts ATP to cyclic AMP (cAMP). The cAMP activates protein kinases (Figure 1, C). In cells that line the small intestine, a cAMP-activated protein kinase causes further signaling that ultimately results in the secretion of chloride ions (Cl^-) from the cells. Under normal conditions, Gsα hydrolyzes GTP to GDP, thus inactivating adenylyl cyclase and stopping the signal (Figure 1, A).

Individuals infected with the bacterium *Vibrio cholerae* experience severe loss of water from the body (dehydration). This is due to the effects of the bacterial cholera toxin that enters intestinal cells. Scientists studied the effects of cholera toxin on four samples of isolated intestinal cell membranes containing the G protein-related signal transduction components shown in Figure 1. GTP was added to samples II and IV only; cholera toxin was added to samples III and IV only. The scientists then measured the amount of cAMP produced by the adenylyl cyclase in each sample (Table 1).

TABLE 1. AMOUNT OF cAMP PRODUCED FROM INTESTINAL CELL MEMBRANES IN THE ABSENCE OR PRESENCE OF CHOLERA TOXIN

Sample	GTP	Cholera Toxin	Rate of cAMP Production (pmol per mg adenylyl cyclase per min)
I	–	–	0.5
II	+	–	10.0
III	–	+	0.5
IV	+	+	127.0

present, +; absent, –

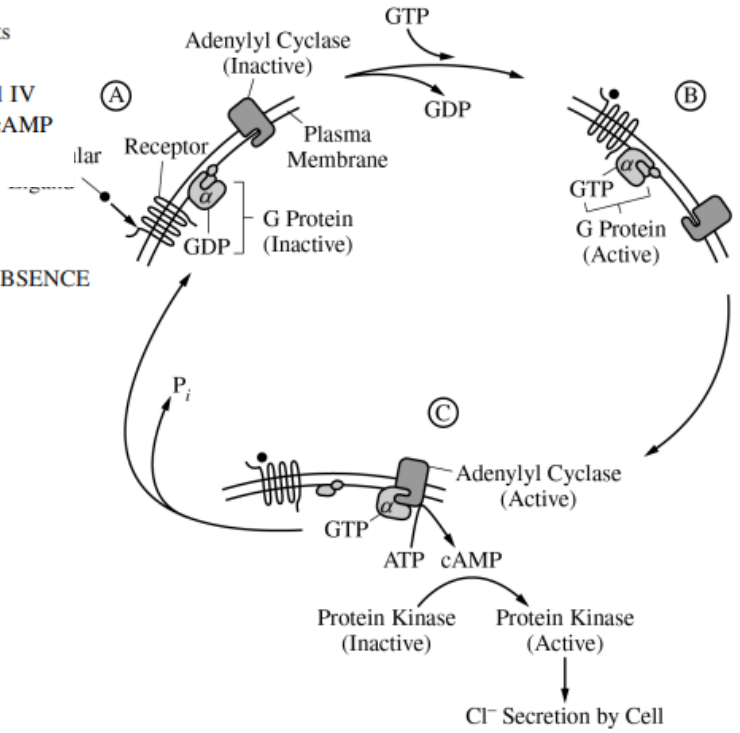


Figure 1. Under normal conditions, ligand binding to a G protein-coupled receptor results in chloride ion transport from an intestinal cell.

2022 FRQ #1

Identify experimental design procedures

(b) **Identify** an independent variable in the experiment. **Identify** a negative control in the experiment. **Justify** why the scientists included Sample III as a control treatment in the experiment.

Accept one of the following:

- The presence or absence of cholera toxin
- The presence or absence of GTP

Accept one of the following:

- The sample lacking both cholera toxin and GTP/sample I
- The samples that lack cholera toxin/samples I and II
- The sample that lacks cholera toxin but contains GTP/sample II
- The samples that lack GTP/samples I and III

2022 FRQ #1

Identify experimental design procedures

(b) **Identify** an independent variable in the experiment. **Identify** a negative control in the experiment. **Justify** why the scientists included Sample III as a control treatment in the experiment.

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II	+	–	10.0
III	–	+	0.5
IV	+	+	127.0

present, +; absent, –

Accept one of the following:

- (Sample III serves as a control) to compare cAMP production with that of the sample having cholera toxin and GTP/sample IV.
- Comparing sample III and sample IV enables the scientists to evaluate whether the activity of cholera toxin requires GTP/acts via the G protein pathway.

2022 FRQ #1

Analyze data

(c) Based on the data, **describe** the effect of cholera toxin on the synthesis of cAMP. **Calculate** the percent change in the rate of cAMP production due to the presence of cholera toxin in sample IV compared with sample II.

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II	+	–	10.0
III	–	+	0.5
IV	+	+	127.0

present, +; absent, –

- 1,170% [(127-10)/10 = 11.7 × 100]

Accept one of the following:

- Cholera toxin increases the production of cAMP in the presence of GTP (IV vs II).
- Cholera toxin has no effect on the production of cAMP in the absence of GTP (III vs I).

2022 FRQ #1

Make and justify predictions

(d) A drug is designed to bind to cholera toxin before it crosses the intestinal cell membrane. Scientists mix the drug with cholera toxin and then add this mixture and GTP to a sample of intestinal cell membranes. **Predict** the rate of cAMP production in pmol per mg adenylyl cyclase per min if the drug binds to all of the toxin. In a separate experiment, scientists engineer a mutant adenylyl cyclase that cannot be activated by Gsα. The scientists claim that cholera toxin will not cause excessive water loss from whole intestinal cells that contain the mutant adenylyl cyclase. **Justify** this claim.

TABLE 1. AMOUNT OF cAMP PRODUCED FROM INTESTINAL CELL MEMBRANES IN THE ABSENCE OR PRESENCE OF CHOLERA TOXIN

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I	–	–	0.5
II	+	–	10.0
III	–	+	0.5
IV	+	+	127.0

present, +; absent, –

- The rate will be 10 (pmol per mg adenyl cyclase per min).

