# SECTION 1

# Scientific Paper Structure

Scientific papers are one of the main methods of communicating results to other scientists. In general, papers follow a standard format with different sections of the paper addressing different things. The following table outlines these sections, the rationale behind them and what to put in them.

|  |  |  |  |
| --- | --- | --- | --- |
| **Section of Paper** | **Rationale** | **How to do it** | **Other useful tips** |
| **Title** | This is first thing your audience reads, the title is a very concise yet accurate summary of your investigation. This is the ‘hook’ to get your reader interested.  | * Include species name if appropriate
* try to include the main finding if possible
* be precise, one sentence only (sometimes two statements separated by : , or a question and statement) See examples below.
 | * often written last
* not necessary to capitalise every word
* with so many papers in existence, often scientists will only read work directly relevant to them as indicated by the title
 |
| **Abstract** | The abstract is a short summary of your investigation, often a paragraph to ½ a page of writing and must make sense to someone who has not read your paper. Readers will typically read this before the whole paper and will often decide to read the paper based on the abstract. The goal is to entice the reader in order to have as many other scientists aware of your work as possible.  | A good abstract includes:* objective of study/research question
* study design: very brief mention
* results: main findings and/or trends
* conclusions: include major conclusions you made.
 | * often written towards the end (ideally the abstract can almost be composed of the first sentence of each paragraph in your paper)
* do not include in-text citations here
 |
| **Introduction** | The introduction is where you set the scene for your reader, and provide context and rationale for your study, providing sufficient background so the reader can understand what you did, why you did it, and why it is relevant. Tell a story that leads to your question, hypothesis and prediction (but do not include irrelevant information – keep it concise).  | A good introduction includes: * enough background information that your reader can understand why the study was performed
* relevant information about the organism or system that you are studying
* a clear statement of your objective/ research question(s)
* your scientific hypothesis
* any predictions you make based on the hypothesis.
 | * do not include any references to null or alternative (statistical) hypotheses
* include in-text citations here: explanations of theoretical background or references to other literature MUST be cited in the text (and the full reference must be included in the reference list at the end)
* do not mention your results
 |
| **Methods** | The materials and methods tell your reader exactly what you did. To uphold scientific rigour, other scientists must be able to repeat the investigation with the information you provide here (and should therefore also reproduce your results if your study was sound).  | Methods includes:* a description of the protocol (what you did) in sentences (not point form) and in past tense
* information about your sample size, number of treatments, factors kept constant, whether you recorded mass of your organisms *etc*.
* a brief description of how the data were summarised and statistically analysed
 | * materials and methods are easy to write, so get them done first
* do NOT include any results here, either in text or figure format
* do not include citations (typically in-text citations are rare here, unless referring specifically to a protocol developed by other authors)
 |
| **Results** | The results of your investigation are your contribution to science and humanity! You want to make your results as clear to your reader as possible so they are easily grasped. Raw data (i.e. your data tables) are difficult to make sense of and are rarely included in papers. Usually data are presented in the form of a figure(s) (graph), as well as a brief description of your data.  | * Include a figure(s), with an appropriate caption
* describe any trends or patterns in your results, indicate their statistical significance, be sure to refer explicitly to your figure(s)
* in the description you can include other information that could not be or were not worthy of being graphed or tabulated (such as relevant qualitative observations)
* state whether or not your results are statistically significant
 | * your results are the whole point of your investigation and form the basis of your discussion, so get these done early
* in your results description, do NOT simply list the values of different points or bars in your graph: the reader can see this for themselves, rather, describe the trend/pattern and the direction of it, and its statistical significance (or lack thereof)
* do not comment on, interpret or discuss your results (i.e. expected or unexpected results – this belongs in the discussion)
 |
| **Discussion** | This is where you interpret your results with respect to other studies and the literature, draw conclusions and place your work and its significance in the context of the bigger picture. The discussion is the interesting part: did you discover something new or unexpected? Are your results in agreement with those of other similar studies? Why, or why not?  | * Refer to your prediction(s)and/or scientific hypothesis: compare your actual results to your predicted results. Are they the same? Provide reasons and explain why they might differ (if they do)
* Are your results supported by other studies in the literature? Are they different? Explain why this may be
* What conclusions can you draw from your study? What are the implications? What further research may be undertaken?
 | * Keep the information in your discussion focused: if it doesn’t relate to the testing of your hypothesis, leave it out
* do NOT ‘prove’ or ‘disprove’ your hypothesis, you can only provide support (or not)
* resist the urge to explain away anomalies or results that differ to other studies as being due to ‘human error’ (you should have minimised this). Rather, think critically, examine methodologies, and come up with a logical explanation for the differences
* cite any literature you refer to
 |
| **Reference List** | The reference list serves to direct your readers to the original work of others that you have cited (they will be able to see if you have cited correctly!) | * Be consistent, use a proper referencing style
* Include all information (such as author names, date, title, journal, *etc.*)
 | * Do not include references that you have not cited in text (this would be a bibliography)
 |

