How to Approach FRQ Writing

WITH A REVIEW OF GRAPHING AND SCIENTIFIC METHOD

Give the Readers Exactly what they are Looking For

- BE SHORT!
  - Do not waste time including material that isn't necessary or wasn't asked for
  - Support your statements with BRIEF, STRONG facts
  - Write in full sentences
    - No bullet points
- Label your sections

Skim All Questions and Order Them

- Take less than a minute to skim through ALL the questions and order them
  - From easiest to hardest
- This will allow you to be able to answer the questions you have the best chances of getting points from

Read Each Questions all the Way Through

- Read each question at least **TWO TIMES**
- Focus on any key words
  - Especially those that are **bold**
- Some questions will contain more than one **bold** term
- **The majority of points are lost because students misread the questions or fail to do what is specifically asked of them**

Popular Key Words—CLAIM

- Make a simple statement that something is true
  - Often will be compounded with providing evidence or reasoning
- Example:
  - The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.
    - (b) Make a **claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support claims.
    - There will be no change in glycolysis, because glycolysis does not require the conversion of pyruvate to acetyl-CoA in order to occur
    - The Kreb's Cycle will be drastically lessened or stopped, because it requires acetyl-CoA in order to occur

How NOT to Write a Claim

- It is my belief that there will be little to not change with glycolysis. OR I think that there would be no change in glycolysis.
  - These are not strong statements because they leave the reader feeling like you are guessing.
- Glycolysis takes place in the cytoplasm of the cell, starting with a molecule of glucose and ending with two molecules of pyruvate. PDC is a catalyst on the conversion of pyruvate into acetyl-CoA, which is then used as a reactant in the Kreb's Cycle. Glycolysis would therefore be unaffected by the absence of PDC, because glycolysis does not require the use of acetyl-CoA.
  - This statement is NOT WRONG. But it contains excessive information that tends to weaken your claim and make it difficult for the reader to find it.

Popular Key Words—EVIDENCE

TABLE 2. NUMBER OF INDIVIDUALS IN EACH PROTIST POPULATION IN BOTH TREATMENT GROUPS

	Group I. Grown Separately		Group II. Grown Together	
Time (h)	Species A	Species B	Species A	Species B
0	10	10	5	5
10	100	50	45	20
20	400	200	100	50
30	1100	500	250	25
40	1400	650	525	20
50	1500	700	900	10
60	1500	700	1250	0
70	1500	700	1400	0

- Evidence is almost always pulled from data in a chart or graph
- Could also say "support" which may come from textual data
- Example:
  - The student claims that species A and B compete for the same food source. **Provide TWO pieces of evidence** from the data to support this claim.
  - The growth rate of species A alone (group 1) is faster than the growth rate of species A grown with species B (group 2)
  - The population density of species B is higher when grown separately (group 1) than it is when grown with species A (group 2)

How NOT to Provide Evi

TABLE 2. NUMBER OF INDIVIDUALS IN EACH PROTIST POPULATION IN BOTH TREATMENT GROUPS

	Group I. Grown Separately		Group II. Grown Together	
Time (h)	Species A	Species B	Species A	Species B
0	10	10	5	5
10	100	50	45	20
20	400	200	100	50
30	1100	500	250	25
40	1400	650	525	20
50	1500	700	900	10
60	1500	700	1250	0
70	1500	700	1400	0

- The table shows that species A in group 1 starts off with 10 individuals and then it grows to 100 then 400 then 1100 all the way to 1500. The table also shows that species A in group 2 starts off with 5 individuals and then grows to 45 and then 100 all the way to 1400.
  - This is just giving numbers from a chart. Evidence is data from the chart, but it clearly supports your claim, and it should be given as simple, direct statements.

