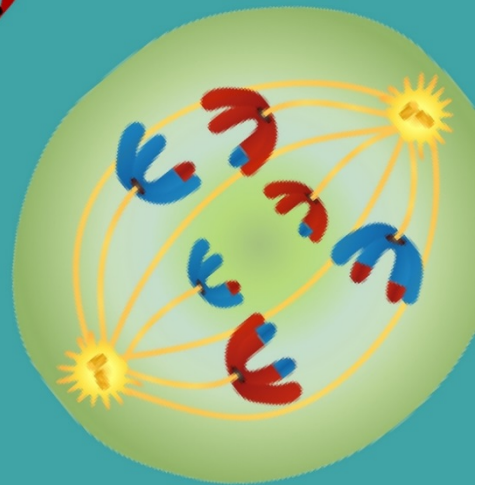
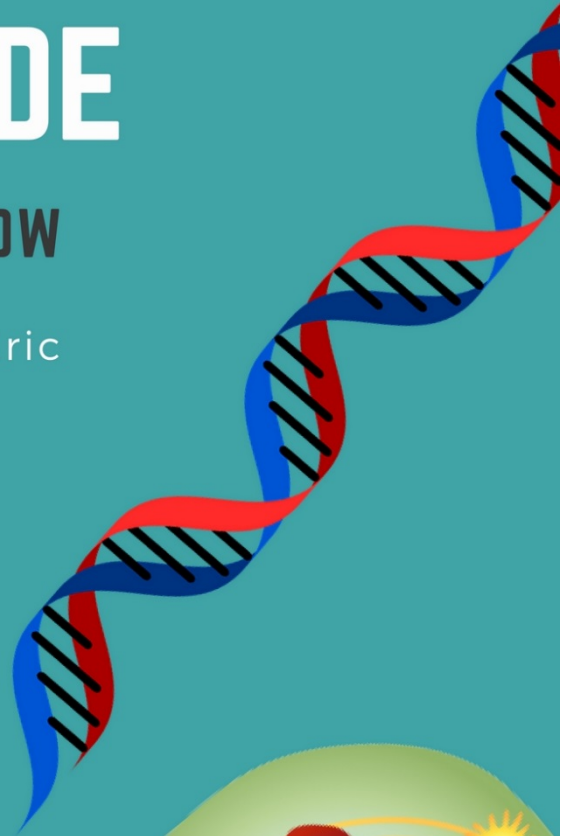
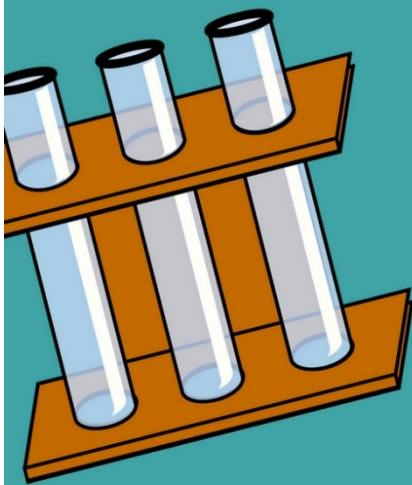


BIOLOGY 105 & 106 LAB REPORT WRITING GUIDE

WHAT GOES WHERE AND HOW

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BIOLOGY 105 & 106 LAB REPORT WRITING GUIDE

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The ORDER in which the lab report sections should be written is as follows:

1. Methods → 2. Results → 3. Introduction → 4. Discussion → 5. Title → 6. References

Things to Remember While Writing:

- A paper needs to flow! Readers should be able to move from one concept or idea to the next. Be succinct.
- Try to stay focused on the subject within a section. 1 Section, 1 subject.
- Words or ideas at the end of a sentence often convey the most importance; finish strong (Schimel 2012).
- Assemble references as you write and add sources to your paper. Each time you find a source, incorporate it into your paper and immediately cite it.
- The majority of your paper will be in the active voice; avoid passive sentences (except in methods, where it will be a mix).