2022 FRQ #1

Make and justify predictions

(d) A drug is designed to bind to cholera t
drug with cholera toxin and then add t
Predict the rate of cAMP production i
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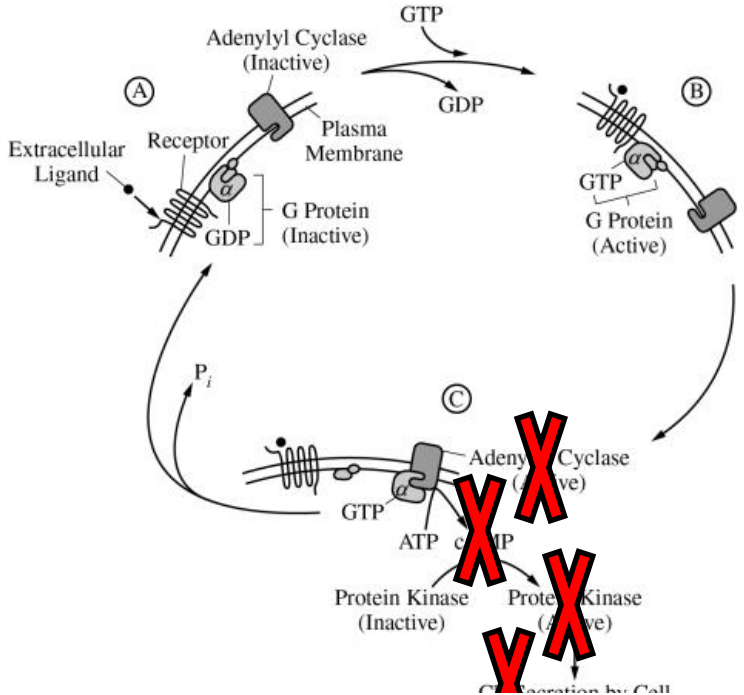


- (Even in the presence of the toxin) cAMP will not be produced (by this pathway), the protein kinases will not be activated, and Cl^- ions will not be secreted (and less water will leave the intestinal cells).

FRQ #2

Interpret & Evaluate Experimental Results with Graphing

- Part A (1-2 pts): Describe and explain biological concepts, processes, or models
- Part B (4 pts): Construct a graph, plot, or chart and use confidence intervals or error bars
- Part C (1-3 pts): Analyze data
- Part D (2-4 pts): Make and justify predictions

2022 FRQ #2

During meiosis, double-strand breaks occur in chromatids. The breaks are either repaired by the exchange of genetic material between homologous nonsister chromatids, which is the process known as crossing over (Figure 1A), or they are simply repaired without any crossing over (Figure 1B). Plant breeders developing new varieties of corn are interested in determining whether, in corn, a correlation exists between the number of meiotic double-strand chromatid breaks and the number of crossovers.

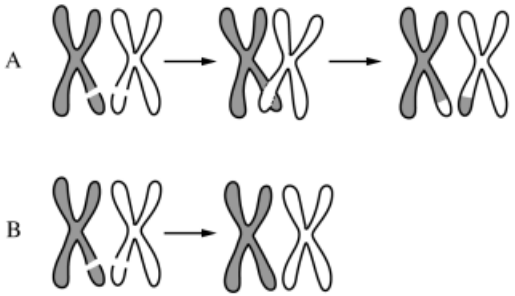


Figure 1. Double-strand breaks in chromatids are repaired with crossing over (A) or without crossing over (B).

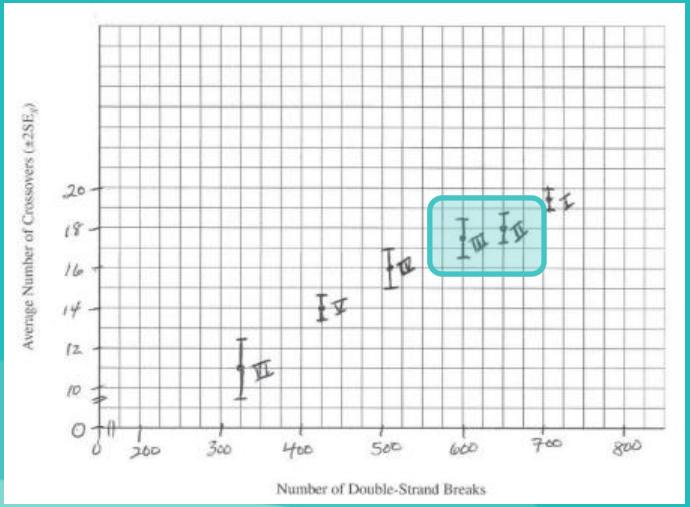
Using specialized staining and microscopy techniques, scientists counted the number of double-strand chromatid breaks and the number of crossovers in the same number of meiotic gamete-forming cells of six inbred strains of corn (Table 1).

TABLE 1. NUMBER OF CHROMATID DOUBLE-STRAND BREAKS AND AVERAGE NUMBER OF CROSSOVERS IN INBRED STRAINS OF CORN

Strain of Corn	Number of Double-Strand Breaks	Average Number of Crossovers ($\pm 2SE_{\bar{x}}$)
I	710	19.5 ± 0.5
II	650	18.0 ± 0.7
III	600	17.5 ± 1.0
IV	510	16.0 ± 1.0
V	425	14.0 ± 0.5
VI	325	11.0 ± 1.5

2022 FRQ #2

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph that represents the data in Table 1 and allows examination of a possible correlation between double-strand breaks and crossovers. Based on the data, **determine** whether corn strains I, II, and III differ in their average number of crossovers.