Popular Key Words—REA

TABLE 2. NUMBER OF INDIVIDUALS IN EACH PROTIST POPULATION IN BOTH TREATMENT GROUPS

	Group I. Grown Separately		Group II. Grown Together	
Time (h)	Species A	Species B	Species A	Species B
0	10	10	5	5
10	100	50	45	20
20	400	200	100	50
30	1100	500	250	25
40	1400	650	525	20
50	1500	700	900	10
60	1500	700	1250	0
70	1500	700	1400	0

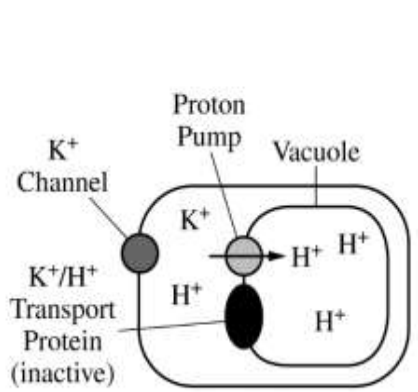
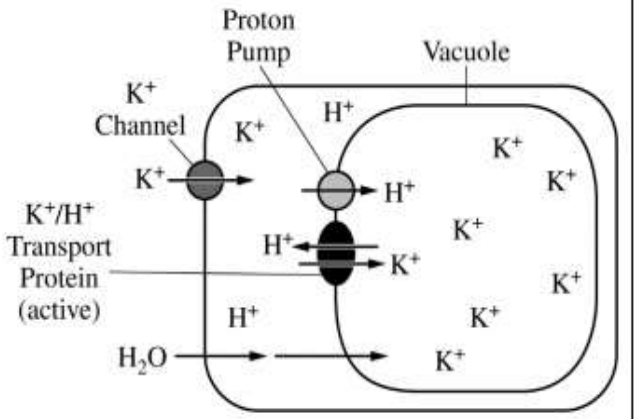
- Justification for HOW or WHY the evidence supports a claim
- Example:
  - Same data from the last question.
  - As shown in the data table, the researcher established treatment group 2 with 5 individuals of each species. **Provide reasoning** for the reduced initial population sizes.
  - Reduced initial population sizes maintain a control for population density of 10 individuals for both experimental groups

How NOT to Give Reasoning

- I think that it is important to make sure there are the same number of individuals in each container
  - The readers do not want to know what you think, they want to know what you know
- The reason behind making sure there are reduced numbers of individuals in group 2 containers is because it is important to carrying out the experiment
  - Vague statements tell us nothing

Popular Key Words—DESCRIBE

TABLE 1. CHANGES IN MORNING GLORY PETAL CELLS DURING FLOWER OPENING

	BUD	OPEN FLOWER
		
Vacuole pH	6.6	7.7
Flower Color	Red	Blue
Cell Volume	Small	Large

- To give a picture of something in words
- Example:
  - **Identify** the cellular component in the model that is responsible for the increase of the pH of the vacuole during flower opening AND **describe** the components role in changing the pH of the vacuole
  - The cellular component in the model that is responsible for the increase of pH is the K+/H+ transport protein. This transport protein opens and closes to allow the passage of H+ ions in or out of the vacuole, which is directly responsible in changing the pH.

How NOT to Describe

- pH is a logarithmic expression of the acidity or alkalinity of a solution. When more H+ is present, the solution creates more H3O+ or hydronium and lowers the pH. When the solution contains more OH- or hydroxide, the pH is increased. Because the K+/H+ transport protein moves H+ across the vacuole membrane, it is a key component in changing the pH.
  - Too much detail. Be SHORT. Only tell the readers what they need to answer the question. We don't need to know about logarithmic expression or hydronium or hydroxide, they simply want to know you that you understand the big idea that the presence of H+ effects pH

Popular Key Words—PREDICT

- Say or estimate what will happen in the future
  - Must be a FACTUAL statement
  - Often coupled with a second key word--JUSTIFY
- Example:
  - Many protists contain an organelle called a contractile vacuole that pumps water out of the cell. If a group of protists were grown in a medium with a lower solute concentration, **predict** the activity of the contractile vacuole and **justify** your prediction.
  - The contractile vacuole activity will increase

How NOT to Predict

- I believe that the contractile vacuole activity will stop OR I think that the contractile vacuole activity will stop
  - The readers do not care about what you think or believe
- It is my prediction that the activity of the contractile vacuole will most likely increase.
  - Too flowery. Just give them a short and sweet statement

Popular Key Words—JUSTIFY

- Give a good reason for something, or show it to be right
- Example (same as before):
  - Many protists contain an organelle called a contractile vacuole that pumps water out of the cell. If a group of protists were grown in a medium with a lower solute concentration, **predict** the activity of the contractile vacuole and **justify** your prediction.
  - The contractile vacuole activity will increase because the environment has a higher water potential than inside the protist, causing an increase of water moving into the protist that must be pumped out.

