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:***

**Experimental Design**
 **Title**

* The purpose/question of the research is clear. The researchers names, class and teacher are all stated.

**Objectives**

* Clear **question(s)** (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) and **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 (is it reliable? Accurate?)/**analyzed**

**Data Presentation**

**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 in the lab book
* **Detailed** observations and sketches in the lab book
* **Ethical treatment** of specimens

**Graphical Representaion**

* 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**

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

**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*

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| --- | --- | --- | --- | --- |
| ***Overall*** | **Beginning** | **Developing** | **Accomplished** | **Exemplary** |
| **Experimental Design** | * Many of the necessary components are not included
* Hypothesis is missing
* Most variables are missing and/or incorrectly identified
* There is no attempt at including appropriate controls and/or repetition
 | * Several of the necessary components are not included
* 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
 | * A few of the necessary components are not included
* 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
 | * All the necessary components are included
* Hypotheses is stated (if, then, because)
* All variables clearly and correctly identified (dependent, independent, constants)
* Appropriate controls and repetition correctly described
 |
| **Data Presentation** | * Data table is incomplete and unclear missing several of the following: title, units, and original data recorded by hand with observations (in lab book)
* 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
 | * Data table is incomplete and unclear missing at least one of the title, units, and original data recorded by hand with observations (in lab book)
* Appropriate graph type is not chosen
	+ Bar for discreet data or best-fit line/curve graphs for continuous data
	+ Line/curve of best fit represents data plot
* Incomplete or unclear title that incorporates “Y vs X” and units
* X axis (Independent) and Y (dependent) variable is missing both
	+ Labelled with units
	+ Uniform interval scale
* Data points are not correctly plotted with dot and circle
* Best-fit line/curve graph type is not chosen, and line/curve does not accurately depicts the data plots
* ***Somewhat*** neat and clear with ruler used; space is somewhat used effectively
 | * Data table is incomplete missing at least one of the title, units, and original data recorded by hand with observations (in lab book)
* Appropriate graph type is not chosen
	+ Bar for discreet data or best-fit line/curve graphs for continuous data
	+ Line/curve of best fit represents data plot
* Incomplete or unclear title that incorporates “Y vs X” and units
* X axis (Independent) and Y (dependent) variable is missing either
	+ Labelled with units
	+ Uniform interval scale
* Data points ***mostly*** correctly plotted
* 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
 | * Data table is complete with title, units, and original data recorded by hand with observations (in lab book)
* 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 plot
* Complete, clear, informative title that incorporates “Y vs X” and units
* X axis (Independent) and Y (dependent) variable
	+ Labelled with units
	+ Uniform interval scale
* Data points ***correctly*** plotted
* Best-fit line/curve graph type is chosen and accurately depicts the data plots
* Neat and clear with ruler used; space used effectively
 |
| **Statistical Analysis**  | All of the components below are inaccurate or missing* The null and alternate hypothesis
* Chi Square analysis.
* Calculations
* Statement rejecting or accepting the null hypothesis.
 | * The null and alternate hypothesis are missing
* Chi Square is not accurate and difficult to follow.
* There is not rought work.
* There is not a statement rejecting or accepting the null hypothesis.
 | * The null and alternate hypothesis are stated but incorrect
* Chi Square is not accurate or difficult to follow.
* There is not at least one example calculation modelled.
* There is a statement either rejecting or accepting the null hypothesis but it is incorrect.
 | * The null and alternate hypothesis are stated
* Chi Square is accurate and easy to follow.
* There is at least one example calculation modelled.
* There is a clear statement either rejecting or accepting the null hypothesis.
 |
| **Discussion** | * Many questions are not answered completely and accurately with depth and insight. There are major omissions and mistake
* It is not clear in the response what was asked in the question.
 | * Some questions are answered completely and accurately with depth and insight.
* It is not clear in the response what was asked in the question.
 | * Most questions are answered completely and accurately with depth and insight.
* It is not always clear in the response what was asked in the question.
 | * All questions are answered completely and accurately with depth and insight.
* It is clear in the response what was asked in the question.
 |
| **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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Additional Comments:

Brady 2019 *adapted from* Wood 2013