- Appropriate axis scaling
- Accurately plotted X,Y graph with separate points for the average number of crossovers for each strain
- Accurate error bars

- There is no (statistical) difference (in the average number of crossovers) between strains II and III. Strain I is higher/is different (in the average number of crossovers) compared with strains II and III.

2021 FRQ #2

Geneticists investigated the mode of inheritance of a rare disorder that alters gluc
shows symptoms in adulthood. The geneticists studied a family in which some in
and III are known to have the disorder. Based on the pedigree (Figure 1), the ge
disorder arose in individual II−2 and was caused by a mutation in mitochondrial

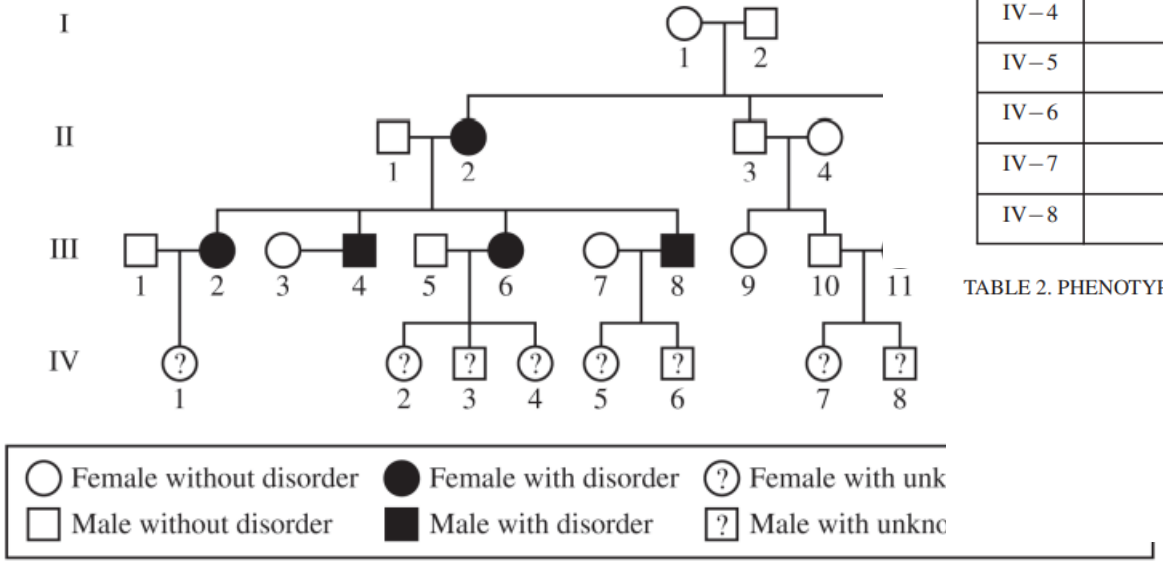


Figure 1. Pedigree of a family showing individuals with the glucose metabolism disorder. A question mark indicates that the phenotype is unknown.

TABLE 1. AVERAGE BLOOD GLUCOSE LEVELS OF INDIVIDUALS IN GENERATION IV

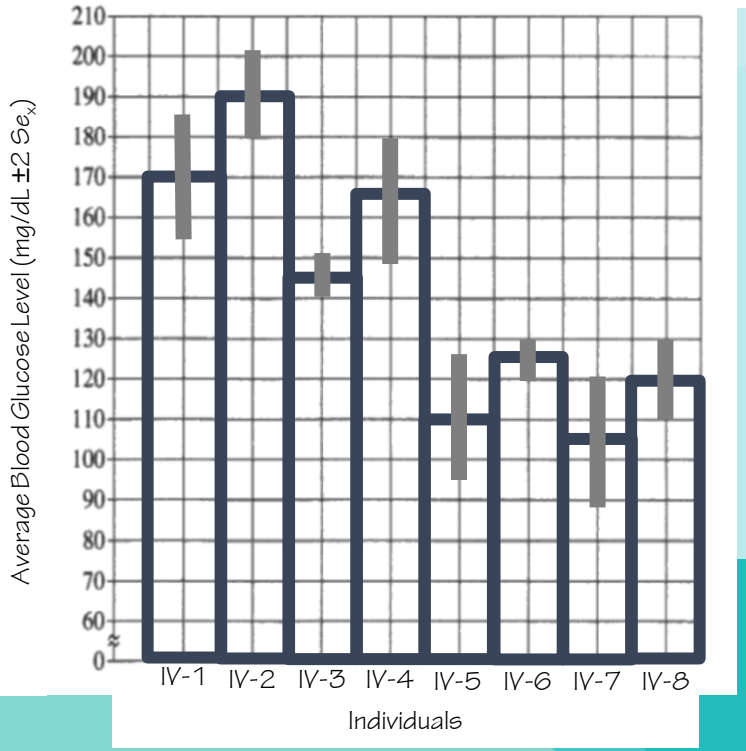
Individual	Average Blood Glucose Level (mg/dL ± $2SE_{\bar{x}}$)
IV−1	170 ± 15
IV−2	190 ± 10
IV−3	145 ± 5
IV−4	165 ± 15
IV−5	110 ± 15
IV−6	125 ± 5
IV−7	105 ± 15
IV−8	120 ± 10