How NOT to Justify

- Water potential in the cell is about the amount of work that water is capable of doing. When there are less solutes in the water, the water potential is higher. Water will tend to move from areas of high water potential to areas of low water potential. Because the protist is in a solution that has less solutes, the water potential will be greater on the outside of the cell and will move into the cell, creating a higher activity of the contractile vacuole to pump the water back out.
  - Again, way too much information

Popular Key Words—EXPLAIN

- Tell how to do, give the meaning of, give reasons for
- Example: Explain how gasdermin pore formation and interleukin release contribute to an organism's defense against bacteria
  - Interleukin is released from the cell as a signaling molecule that will active the immune response. Pores in the cell membrane will cause the cell to fill with water and burst. The bursting of the cell will keep the infection from spreading

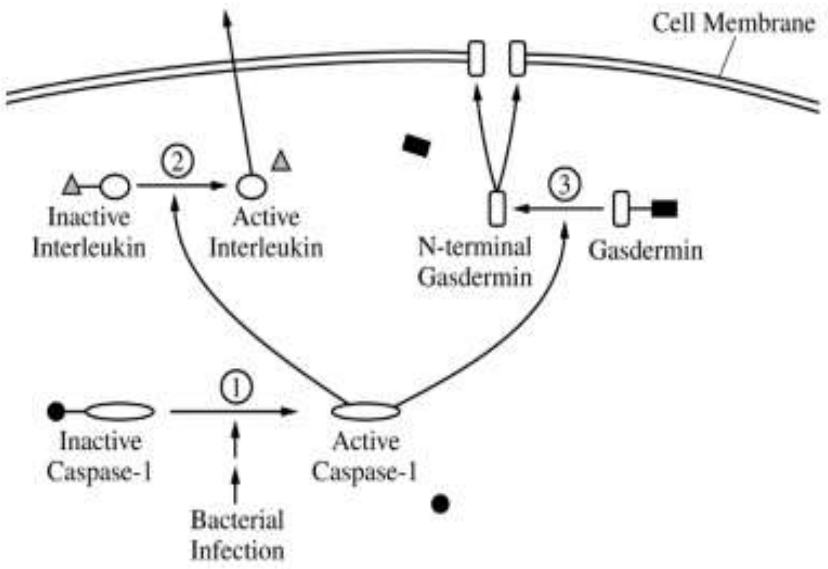


Figure 1. Cellular response to infection by pathogenic bacteria

Some pathogenic bacteria enter cells, replicate, and spread to other cells, causing illness in the host organism. Host cells respond to these infections in a number of ways, one of which involves activating particular enzymatic pathways (Figure 1). Cells normally produce a steady supply of inactive caspase-1 protein. In response to intracellular pathogens, the inactive caspase-1 is cleaved and forms an active caspase-1 (step 1). Active caspase-1 can cleave two other proteins. When caspase-1 cleaves an inactive interleukin (step 2), the active portion of the interleukin is released from the cell. An interleukin is a signaling molecule that can activate the immune response. When caspase-1 cleaves gasdermin (step 3), the N-terminal portions of several gasdermin proteins associate in the cell membrane to form large, nonspecific pores.

Researchers created the model in Figure 1 using data from cell fractionation studies. In the experiments, various parts of the cell were separated into fractions by mechanical and chemical methods. Specific proteins known to be located in different parts of the cell were used as markers to determine the location of other proteins. The table below shows the presence of known proteins in specific cellular fractions.