1. Active and passive voice examples

"Doug changed the flat tire." - Active
 "The flat tire was changed by Sue." - Passive
 "We are going to watch a movie tonight." - Active
 "A movie is going to be watched by us tonight." - Passive
 "The critic wrote a horrible review." - Active
 "A horrible review was written by the critic." - Passive

TITLE

- This is where you concisely tell the reader exactly what you studied.
 - Should be long and descriptive (it should be close to a full sentence in length!)
 - Should include:
 - Processes
 - Variables (dependent and independent)
 - Systems
 - Organism scientific name (fully written-out and italicized)

Bad titles:

An Investigation of Hormone Secretion and Weight in Rats
 Fat Rats: Are their Hormones Different?
 Studying How E. coli Grow in Different Mouthwash Solutions

Good titles:

The Relationship of Luteinizing Hormone to Obesity in *Rattus norvegicus*
 Effect of Mouthwash Alcohol Concentration on *Echerichia coli* Growth

INTRODUCTION

- This is where you provide the background for your research and thus set the stage by orienting the reader to the nature and scope of your research. This is also where you will offer rationale for your research. Be specific!

First paragraph:

1. **Define** the concept (e.g. osmosis) in 1-2 sentences.

“ _____ is a process in which _____ (*description of concept*).”
“ _____ determines whether or not _____ can occur.”

2. **Describe** the context in which the concept is found relative to the study in 1-2 sentences.

“ _____ serves an important function in _____.”
“In biological systems, _____ can be found in _____, where _____ (*description of the environment/conditions*).”¹

3. **Explain** the bigger-picture application or relevance of the concept in 1-2 sentences.

“An understanding of _____ (*name of concept*) is essential in _____ (*specific medical/environmental/etc. application*), such as _____ (*description of the application*).”
“A synthetic application of _____ (*name of process*) occurs in _____ (*industrial application example*), where _____ (*the process*) is used to _____.”¹

4. **Transition** sentence from “background” to “rationale.”

“I wished to provide proof of _____ and thus open the door to further experimentation.”
“To understand this system more deeply, I tested/examined _____.”¹

Second paragraph:

1. **Justify** your rationale in 2-3 sentences.
 - Explain why your study is relevant: say how you will add to, challenge, or confirm the current, overall scientific understanding of the concept
 - Use sources and include citations.

“Other studies show that _____, and/but I intend to demonstrate that _____.”

“The work of Y and Z appears to show that _____, but their experimental design does not control for _____. I therefore wish to _____.”

“X’s work leads to the question of _____. Therefore, I investigated _____.”

“To see whether these findings apply to _____, I propose to _____.”

“Because _____ does not account for _____, we instead used _____ to demonstrate that _____.”¹

2. **Transition** sentence from “rationale” to “hypothesis”
 - Your rationale should naturally lead to your hypothesis. It should lead the reader to understand that there are questions that need to be answered or reinforced and that you will be the one who addresses them through your study.

3. **State** your hypothesis and research question in 1-2 sentences.
 - Describe the question you are trying to answer with your lab experiment. (Note: no explanation is necessary after you describe your question.)
 - State your initial answer; predict what your findings will be (Note: no outside source is necessary after you state your hypothesis.).

“Based on previous research, the difference between _____ and _____ is probably due to _____. I therefore predict that _____.”¹

METHODS

- Methods is where you explain, in a detailed fashion, how you carried out your study, to demonstrate that you used scientifically valid techniques and methods (Turbek 2016). Avoid any interpretations, conclusions, or results. This section should be a narrative in the **PAST TENSE**, not a list. If someone who knows nothing about the lab were to read only this section, s/he should be able to replicate your procedures exactly. Remember: be as specific as possible. More detail is better than less. Organize this section carefully and logically so the reader does not get lost in the details. While it is advisable to use active voice throughout the paper, you may use a mixture of active and passive voice in the Methods section to avoid repetitive clauses (Turbek 2016). Also, **IT IS OKAY TO USE I SPARINGLY** in this section. However, do not become repetitive, starting each sentence with I.

1. **Explain** your methods in 2-3 paragraphs.
 - What actions, materials, qualitative and quantitative quantities did you use?
 - Be specific (give exact measurements, volumes, times, etc. using correct scientific notation). At the same time, be brief and include only details that are relevant and necessary to someone who may wish to replicate the experiment.
 - Do not describe common lab practices, such as *how* you weighted or measured things,

labeled samples, etc. You must, however, include composition, source, and quantities of chemical substances, growth media, test solutions, etc.

- Include a description of all your variables, control(s), and number of trials.
- How many times did you replicate your experiment? Did you replicate any of your variables? Be sure to mention number of replicates.

"Three agarose cubes were cut, using _____ (*tools used*), to _____ (*dimensions with units*)."