TABLE 2. PHENOTYPIC CLASSIFICATIONS BASED ON BLOOD GLUCOSE LEVELS

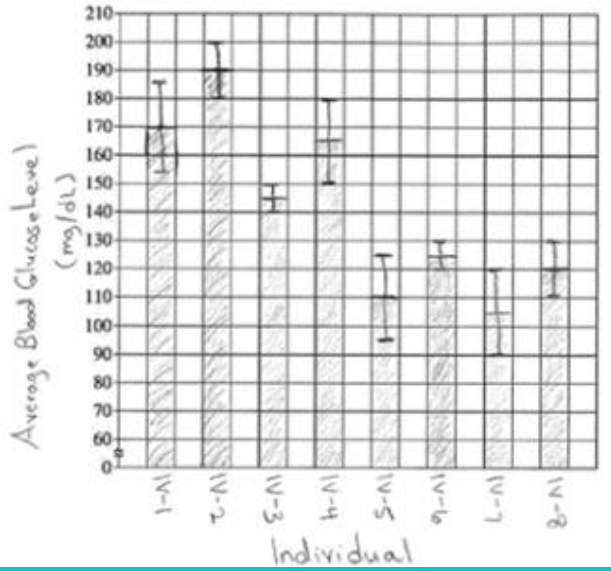
Phenotype	Blood Glucose Level (mg/dL)
Normal	< 140 mg/dL
At risk	140 − 199 mg/dL
Affected	≥ 200 mg/dL

2021 FRQ #2

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph based on the data in Table 1. **Determine** one individual who is both at risk of developing the disorder and has a significantly different blood glucose level from that of individual IV–1.



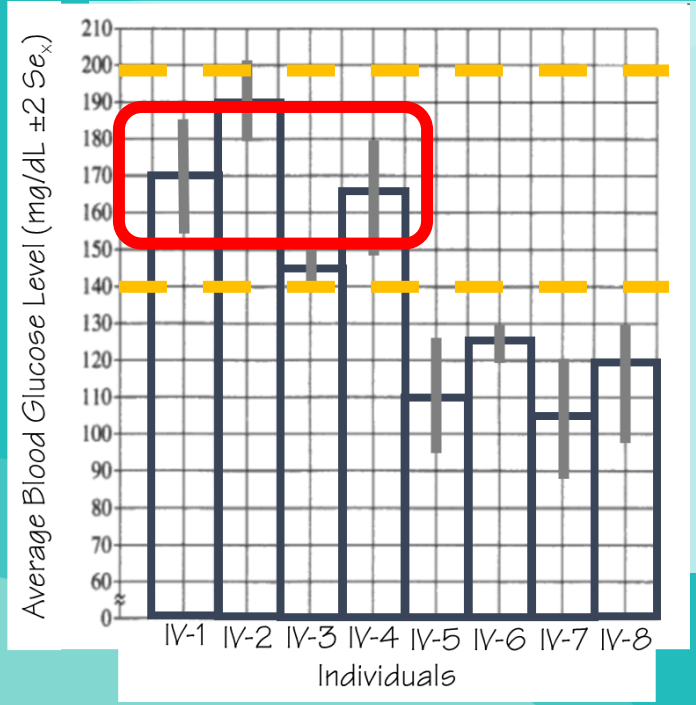
TABL N IV



- Point distribution: Axis labels; plotting in a bar graph or modified bar graph; error bars

2021 FRQ #2

(b) Using the template in the space provided for your response, **construct** an appropriately labeled graph based on the data in Table 1. **Determine** one individual who is both at risk of developing the disorder and has a significantly different blood glucose level from that of individual IV – 1.



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Normal	< 140 mg/dL
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Affected	≥ 200 mg/dL

- IV-3

FRQ #3

Scientific Investigation

- Part A (1 pt): Describe biological concepts, or processes
- Part B (1 pt): Identify experimental procedures
- Part C (1 pt): Predict results
- Part D (1 pt): Justify predictions

2022 FRQ #3

Describe biological concepts, or processes

Fireflies emit light when the enzyme luciferase catalyzes a reaction in which its substrate, D-luciferin, reacts to form oxyluciferin and other products (Figure 1). In order to determine the optimal temperature for this enzyme, scientists added ATP to a solution containing D-luciferin, luciferase, and other substances needed for the reaction. They then measured the amount of light emitted during the first three seconds of the reaction when it was carried out at different temperatures.

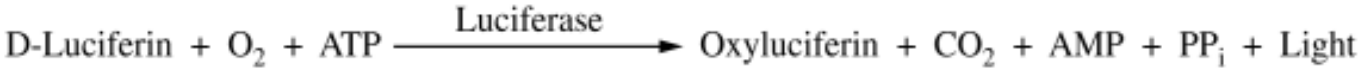


Figure 1. Light is emitted as a result of the reaction catalyzed by luciferase.

(a) **Describe** a characteristic of the luciferase enzyme that allows it to catalyze the reaction.

Accept one of the following:

- It has an active site/a shape that can bind with the substrate(s)/brings reactants together.
- It has a charge that is compatible with the substrate(s).

2022 FRQ #3

Identify experimental procedures

Fireflies emit light when the enzyme luciferase catalyzes a reaction in which its substrate, D-luciferin, reacts to form oxyluciferin and other products (Figure 1). In order to determine the optimal temperature for this enzyme, scientists added ATP to a solution containing D-luciferin, luciferase, and other substances needed for the reaction. They then measured the amount of light emitted during the first three seconds of the reaction when it was carried out at different temperatures.

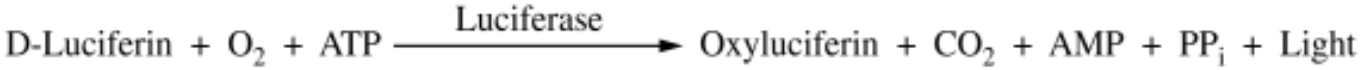


Figure 1. Light is emitted as a result of the reaction catalyzed by luciferase.

(b) **Identify** the dependent variable in the experiment.

- The amount of light emitted

2022 FRQ #3

Predict results

Fireflies emit light when the enzyme luciferase catalyzes a reaction in which its substrate, D-luciferin, reacts to form oxyluciferin and other products (Figure 1). In order to determine the optimal temperature for this enzyme, scientists added ATP to a solution containing D-luciferin, luciferase, and other substances needed for the reaction. They then measured the amount of light emitted during the first three seconds of the reaction when it was carried out at different temperatures.

$$\text{D-Luciferin} + O_2 + \text{ATP} \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + CO_2 + \text{AMP} + PP_i + \text{Light}$$

Figure 1. Light is emitted as a result of the reaction catalyzed by luciferase.