How NOT to Explain

- The release of interleukins activates the adaptive immune response. The adaptive immune system is a developed immune response that targets specific pathogens that the body has come into contact with before. When the interleukin is released from the cell, it acts as a signaling molecule and docks in a receptor on B cells and T cells—specific white blood cells of the immune system. When the docking occurs, B cells and T cells become activated through a signal transduction pathway to respond to the infection.
  - Too much information. The reader just wants to see that you understand one cell signaling to another to come and help destroy the pathogen—the activation of an immune response.

Popular Key Words—IDENTIFY

- Name, list, or give an example
- Example:
  - Identify the molecule that would be absent if enzyme YUC is non-functional
  - The molecule that would be absent would be IAA.

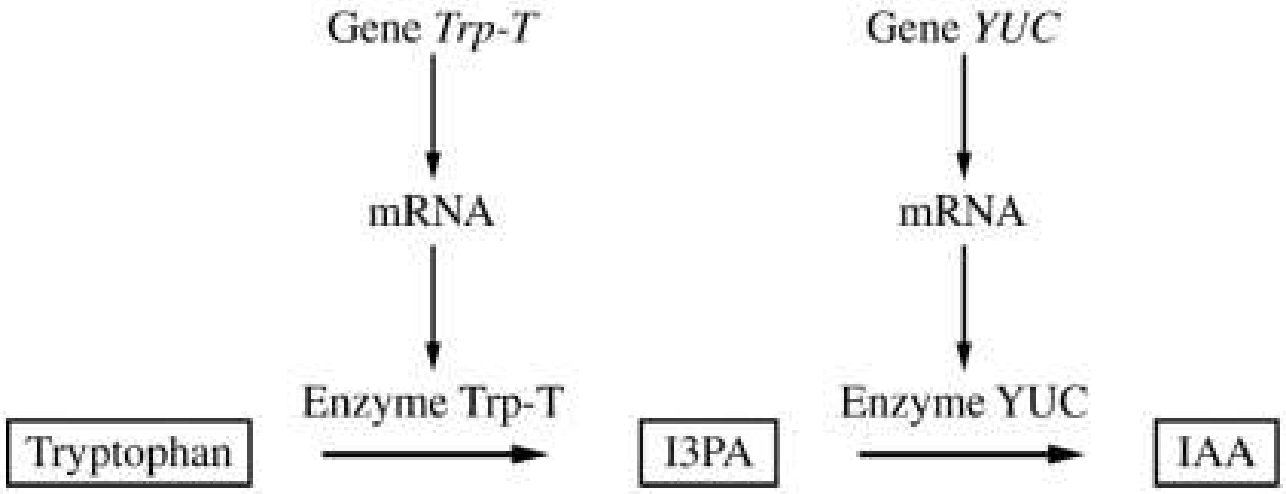


Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

How NOT to Identify

- IAA
  - The College Board prefers that you write in complete sentences/complete thoughts
- The molecule that would be absent is IAA. When an enzyme is non-functioning, it is next to impossible for a product to be made randomly, without catalyzation. For this reason, if the enzyme YUC is ineffective, the product IAA will not be able to be made from the reactants.
  - Too much information to sift through. Make it easier for them to read.

Popular Key Words that are More Specific

- **Complete or Construct**—occasionally they will ask you to complete a diagram or construct a graph. They will ALWAYS provide you with a template or framework to do so. Be sure to read carefully what is specifically asked of you to complete and do no more.
- **Calculate**—math does make an appearance in FRQs. Be sure to do all the math on the paper to ensure you don't make mistakes. Report the math requested in sentence form and be sure it is well labeled.
- **Circle or Draw**—sometimes they will ask more specific things of you, such as circling a portion of a diagram or model that is responsible for a certain function or they may ask you to draw a model of something
  - Artistic skills are not graded here. They are simply seeing if you can demonstrate your knowledge through modeling or selecting specific areas of a model
- **Estimate**—estimations are occasionally asked for and are usually in regard to extrapolating or interpolating data on a graph

Designing an Experiment Example

Design an experiment using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. **Identify** the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis.