**Some example paper titles:**

* Responses to low salinity by the sea star *Pisaster ochraceus* from high- and low-salinity populations.
* Sea otters *Enhydra lutris* homogenize mussel beds and reduce habitat provisioning in a rocky intertidal ecosystem.
* Ferry wakes increase seaweed richness and abundance in a sheltered rocky intertidal habitat.
* Community ecology in a warming world: the influence of temperature on interspecific interactions.

# SECTION 2

# Figure (Graph) Formatting Conventions

In scientific writing, a graph is referred to as a figure. Figures serve to summarise data in a visual format so that the information is easy for the reader to understand. It is difficult to see trends or patterns in raw data (the data recorded during the actual experiment), and therefore raw data are rarely included in scientific papers (if they are, it is usually in supplemental material). **You should be able to interpret a figure (together with its caption) in isolation from the rest of the paper**, so it must contain sufficient information for this to be the case. Within a piece of writing, figures (and tables) are numbered in the order in which they appear (Figure 1., Figure 2. *etc*.). A good figure should be self-explanatory and should show the key patterns or trends of the data.

The following information outlines specific Figure Conventions to follow:

**Variables** The independent variable (what you change) is plotted on the x-axis, and the dependent variable (what you measure) is plotted on the y-axis. Variable categories should appear in a sensible order. If they are numerical, they should appear from smallest to largest (e.g. 10 °C, 20 °C, 30 °C). This will help make the data easy to interpret.

**Figure type** In Biology 140 you will use either a point graph, or a bar graph.

**Variation** If you plot mean (average) values in a figure, include a graphic representation of the amount of variation in the data. Add vertical bars on either side of each data point or data bar. The vertical bars represent different measures of variation, such as standard deviation, 95% confidence intervals or standard error of the mean, depending on the situation.

**Axes Labels** Both axes must be labeled and must include the units of measurement. The x-axis label goes horizontally underneath the axis, and the y-axis label goes to the left of the axis, rotated vertically.

**Figure Caption** In biology, scientific figures do not have a title above them, but rather a caption below them (usually). The figure caption is a short piece of text that includes the number of the figure (e.g. Figure 1.) and a brief explanation or description that accompanies the figure and includes all the information necessary to understand the figure without having to read the text of the paper.

**Important details about figure captions**:

* Describe what results are shown in the figure (such as jump distance), but do not include specific data values.
* Include the name of the species, sample size (e.g. n = 10), what the data and error bars represent (e.g. average height in cm ± 95% CI).
* Describe in words the symbols/colours/shading used (e.g. shaded bars represent limpets or solid diamonds represent seagulls – this will only apply if you represent multiple species in one figure).
* Do not include a figure legend.
* Avoid Colour. Unless you have a complex figure, it is better to use different grayscale shading if necessary rather than colours to differentiate different information in your figure. Colour is fine if you view the figure on a screen, but often your reader might print your paper without realising a figure has colour.

The following example figures show the same data in both point and a bar graph form for separate treatment experiments. They show data for maximum jump distance of a species of cane toad *Bufo marinus*.

**☺ Example of a complete caption for these figures (specifically the bar graph):**

**Figure 1.** The maximum jump distance of *Bufo marinus* at different body temperatures.Bars represent the mean (± 95% confidence intervals) jump distance in cm observed at 20 °C (n = 12) and 30 °C (n = 12). Air temperature during jumps was maintained at 25 °C.

*Note: the information contained in the caption can be worded differently.*

**☹ Two examples of poor or incomplete captions for these figures:**

 **Figure 1.** Jump Distance vs Body Temperature of Toad.

**Figure 1.** Jump Distance and *Bufo* temperature*.* Bars *(or points)* represent the mean (± 95% confidence intervals) jump distance. Air temperature during jumps was maintained at 25 °C.

**Here is a complete example of a figure with its (complete and satisfactory) caption as it would appear in text:**

**Figure 1.** The maximum jump distance of *Bufo marinus* at different body temperatures.Bars represent the mean (± 95% confidence intervals) jump distance in cm observed at 20 °C (n = 12) and 30 °C (n = 12). Air temperature during jumps was maintained at 25 °C.