(c) **State** the null hypothesis for the experiment.

- Temperature has no effect on the amount of light emitted.

2022 FRQ #3

Justify predictions

Fireflies emit light when the enzyme luciferase catalyzes a reaction in which its substrate, D-luciferin, reacts to form oxyluciferin and other products (Figure 1). In order to determine the optimal temperature for this enzyme, scientists added ATP to a solution containing D-luciferin, luciferase, and other substances needed for the reaction. They then measured the amount of light emitted during the first three seconds of the reaction when it was carried out at different temperatures.

$$\text{D-Luciferin} + O_2 + \text{ATP} \xrightarrow{\text{Luciferase}} \text{Oxyluciferin} + CO_2 + \text{AMP} + PP_i + \text{Light}$$

Figure 1. Light is emitted as a result of the reaction catalyzed by luciferase.

(d) A student claims that, as temperature increases, there will be an increase in the amount of light given off by the reaction in the first three seconds. **Support** the student's claim.

Accept one of the following:

- Higher temperature increases the frequency of collisions/interactions between molecules, resulting in an increase in reaction rate.
- The higher temperature results in a change to the active site that enhances substrate binding.

FRQ #4

Conceptual Analysis

- Part A (1 pt): Describe biological concepts, or processes
- Part B (1 pt): Explain biological concepts or processes
- Part C (1 pt): Predict cause or effects of a change in a biological system
- Part D (1 pt): Justify predictions

2022 FRQ #4

Existing isolated brook trout populations in Newfoundland, Canada, were once part of a larger population that was fragmented at the end of the most recent glaciation period about 10,000 to 12,000 years ago. Researchers investigated 14 naturally separated stream populations of brook trout. They found that the populations are all genetically distinct and show differences in morphology.

(a) **Describe** the prezygotic barrier that results in these genetically distinct populations.

(b) Brook trout with longer fins are able to swim faster than brook trout with shorter fins. In one of the Newfoundland streams, the main prey of the brook trout evolved to move faster. For brook trout living in this stream, **explain** the difference in fitness between longer-finned individuals and shorter-finned individuals.

(c) If two morphologically and behaviorally distinct populations of brook trout remain isolated for many generations, **predict** the likely impact on both populations.

(d) Researchers claim that there are more genetic differences between any two current brook trout populations than there are between any single current population and the ancestral brook trout population from which all the trout are descended. Provide reasoning to **justify** their claim.

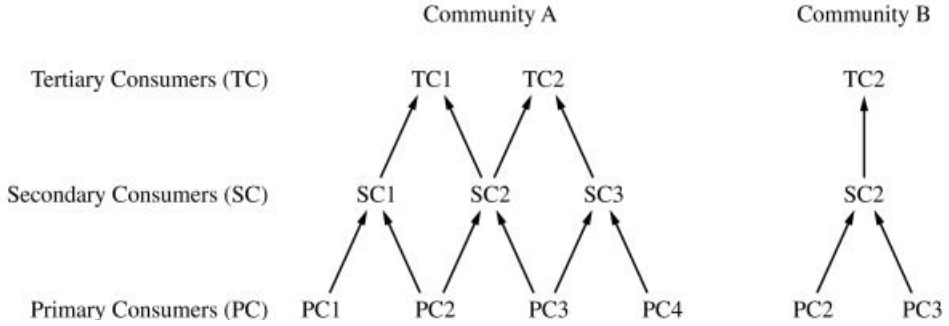
FRQ #5

Analyze Model or Visual Representation

- Part A (1 pt): Describe characteristics of a biological concept, process, or model represented visually.
- Part B (1 pt): Explain relationships between different characteristics of a biological concept or process represented visually
- Part C (1 pt): Represent relationships within a biological model
- Part D (1 pt): Explain how a biological concept or process represented visually relates to a larger biological principle, concept, process or theory

2022 FRQ #5

The following models represent all the interacting species in two different communities with some of the same species and feeding relationships. These models assume that both communities have the same initial biomass. The models can be used to understand the effects of human activities on the communities.



(a) **Describe** a characteristic of a community that makes a species invasive in that community but not invasive in a different community.

(b) **Explain** why removing species PP1 will have a greater effect on community B than on community A.

(c) An invasive species (INV) that eats individuals of species SC2 is introduced into community B. Using the template in the space provided for your response, for community B, indicate the feeding relationship for this invasive species by correctly placing **INV** to represent the invasive species and an **arrow** to represent the feeding relationship within community B.

(d) **Explain** how human activities that add toxins to the soil could change a community with many species at each trophic level, such as community A, into a community with few species at each trophic level, such as community B.

CED FRQ #5

In humans, the gene that determines a particular condition has only two alleles, one of which (B) is completely dominant to the other (b). The phenotypes of three generations of a family with respect to the condition are shown in the pedigree in Figure 1. Individuals are numbered.