- What would be the null hypothesis?
  - Caffeine has no effect on the number of floral visits by bees
- What would be the appropriate control treatment?
  - A flower without caffeine added
- What is your prediction?
  - Caffeine would stimulate bee visits because…

Popular Key Phrases—DESIGN AN EXPERIMENT

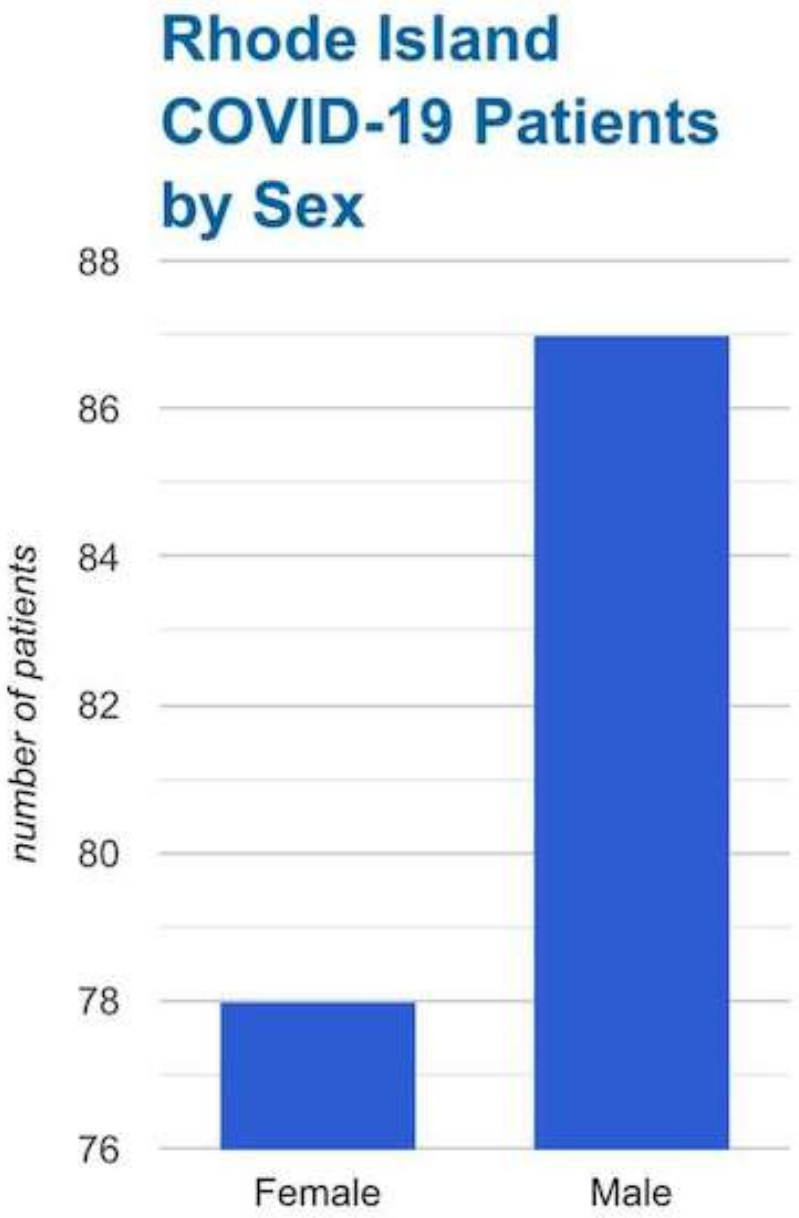
1. Understand the problem
2. Determine your independent variable—what are you manipulating?
3. Determine your dependent variable—what is the measured outcome?
4. Determine your controlled variables—what things have to stay the same from group to group?
5. Design a control group—the standard to compare your experimental groups to
6. Write out a null hypothesis and an experimental hypothesis

Proper Graphing Techniques

- Use the correct graph
  - Bozeman science has the best review of graph types and uses
- Be sure to title the graph
  - Include the dependent variable as well as the independent variable
- Label the X axis and Y axis
- Use appropriate increments on your grid lines

Recent Graphs in the New

- What does this graph lead you to believe at first glance?



More Appropriate Graph