**Guidance for Analysis, Evaluation, & Conclusions**

Data Analysis

Patterns, Relationships, & Links to relevant concepts

**Describe the pattern of results:**

* Refer to your graph specifically using correct units
* Describe the slope of the line or the shape of the curve of best fit
* If helpful, break the trendline/curve into distinct sections and describe each

**Link your results to relevant concepts:**

* Attempt to explain the different parts of your graph using your knowledge of relevant concepts, and justify your thinking
* Use phrases like, ‘The most likely explanation of this is …., because….’
* Discuss any key ideas and concepts that your results seem to demonstrate
* Use key biological vocabulary in your descriptions and explanations

**Compare to trials or class average:**

* Any overall comparisons between your trials or the class average (if you did one), and possibly reasoning for differences with justification

**Link to hypothesis:**

* Provide reasoning based on your data for rejecting or confirming your hypothesis
* Describe and attempt to account for any expected or unexpected results as seen on your graph
* Mention any evidence of errors and justify thinking

Data Evaluation

Precision, Accuracy, Reliability & Validity

**Summary of you what you need to do:**

* Identify evidence of error (sources of uncertainty) in the data (scatter, departure from class/group average, unexpected results)
* For each one you identify, state to what degree it likely affects your data
* Assess the accuracy, precision, reliability, and validity of your data
* Suggest how effect of random and systematic errors could be minimized to increase quality of your data
* Draw conclusions from your analysis and evaluation that links to your hypothesis

Errors can affect the quality of your data and the four aspects of data below.

**What is a mistake?**

* If you did not follow the instructions properly.
* If you don’t use the equipment properly – eg. *You don’t read the meniscus in a measuring cylinder.*
* **Note:** these are not the focus of your data evaluation in lab reports.

**Are we ever certain the data is correct?**

*No. Even if you didn’t make mistakes, you can’t be sure that the data is perfect. Why?*

* Because the equipment is not perfect.
* There are factors out of your control. Examples include:
	+ Your reaction time using a timer
	+ Your eyesight measurements
	+ Airflow through the room
	+ Temperature changes in the room

**However**, your job is to determine to what degree you can be certain of your data while considering the role of errors (below). This will help you draw conclusions about the quality of your data and its ability to either support or not support the hypothesis.

**Let’s Look at Errors…**

**Defining Errors:**

*Errors are the differences between the measurements you got and what they actually should have been (the true value).*

1. Random Errors **– what are they?**
	1. Measurements being inconsistently different from what you should get
	2. They lead to data scatter around the trendline (the more scatter the larger the randomness of the error)
	3. There is no noticeable pattern with these errors
	4. Even if you follow the procedure and make no ‘mistakes’, you could get a different number every time
	5. Can be caused by your imperfect use of the equipment (even if you are not making ‘mistakes’).

**How do we *reduce* the impact of random errors?**

1. By increasing sample size
2. By using an average of your trials (or class results)

**How do I talk about it in my lab report?**

1. Random error reduces the reliability of your results – discuss reliability
2. Use these to discuss to what degree you are certain/uncertain about your data.
3. Identify any possible ones and suggest their potential impact? Justify
4. Examine the scatter in your graph and make a judgement about the amount of random error.
5. Discuss the resolution (level of detail) of the equipment and make a judgement about how much error this might allow for
6. Suggest to what degree these errors may have impacted your data and justify your thinking
7. Systematic Errors **– what are they?**
	1. These are usually caused by the equipment calibration issues
	2. These are harder to notice – because they can change all the measurements you make with that piece of equipment in the same way (or amount)
	3. They usually will cause an overall shift in the graph (up or down) – away from what you should get
	4. These can only be detected by repeating the experiment with different equipment (this will indicate if one of your experiments used equipment that was incorrectly calibrated)
	5. These errors effect the accuracy of your data

**How do we *reduce* the impact of systematic errors?**

1. By repeating the same method with different equipment
2. By choosing as accurate equipment as possible in the first place – possibly testing the equipment against another that you know to be accurate, before you start.

**How do I talk about it in my lab report?**

1. Discuss accuracy – systematic errors affect accuracy
2. Talk about the quality of calibration on the measuring equipment you used, and to what degree this may impact
3. Look for values that may be consistently higher or lower than what you might have expected to get, and discuss if this may be the result of a systematic error
4. Suggest to what degree these errors may have impacted your data and justify your thinking

**The BIG 4 Qualities of Data to Address with Reference to Errors:**

**Accuracy** – how close to the actual value might it be? Ie. are your results correct?

* Tools being calibrated correctly achieves better accuracy
* Random and systematic errors can affect the accuracy; however, accuracy is mainly INCREASED when there are less systematic errors.

**Precision** – how consistent is the data? How fine in resolution?

* How consistently you can get the results using the same method?
	+ Compare to class average, etc.
	+ Improve by more finely tuned equipment and when your method allows for less guessing and estimating

**Reliability** – can you trust it?; are you sure you would get these results again?

* This is related to precision and accuracy above – an overall judgement
* You can focus on the method – does it allow for reliability?
* How could it be improved so it does so better?
* Reliability is INCREASED when there is LESS random errors.

**Validity** – does the investigation actually answer what you want to know? Can it do so?

* Is it measuring what it is supposed to measure?
* Are there any parts of the method that would not represent real life? *(Eg. Doing this in a beaker verses a cell in a real body?)*
* To what extent could you apply the results from this method to other situations?
* What assumptions are made using this method? *(eg. Can a potato really represent what happens in a cell?)*
* Does your conclusion, using this method, actually answer the aim/question/problem, or are is there reason to think it may not totally? Why or why not?

Conclusion

Overall Summary and Judgement

**Address the following elements:**

* Does the method of this investigation allow for aim to be met in a valid manner? If not – what limits this?
* Overall, what is the reliability of your findings?
* Was your hypothesis confirmed or not?
* Does the method give you confidence that you can generalise the results to be true in other contexts? Why or why not? To what degree?