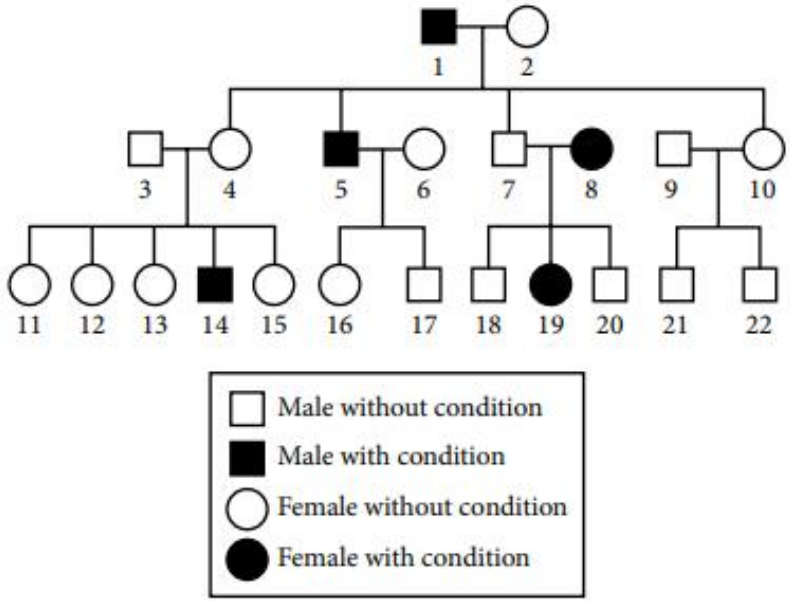


Figure 1. Inheritance of a particular condition over three generations of a family

CED FRQ #5

Describe characteristics of a biological concept, process, or model represented visually.

(a) **Describe** the process in eukaryotes that ensures that the number of chromosomes will not double from parent to offspring when gametes fuse during fertilization.

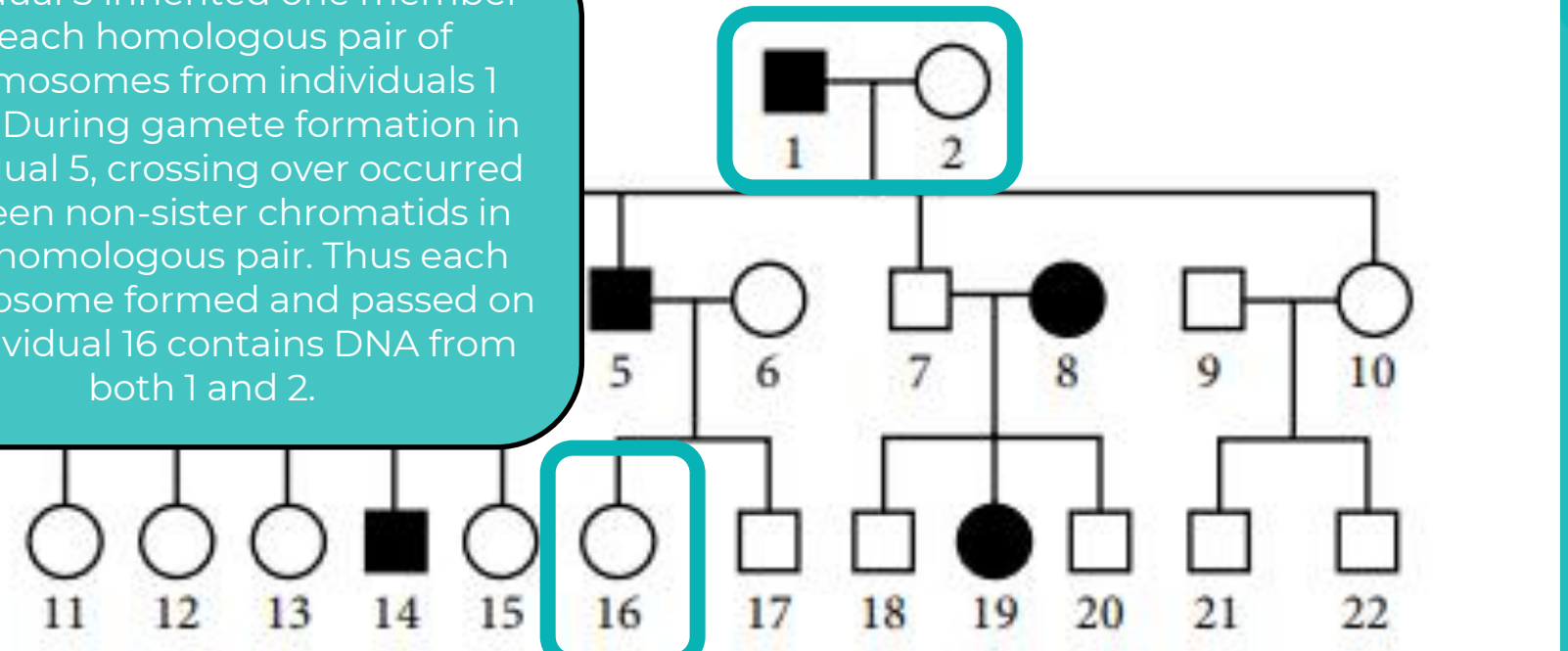
Homologous pairs of chromosomes separate in meiosis I, so the gametes are haploid (n), and each gamete receives only one member of each chromosome pair

CED FRQ #5

Explain relationships between different characteristics of a biological concept or process represented visually

(b) **Explain** how any one chromosome in individual 16 contains DNA that came from both individuals 1 and 2.