# Describing Results (in words)

In addition to graphically representing the results of an investigation, it is important to describe the results in words to focus the reader’s attention on the main message that we want to convey through the figures.

When describing results in words, you must:

* Refer to the figure or table and make comparisons among relevant data points.
* Clearly state any differences among data points, including the direction (*e.g.* increasing or decreasing trend) and the magnitude of any differences (*e.g*. ‘twice as high’, ‘10% increase’, ‘less than 1% higher’, *etc.*).
* Only mention values relevant to your comparisons (do not just list all the values that are in the figure!). Include variation around the mean (*e.g.* ± standard deviations) or confidence intervals.
* If you have conducted a statistical test, state whether you found a statistical difference between data points and report the specific statistics (*e.g.* *p*-value).
* Describe any additional observations (*e.g*. qualitative observations) that may provide insight into your research question but were not included in the figure.

# SECTION 3

# Biology 140 Glossary – REVIEWERS PLEASE FOCUS ONLY ON HIGHLIGHTED TERMS

The following list includes many important terms used in the context of this course. They are arranged in the order in which you they will appear in the course.

## Biology

**Well-being:** In Biology 140 the ‘well-being’ of an organism refers to how fit an organism is (in the sense that it will pass on its genes to the next generation). Well-being refers to the survival, health, growth and ultimately reproduction of an organism.

**Range of tolerance:** range of an environmental factor in which an individual can survive, grow and reproduce. Within the range of tolerance, the optimum range encompasses the conditions that are most favourable for survival, growth and reproduction of the organism. (Adapted from: Smith *et al*. (2014)).

## Experimental design

**Bias**: an intentional or unintentional attitude or action in favour of or against something or someone. In science, bias can occur when researchers unintentionally act in ways that may ‘favour’ some samples, ideas, treatments or methods over others, thus affecting (skewing) the results.

***Example:*** A researcher wants to test whether shell size has an effect the choice a hermit crab makes when selecting a new empty shell to protect itself. She sets up a testing arena with the small shell on the left and the large shell on the right and places a crab equidistant from both shells. She waits for five minutes before recording which shell the crab chose, then repeats exactly the same procedure with another 20 hermit crabs.

By always placing the small shell on the left and the large shell on the right, the researcher has introduced potential *bias* in the experiment: one of the two shell sizes (*treatments*) may appear to be ‘favoured’ by the hermit crabs, but because of its location rather than because of its size. The introduction of this potential bias is a *design flaw* that makes it impossible to draw conclusions about the effect of shell size on hermit crab choice.

**Biological variation:** the natural differences that exist among individuals in a population of organisms.

***Examples:*** Differences in size, age, sex, health, genetic makeup, *etc*.

**Control:** a ‘mock treatment’ or procedure that has the purpose of isolating the effect of the factor under investigation on the response being measured. Controls can be conducted for different reasons.

Note that many discovery-based investigations do not have controls. Also, comparative hypothesis-testing experiments, such as those performed in Biology 140, have built-in controls where each of two more treatments effectively serves as a control for the other.

***Example 1:*** Placebo *treatments* (*e.g.* an injection of saline instead of an injection of the drug being tested) in medical/clinical trials are typical *controls*: they allow researchers to distinguish between the effect of the drug itself and the effect of administering (*e.g*. the act of injecting) the drug.

***Example 2:*** A farmer is interested in measuring the effects of a fertilizer on the growth rate of corn. In order to do this, she first needs to know the growth rate of corn under ‘standard’ conditions (i.e. without the fertilizer): she grows one groups of randomly selected corn plants (control) without the fertilizer, and another group with the fertilizer (treatment), and keeps all other factors identical between the two groups. This allows her to quantify the effect of the fertilizer on growth rate of corn.

**Design flaw:** an aspect of the way an experiment is designed that makes it logically impossible to obtain an answer to the question that the experiment was meant to address, regardless of how rigorously the experiment is executed.

***Example:***A researcher sets up an experiment to test the effect of temperature on the reproductive rate of an animal using two *treatments*, 17ºC and 25ºC. The animals in the 17ºC treatment are kept in an environment that also happens to have low light intensity, while those 25ºC are in an environment with high light intensity. This researcher will never be able to achieve his goal of drawing conclusions about the effect of temperature on the reproductive rate on the animal, because both temperature and light intensity differ between the two treatments (so, whatever the effect, is it because of temperature, light intensity, or a combination of both? We would not be able to tell!).

Failing to keep all *extraneous variables* constant across *treatments* is a *design flaw*; it makes it impossible to achieve the experiment objective by introducing *bias* in the experiment.