"Agarose cubes were _____ (*actions*) for _____ (*time*) using _____ (*products or processes involved*)."¹

2. **State** which statistical tests you used to analyze your data, as well as the parameters you used (e.g. critical values, $p = 0.05$, etc.) in 1-2 sentences.

"A two-tailed t-test was used to analyze differences between group means at an alpha value of 0.05."

"A one-way ANOVA was used to determine differences between all group means ($\alpha = 0.05$)."

RESULTS

- This is where you summarize what you found. Do not analyze or interpret anything, just describe your most significant findings. What did you observe? For each experiment or procedure, briefly describe and report the main result(s). When writing the results, move from the most general information to the most specific. Point the reader to any patterns or trends observed in the data (but do not interpret such patterns or trends... do not address the "why?" of anything. Simply state the pattern).
1. **Summarize** your data in 1-2 paragraphs. Everything you mention must be significant to your hypothesis and help support/complicate/confirm/challenge the research question. This may include:
 - Maximum and minimum measurements, means, errors; Results of statistical tests; Patterns observed
 - **Highlight** your significant data in figures and/or tables. Refer to your figures or tables in the text.
 - Understand which variables are dependent vs. independent. This will help you decide which one goes on each axis, and whether you should use a column or line graph.
 - Refer to your figure in the text by citing it at the end of the sentence or using parentheses; for example, "see Figure 1", or "(Figure 2)."
 - All figures must have descriptive captions below them. This should be a short description that succinctly explains the graph. Do not include a figure title. Do not begin your sentences with, "Figure 2 shows...." .
 - Tables and graphs should not substitute for the written description. Be sure to fully describe the results in the text. You must describe the data—not simply rely on the graph. Tables and graphs are there to support your text, not the other way around.

"Sample X was three times greater than sample Y, which resulted in a statistically significant difference (ANOVA: $p < 0.01$, $f = 0.12$)."

"I measured _____ (sample size) subjects, and the mean response was _____ (mean with units) with a range of _____ (lower value) to _____ (upper value)."

"Heart rates of maze mice were \pm _____% higher than non-maze mice."

"Before training, mean running speed was \pm _____ kilometers per hour, _____ kilometers per hour slower than running speed after training."¹

DISCUSSION

- This is where you explain the results. Provide your interpretation and explore the significance and relevance of the results. The discussion is NOT a conclusion. You do not conclude anything but rather speculate on what the results mean. Describe potential patterns, principles, underlying mechanisms, or relationships that your results show.

First paragraph:

1. **Re-describe** your study in 1-2 sentences. Refresh the reader's memory about the study by opening with a broad statement about your experiment. Restate your hypothesis.

"To test the hypothesis that _____, I measured _____ and found that _____."¹

2. **Interpret** what your results mean for your hypothesis in 1-2 sentences. Do not make any final conclusions. Instead, discuss the range of implications of the data.

To signify a moderate level of confidence:

"My data *suggest/hint/imply* _____."

To express a greater degree of certainty:

"My results *show/demonstrate* _____."¹

3. **Explain** how/why your significant or non-significant findings support or complicate your hypothesis in 3-4 sentences.

"_____ may be the underlying mechanism/pattern/relationship that explains my observations."

"It is likely that _____ influenced my data because _____."

"_____ was a confounding variable in our experiment, which could have led to _____."

"This experimental design does not account for _____, which may have led to _____."¹

Second paragraph:

1. **Confirm** your results with other studies that had similar findings to yours in 1-2 sentences.
 - Include information from an authoritative source to back up your statements.
 - E.g. "This finding is unsurprising, since others have had similar results. Leake and Read (1995) found that the optimum pH for activity of the enzyme proteinase in fungi was 4.0 – 5.0, while higher pH conditions inhibited enzyme action. Cellobiase is likely affected in similar ways because it is also a fungal enzyme."

"Our findings *were similar* to X in that _____."

"Our data *support/confirm/verify* the work of X by showing that _____."

"Our data are *consistent* with X's hypothesis that _____." ¹

2. **Provide arguments** against your case by presenting conflicting data from sources that found something different than you.

"Our findings *call into question* the widely accepted theory that _____."

"Our results *contradict/refute* Y's conclusion that _____." ¹

"Experiments showing _____ and _____ have led scientists to propose that _____. Our work, however, suggests that _____ is occurring instead."

"Although most scientists attribute _____ to _____, my results of _____ lead to the possibility that _____."

"Many scientists think that _____ causes _____, but my evidence shows that it actually _____."