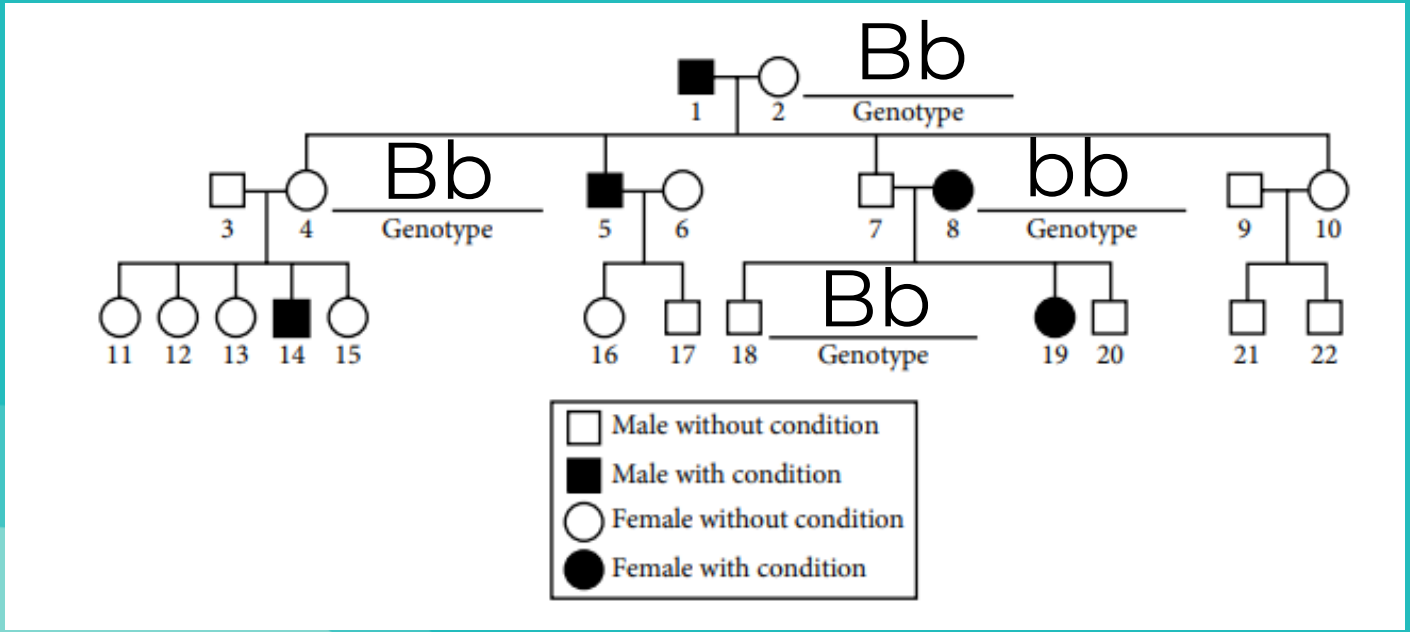
Individual 5 inherited one member of each homologous pair of chromosomes from individuals 1 and 2. During gamete formation in individual 5, crossing over occurred between non-sister chromatids in each homologous pair. Thus each chromosome formed and passed on to individual 16 contains DNA from both 1 and 2.



CED FRQ #5

Represent relationships within a biological model

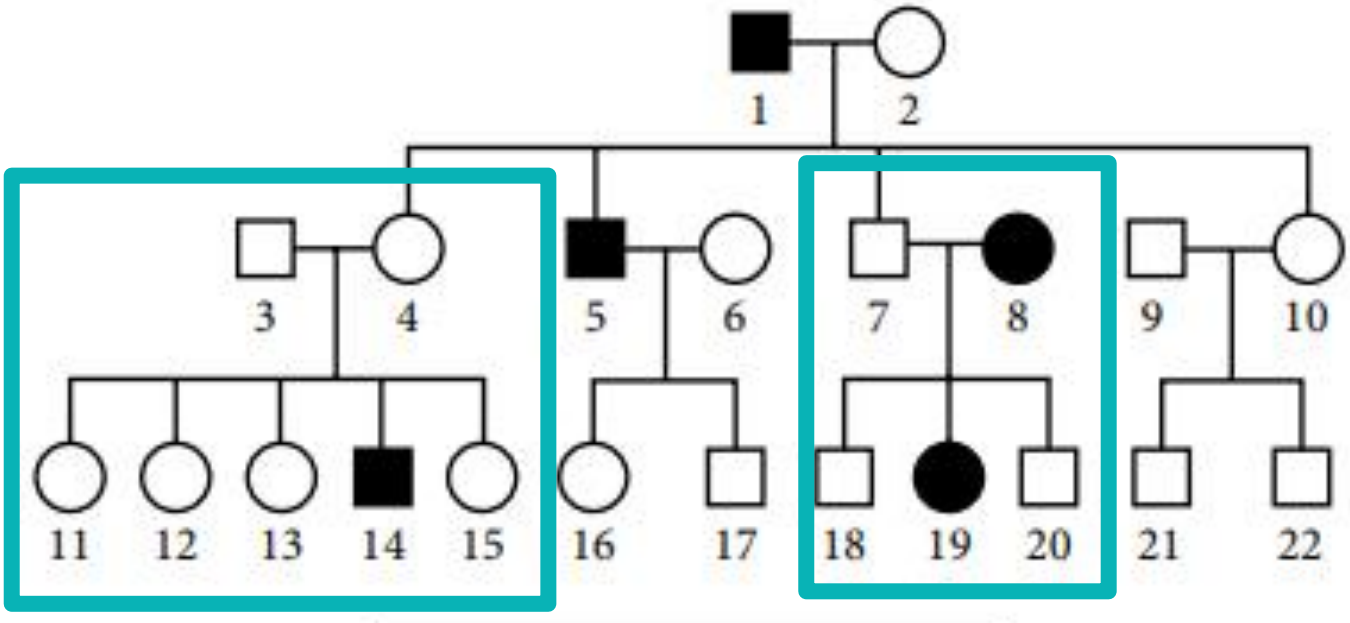
(c) **Use the template** figure of the pedigree and the allele designations *B* and *b* to **indicate** the genotypes of individuals 2, 4, 8, and 18.



CED FRQ #5

Explain how a biological concept or process represented visually relates to a larger biological principle, concept, process or theory

(d) Based on the pedigree, **explain** whether the inheritance pattern of the condition is sex-linked or autosomal and dominant or recessive.



CED FRQ #5

Explain how a biological concept or process represented visually relates to a larger biological principle, concept, process or theory

(d) Based on the pedigree, **explain** whether the inheritance pattern of the condition is sex-linked or autosomal and dominant or recessive.

The disease phenotype is recessive and is autosomal/not sex-linked. It cannot be dominant because individuals 3 and 4 do not have it, but their offspring 14 does. It is not sex-linked because if it was Y-linked, all male offspring of males with the disease phenotype would have the trait, and they do not.

