AP Biology – Investigation Lab – Animal Behaviour Name(s):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
*Experimental Design Criteria*  Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

 **Learning Goals:**

1. To demonstrate science as a process designing a controlled experiment and synthesizing an organized, professional laboratory reports with clear communication of creative, original thinking.
2. To question, hypothesis, and analyze the proximate causes of isopod choice behaviour.

**Components for an Exemplary Lab Report:**
 **Title**

* The purpose/question of the research is clear

**Objectives**

* Clear **question(s)** (If… then will…?/ How…?)
* Clear **hypothesis** – (If… then… because…)

**Experimental Design – Ensure you follow the criteria below for EACH of your investigative questions!**

* Complete list of **materials/equipment**
* Thoroughly and logically explained **step-by-step** procedure
* Identification of at least eight **constant** variables
* Identification of the *specific* **independent** (manipulated) variable *with units if appropriate*
* Identification of the *specific* **dependent** (measured) variable *with units if appropriate*
* Explanation of how you will **control** for constant variable (Controlled Test)
* Explanation of how you will gather your sample **specimens** (pill bugs) is taken, and **size** of sample
* Explanation of other measurements/**observations** to be taken
* Explanation of how data will be evaluated/**analyzed**
* Possible **sources of error** (*at least three*)

**Experimental Design – Flow Chart**

* **Logical**, clear, and easy to follow
* Complete with **sketches/diagrams**

**Preparation of Results Tables**

* Tables for data are **prepared** for the lab with a ruler, **units**, **titles**

**During Lab Results**

* All data recorded in **pen** with correct units
* **Detailed** observations and sketches
* **Ethical treatment** of specimens

**Graphical Analysis (1 *bar graph for “discrete” data… continuous data would use best fit line/curve*)**

* Proper placement of independent (X) and dependent (Y) variables
* Axis drawn with ruler and labeled with measurement, and units
* Uniform scale that includes origin and uses space effectively
* Title follows “Y vs X”, includes measurements and units
* For bar graph: Data plotted correctly with bars

**Statistical Analysis**

* Adapted Chi-Square analysis
* Statement that supports or rejects statistical hypothesis and what this means

**Discussion**

* Clear communication through structured sentences that connect one idea to the next
* All answers demonstrate a thorough, in depth understanding of concepts

**Conclusion**

* Clear communication through structured sentences that connect one idea to the next
* Answers purpose by comparing key results to predictions/hypothesis (supported/not supported/rejected/inconclusive)
* States 2 or more insightful sources of error and suggests improvement to this lab
* Connects to big picture (relevance)
* Asks new questions and suggests new experiments for the future

*Discussion Questions:*

1. According to the analysis, are you able to support or reject your original hypothesis? Elaborate. Is there anything else you would like to say?
2. Is the response to the condition best classified as kinesis or taxis (or neither)? Explain.
3. What do you think are *proximate* and *ultimate* causes of the behaviour observed?
4. If you suddenly turned a rock over and found isopods under it, what would you expect them to be doing? If you watched the isopods for a few minutes, how would you expect to see their behaviour change?
5. A student wanted to study the effect of nitrogen fertilizer on plant growth, so she took two similar plants and set them on a window sill for a two-week observation period. She watered each plant the same amount, but she gave one a small dose of fertilizer with each watering. She collected data by counting the total number of new leaves on each plant and also measured the height of each plant in centimetres.
What is good about the design of this experiment?
What is a significant flaw in this experimental set-up?

***Assessment Criteria:*** *Please highlight evidence according to the performance standards below*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| ***Overall*** | **Beginning** | **Developing** | **Accomplished** | **Exemplary** |
| **Experimental Design** | * Hypothesis is missing
* Most variables are missing and/or incorrectly identified
* There is no attempt at including appropriate controls and/or repetition
 | * Hypothesis is stated but not appropriate

* Almost all variables identified correctly (dependent, independent, constants)
* There is an attempt at including appropriate controls and/or repetition, but they are incorrect
 | * Hypotheses is stated (if, then) but incomplete (no because)
* All variables identified correctly (dependent, independent, constants), but lacking in clarity
* Controls and repetition are included but and are almost appropriate to the experiment
 | * Hypotheses is stated (if, then, because)
* All variables clearly and correctly identified (dependent, independent, constants)
* Appropriate controls and repetition correctly described
 |
| **Graph***Please refer to Appendix B in AP Investigative Lab Manual* | * Title is missing or incorrect
* X and Y axis are not properly placed (independent and dependant variables are switched)
* Data points are not plotted correctly
* Choice of bar graph and/or best fir line/curve is not appropriate for the data

* Graph is not neat or clear and/or space is not used effectively
 | * Title incorporates “Y vs X,” but missing units and/or relevant information
* X axis
	+ Has independent variable labelled but is missing units
* Y axis
	+ Has dependent variable with labelled, but is missing units
* Data points are ***somewhat*** correctly plotted with dot and circle
* Appropriate bar or best-fit line/curve graph type is chosen, however, best fit line/curve ***does not*** accurately depict the data plots (watch out for inappropriately including a “zero”)
* ***Somewhat*** neat and clear with ruler used; space is somewhat used effectively
 | * Title incorporates “Y vs X” and units, but missing other relevant information
* X axis
	+ Has independent variable labelled with units, but interval scale is not completely uniform
* Y axis
	+ Has dependent variable labelled with units, but interval scale is not completely uniform
* Data points ***mostly*** correctly plotted with dot and circle, clearly marked with **standard error bars** and legend if appropriate
* Appropriate bar or best-fit line/curve graph type is chosen, however, line/curve ***almost*** accurately depicts the data plots (watch out for inappropriately including a “zero”)
* ***Mostly*** neat and clear with ruler used; space is mostly used effectively
 | * Complete, clear, informative title that incorporates “Y vs X” and units
* X axis
	+ Independent variable
	+ Labelled with units
	+ Uniform interval scale
* Y axis
	+ Dependent variable
	+ Labelled with units
	+ Uniform interval scale
* Data points ***correctly*** plotted with dot and circle, clearly marked with **standard error bars** and legend if appropriate
* Appropriate graph type is chosen
	+ Bar for discreet data or best-fit line/curve graphs for continuous data
	+ Line/curve of best fit represents data plots
* Neat and clear with ruler used; space used effectively
 |
| **Conclusion** | * Hypothesis and/or results not referred to

* No sources of error
* Does not discuss relevance
 | * Refers to purpose, summarizes results without insight

* Sources of error not relevant
* Relevance inappropriate
 | * Answers purpose by summarizing results
* States 1-2 relevant sources of error
* Reveals relevance of results
 | * Answers purpose by comparing key results to objectives and predictions/hypothesis (supported/not supported/rejected)
* States 2 or more insightful sources of error and suggests improvements
* Connects to big picture (relevance)
* Asks new questions and suggests new experiments for the future
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 Brady 2015 *adapted from* Wood 2013