"Although previous work suggests _____, my data argue _____." ¹

3. **Describe** what your findings mean in the world beyond basic science in 2-3 sentences. Explain any applications of your work.
 - What does your finding do in the world? How does your experiment live and function in the world? Who is your audience, and why should they care?
 - Tie this into what interests you, and make it relatable (e.g. medicine, human health, the environment, animal behavior, etc.)
 - This is the only place where you can use one credible internet source.

"Our finding is important because of its potential influence on _____."

"This result holds great application value in the field of _____ because _____."

"The utility of this research is evident in _____, where _____." ¹

4. **Review** the study and its significance. Make a final, grand statement by addressing the question, “What was the impact of my study on the literature?”
- Explain how/why your study was significant with regards to any literature gaps, extensions, speculations, or future studies.
 - E.g. “This is what I’ve done, and here’s where I can see my work going...” (How will your study contribute to the broader conversation in the scientific community or beyond?)

“By demonstrating _____, my work *extends* the findings that _____.”

“In summary, my study shows that _____, but the issue of _____ remains unsolved.”

“These results open the door to studies that _____.”

“The methodologies I developed will be useful for _____.”

“My findings are the first step toward _____.”

“Further work in this area may lead to the development of _____.”

WORD PHRASE BANKS AND USEFUL VOCABULARY

WORDS TO AVOID

- There are certain words that you should avoid when writing your papers. Words that are ambiguous, unclear, or absolute should be avoided.
- Science is a ceaseless process of discovery. There are no absolutes and certainties in the scientific endeavor. You can, however, be very confident about a finding or have data of strong significance. Try to use terms such as “highly likely,” “significantly,” or “strongly suggest” instead.

Words to Avoid			
<ul style="list-style-type: none"> • <i>Exactly...</i> • <i>Definitely...</i> • <i>Absolute(ly)...</i> • <i>Completely...</i> • <i>Totally...</i> • <i>Entirely...</i> 	<ul style="list-style-type: none"> • <i>Very...</i> • <i>A bit...</i> • <i>A lot of...</i> • <i>Perfect(ly)...</i> • <i>Always...</i> • <i>Never...</i> 	<ul style="list-style-type: none"> • <i>Best...</i> • <i>Worst...</i> • <i>A bad result...</i> • <i>A good example...</i> • <i>Literally...</i> • <i>Would of...</i> 	<ul style="list-style-type: none"> • <i>Prefer(ably)...</i> • <i>Stuff...</i> • <i>Thing...</i>

PROVIDING BACKGROUND INFORMATION

- Research is an essential part of any good academic paper. Without it, claims and opinions are not viable and hardly believable. Plus, without research, it is difficult to know much about your chosen subject. By providing evidence of research in your Introduction and Discussion sections, readers can trust that what you write is concrete, accurate to the best of your knowledge, and reliable.

Invoking Other Studies	Established Patterns	Lacking Data	Providing Rationale
<i>a few studies...</i>	<i>the underlying concept...</i>	<i>little attention has been devoted to the impact...</i>	<i>what we set out to demonstrate was...</i>
<i>other studies...</i>	<i>several schools of thought have emerged...</i>	<i>given the lack of critical attention paid to...</i>	<i>the central issue we address here is the relationship between...</i>
<i>a certain study, ... indicated that...</i>	<i>a deeper understanding of the process of...</i>	<i>the topic of warrants research attention for reasons.</i>	<i>our present study attempts to crystallize factors which influence by...</i>
<i>as shown previously... as noted earlier...</i>	<i>our research builds on existing knowledge in the fields of...</i>	<i>in order to better understand...</i>	<i>we will analyze the relationship between and...</i>
<i>prior research has suggested...</i>	<i>against this backdrop, we... in this respect,...</i>	<i>to answer these questions...</i>	<i>in examining, we...</i>
<i>research indicates...</i>	<i>there is evidence that has a effect</i>	<i>another factor...</i>	<i>our contention is that... or we contend that...</i>
	<i>these arguments suggest...</i>		<i>we illustrate this process by...</i>
	<i>generally, ... typically, ... traditionally, ...</i>		<i>we will supplement the insights drawn from scholarly literature by...</i>
	<i>in this context, it is worthwhile to consider...</i>		<i>the issue is whether or not...</i>