FRQ #6

Analyze Data

- Part A (1 pt): Describe data
- Part B (1 pt): Describe data
- Part C (1 pt): Use data to evaluate a hypothesis or prediction
- Part D (1 pt): Explain how experimental results relate to biological principles, concepts, processes, or theories

2022 FRQ #6

Researchers are studying the use of RNA vaccines to protect individuals aga
the vaccines, particular cells are first removed from an individual. Then mR
from a pathogen are introduced into the cells. The altered cells are injected b
cells make the proteins encoded by the introduced mRNAs. The individual t
to the proteins that will help to protect the individual from developing a dise
the future.

When introduced into cells, the mRNAs used for vaccines must be stable so
the encoded proteins are produced. Researchers developed several modified
make the introduced mRNAs more stable than mRNAs with the normal GTP cap. To test the effect of the
modified
cap, or m
cells and
total amo

TABLE 1. EFFECT OF mRNA CAP STRUCTURE ON mRNA HALF-LIFE AND PROTEIN TRANSLATED FROM THE INTRODUCED mRNA

5′ Cap Structure	mRNA Half-Life $\pm 2SE_{\bar{x}}$ (hours after introduction into cells)	Total Amount of Protein Translated from mRNA $\pm 2SE_{\bar{x}}$ (relative to amount in normal cap)
No cap	1.41 ± 0.02	0.011 ± 0.000
Normal GTP cap	16.10 ± 1.83	1.000 ± 0.007
Modified cap I	15.50 ± 1.57	4.777 ± 0.042
Modified cap II	27.00 ± 2.85	13.094 ± 0.307
Modified cap III	18.09 ± 0.81	6.570 ± 0.075

(a) Based on the data, **identify** which cap structure is most likely to protect the end of the mRNAs from degradation.

(b) Based on the data for the mRNAs with modified caps, **describe** the relationship between the mRNA half-life and the total amount of protein produced.

(c) After examining the data on mRNA half-lives and the amount of protein produced, the researchers hypothesized that each mRNA molecule with modified cap I was translated more frequently than was each mRNA molecule with the normal GTP cap. **Evaluate** their hypothesis by comparing the data in Table 1.

(d) Introduction of mRNAs into cells allows the cells to produce foreign proteins that they might not normally produce. **Explain** why the production of a foreign protein may be more likely from the introduction of mRNA than DNA into cells.

Helpful Resources:

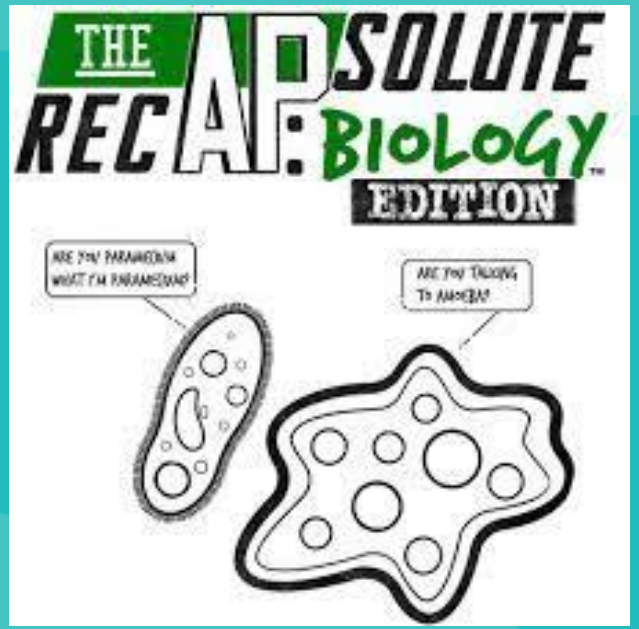
AP Bio Penguins:

- 316 page Review Guide
- 60+ Quizizz Games
- Topic TikTok Videos
- Review PowerPoints
- Review Videos

www.apbiopenguins.weebly.com

@apbiopenguins (IG, TT, YT)

Helpful Resources:



The Apsolute RecAP:

- 82 episodes (FREE) on any platform that offers podcasts
- Guided listening sheets developed with podcast

www.theapsoluterecap.com

Helpful Resources:

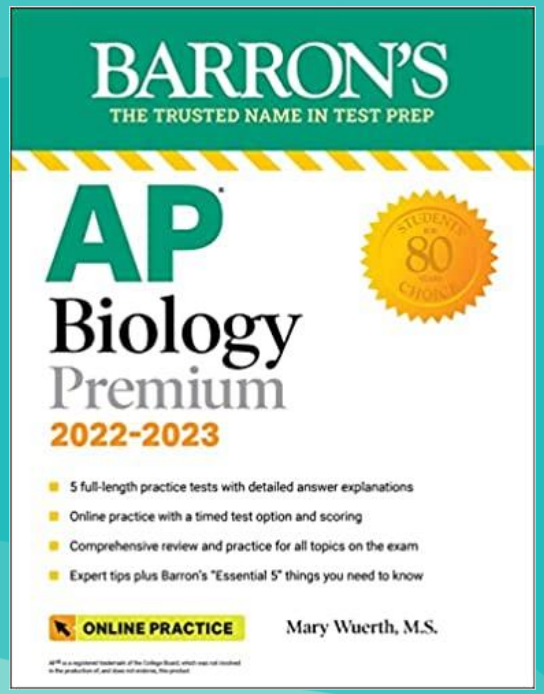
Bozeman Biology

YouTube

Crash Course

Ameoba Sisters

Helpful Resources:



Barron's Review Book:

- Section Reviews
- Section Quizzes
- Practice Exams with Explanations

Other Books:

- Princeton Review
- 5 Steps to a 5
- Pearson (Holtzclaw)

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