Useful Transitions for Providing Background Information			
<ul style="list-style-type: none"> • <i>the likelihood that...</i> • <i>given this orientation...</i> • <i>the same logic underlies...</i> • <i>a major trait...</i> • <i>initially, it may seem...</i> • <i>this leads to...</i> 	<ul style="list-style-type: none"> • <i>as a result...</i> • <i>hence...</i> • <i>accordingly...</i> • <i>respectively...</i> • <i>consequently...</i> • <i>thus, ...</i> 	<ul style="list-style-type: none"> • <i>therefore, ...</i> • <i>for this reason...</i> • <i>because of this...</i> • <i>also, ...</i> • <i>whereas...</i> • <i>surprisingly, ...</i> 	<ul style="list-style-type: none"> • <i>still, ...</i> • <i>yet...</i> • <i>in contrast, ...</i> • <i>next,...</i> • <i>nevertheless...</i>

EXPLAINING THE TOPICS AND ISSUES WITHIN YOUR SUBJECT

- Explaining the topics and issues within your main subject is intrinsic for writing well in academic writing. Without going into detail about the information you present, you are doing a disservice to your readers who expect to know more about the subtle side of an issue or topic. Explanation gives readers the needed substance for learning about something new. You should neither over-explain nor under-explain. Finding balance in your academic writing will come with time and experience.

Useful Phrases and Words			
<ul style="list-style-type: none"> • <i>in order to...</i> • <i>in other words...</i> • <i>to put it in another way...</i> • <i>that is to say...</i> • <i>to that end...</i> 	<ul style="list-style-type: none"> • <i>besides...</i> • <i>furthermore...</i> • <i>in addition,...</i> • <i>moreover...</i> • <i>likewise...</i> 	<ul style="list-style-type: none"> • <i>indeed...</i> • <i>in fact, ...</i> • <i>also, ...</i> • <i>as well...</i> • <i>foremost...</i> 	<ul style="list-style-type: none"> • <i>above all...</i> • <i>preceding all else...</i>

ADDING ADDITIONAL INFORMATION TO SUPPORT A POINT

- It is never enough to give one line of thought to describe or support a claim. A claim is always weak if it is backed up in a one-sided way. That is why it is important to give a comprehensive view of your main topic to your readers.

Useful Phrases and Words			
<ul style="list-style-type: none"> • <i>moreover...</i> • <i>furthermore...</i> • <i>what's more...</i> • <i>likewise...</i> • <i>similarly...</i> • <i>another key thing to remember...</i> • <i>as well as...</i> 	<ul style="list-style-type: none"> • <i>not only.... but also...</i> • <i>coupled with...</i> • <i>initially...</i> • <i>subsequently...</i> • <i>not to mention...</i> • <i>additionally, ...</i> • <i>in addition, ...</i> 	<ul style="list-style-type: none"> • <i>also, ...</i> • <i>besides that, ...</i> • <i>and...</i> • <i>apart from...</i> • <i>in addition to...</i> • <i>such as...</i> • <i>another...</i> • <i>besides, ...</i> 	<ul style="list-style-type: none"> • <i>further...</i> • <i>too...</i> • <i>then...</i> • <i>of equal importance...</i> • <i>equally important...</i> • <i>another...</i>

DEMONSTRATING CONTRAST

- In order to fully present your main topic and its components, it is important to show that other views that are valid. Usually, these other views are shown to demonstrate which side of the argument or issue is most appropriate to consider.

Useful Phrases and Words			
<ul style="list-style-type: none"> • <i>however, ...</i> • <i>on the other hand, ...</i> • <i>having said that, ...</i> • <i>by contrast, ...</i> • <i>by comparison, ...</i> • <i>then again, ...</i> • <i>that said, ...</i> • <i>yet...</i> • <i>at the same time, ...</i> • <i>nonetheless, ...</i> • <i>on the contrary, ...</i> 	<ul style="list-style-type: none"> • <i>after all, ...</i> • <i>though...</i> • <i>in contrast...</i> • <i>nevertheless, ...</i> • <i>but...</i> • <i>otherwise...</i> • <i>notwithstanding...</i> • <i>conversely, ...</i> • <i>instead, ...</i> • <i>rather...</i> • <i>on one hand...</i> 	<ul style="list-style-type: none"> • <i>on the other hand...</i> • <i>a clear difference...</i> • <i>a conflicting viewpoint...</i> • <i>despite...</i> • <i>even so, ...</i> • <i>for all that...</i> • <i>still another...</i> • <i>in another way...</i> 	<ul style="list-style-type: none"> • <i>the antithesis of...</i> • <i>still...</i> • <i>and yet...</i> • <i>of course, ...</i> • <i>or...</i> • <i>in spite of this...</i> • <i>actually, ...</i> • <i>a year ago, ...</i>

Table of task words	
Words	What they (might) mean...
Account for	Explain, clarify, give reasons for. (Quite different from "Give an account of which is more like 'describe in detail'").
Analyze	Break an issue down into its component parts, discuss them and show how they interrelate.
Assess	Consider the value or importance of something, paying due attention to positive, negative and disputable aspects, and citing the judgements of any known authorities as well as your own.

Argue	Make a case, based on appropriate evidence for and/or against some given point of view.
Comment on	Too vague to be sure, but safe to assume it means something more than 'describe' or 'summarize' and more likely implies 'analyze' or 'assess'.
Compare	Identify the characteristics or qualities two or more things have in common (but probably pointing out their differences as well).
Contrast	Point out the difference between two things (but probably point out their similarities as well).
Criticize	Spell out your judgement as to the value or truth of something, indicating the criteria on which you base your judgement and citing specific instances of how the criteria apply in this case.
Define	Make a statement as to the meaning or interpretation of something, giving sufficient detail as to allow it to be distinguished from similar things.
Describe	Spell out the main aspects of an idea or topic or the sequence in which a series of things happened.
Discuss	Investigate or examine by argument. Examine key points and possible interpretations, sift and debate, giving reasons for and against. Draw a conclusion.
Evaluate	Make an appraisal or the worth of something, in the light of its apparent truth; include your personal opinion. Like 'assess'.
Enumerate	List some relevant items, possibly in continuous prose (rather than note form) and perhaps 'describe' them (see above) as well.
Examine	Present in depth and investigate the implications.
Explain	Tell how things work or how they came to be the way they are, including perhaps some need to 'describe' and to 'analyze' (see above).
To what extent...?	Explore the case for a stated proposition or explanation, much in the manner of 'assess' and 'criticize' (see above), probably arguing for a less than total acceptance of the proposition.
How far	Similar to 'to what extent...?' (see above)
Identify	Pick out what you regard as the key features of something, perhaps making clear the criteria you use.
Illustrate	Similar to 'explain' (see above), but probably asking for the quoting of specific examples or statistics or possibly the drawing of maps, graphs, sketches etc.
Interpret	Clarify something or 'explain' (see above), perhaps indicating how the thing relates to some other thing or perspective.
Justify	Express valid reasons for accepting a particular interpretation or conclusion, probably including the need to 'argue' (see above) a case.
Outline	Indicate the main features of a topic or sequence of events, possibly setting them within a clear structure or framework to show how they interrelate.
Prove	Demonstrate the truth of something by offering irrefutable evidence and/or logical sequence of statements leading from evidence to conclusion.
Reconcile	Show how two apparently opposed or mutually exclusive ideas or propositions can be seen to be similar in important respects, if not identical. Involves need to 'analyze' and 'justify' (see above).
Relate	Either 'explain' (see above) how things happened or are connected in a cause-and-effect sense, or may imply 'compare' and 'contrast' (see above).
Review	Survey a topic, with the emphasis on 'assess' rather than 'describe' (see above).

State	Express the main points of an idea or topic, perhaps in the manner of 'describe' or 'enumerate' (see above).
Summarize	'State' (see above) the main features of an argument, omitting all superfluous detail and side-issues.
Trace	Identify the connection between one thing and another either in a developmental sense over a period of time, or else in a cause and effect sense. May imply both 'describe' and 'explain' (see above).

Other useful definitions	
Words	What they (might) mean...
Assumption	Something which is accepted as being true for the purpose of an argument.
Issue	An important topic for discussion; something worth thinking and raising questions about.
Methodology	A system of methods and principles for doing something. Often used to explain methods for carrying out research.
Objective	It is the point or the thing aimed at. It is what you want to achieve by a particular activity.

References

¹ Graff, G., & Birkenstein, C. (2010). They say / I say: The moves that matter in academic writing. New York (NY): W.W. Norton 245 p.

Schimel J. 2012. Writing science: how to write papers that get cited and proposals that get funded. Oxford University Press, Oxford.

Turbek SP, Chock TM, Donahue K, Havrilla CA, Oliverio AM, Polutchko SK, Shoemaker LG, and Vimercati L. 2016. Scientific writing made easy: a step-by-step guide to undergraduate writing in the biological sciences. *Eco* 101. 97(4):417–426.