**Design limitation:** an aspect of how a scientific investigation is designed that prevents us from drawing certain conclusions or inferences, or making certain extrapolations, from the data obtained. Note that all scientific investigations have some design limitations, as they are usually designed to address a specific question and are therefore optimized towards that purpose.

***Example 1:***A researcher designs and conducts an experiment to investigate food preference in the fruit fly *Drosophila simulans*. The researcher is specifically interested in the food preference of female *D. simulans*, so she only uses females in the experiment. The results obtained from this experiment will therefore allow us to draw conclusions on food preferences of female *D. simulans* (which is exactly what the researcher set out to do). However, the results will not tell us anything about food preferences of males, or of other species of fruit fly: this is a *design limitation*.

***Example 2:***A group of students set out to investigate whether or not there is a correlation between altitude and number of plant species present in a particular temperate forest. The students rigorously collected data on the number of plant species present at many different altitudes in their forest of interest. The results obtained will allow us to conclude whether or not there is a correlation between the two variables, altitude and number of plant species (which is exactly what the students set out do). However, the results will not tell us anything about cause-effect relationships between altitude and number of plant species present: this is a *design limitation*.

**Experimental uncertainty:** refers to uncertainty that can arise due to unintentional differences in how the equipment was used, as well as differences between pieces of equipment.

***Example:***Two researchers may use the same stopwatch to measure an animal’s response, but may have different reaction times, thereby introducing variation in the data. Alternatively, the same person may use two different stopwatches that keep time slightly differently.

**Extraneous variables:** variables (other than the factor of interest) that may have an effect on the response that is measured.

***Example:*** A researcher might want to measure the response of an animal to different levels of salinity, but temperature may also influence the organism’s response. In this case, temperature would be an extraneous variable and it should be kept constant across treatments. Failing to do so would prevent the researcher from drawing any conclusions about the effects of salinity on the animal’s response (it would be a *design flaw*).

**Qualitative data:** data that are generally descriptive in nature and do not include numerical information.

***Examples:*** Rigorously recorded observationson an animal’s colours, sex, overall shape, or behaviours, field site descriptions, weather conditions, *etc*.

**Quantitative data:** data that aretypically numerical in nature.

***Examples:*** Measurements such as ambient temperature, organism’s weight, water salinity, rate of movement, *etc*., recorded during a scientific investigation.

**Raw data:** the first hand data points and observations that are recorded during an experiment (*i.e.* the data in your data tables). Raw data are very important to keep, but are often messy and difficult to interpret and draw conclusions from. They are therefore rarely included in scientific papers.

***Examples:*** The measurements and observations recorded in the field, the data recorded and/or pictures taken during a lab experiment.

**Replicate:** independent runs of the same experimental procedure, observation, or measurement, with the same setup and the same treatments, conducted during a *trial*.

***Examples:*** A researcher sets up a testing arena with a small shell on one side and a large shell on the other, and places a hermit crab equidistant from both shells. She waits for five minutes before recording which shell the crab chose, then repeats exactly the same procedure with another 20 hermit crabs. In total, this researcher has performed 21 independent *replicates* of her experiment/measurement.

**Replication:** conducting multiple identical *replicates* so that the variability associated with a phenomenon can be estimated. Note that in order for replication to be valid, each replicate must be independent (replication is not the same as repeated measurements of the same item/organism!)

***Examples:*** measuring the abundance of a species in several different quadrats at a specific study location, running multiple animals (independently) through the same experimental procedure and collecting data for each one.

**Reproducibility:** the tendency for a set of findings to be obtained again in a different experiment (or *trial*). Reproducible findings increase our level of confidence in the results.

***Example:*** students in Biology 140 performed one trial of their experiment on October 20 and another on October 27. In both cases they found that crabs have a preference for gravel over sand: their results were reproducible.

**Sample:** a subset of individuals from a population, or a portion of area from a larger area, or a subset of cells from a tissue

***Examples:*** a group of 150 crabs collected at Tower Beach represent a *sample* of the population of crabs living in that area; a group of 10 quadrats (1 x 1m squares) is a sample of the whole coniferous forest.

**Sample size (n):** the number of independent measurement events (often, the number of replicates in a treatment).

***Examples:*** If we measure the mass of 20 fish out of a larger population, we shave a sample size of 20 (or n=20); if we or survey vegetation diversity in 10 quadrats (1 x 1m squares) in a particular forest we have a sample size of 20 (or n=20).

**Treatment:** in Biology 140, the treatment is something that the researcher administers to the experimental organisms.

***Example:*** If we investigate the effect of two different temperatures (e.g. 10ºC and 30ºC) on the behaviour of an animal, we have two temperature *treatments*: 10ºC and 30ºC.

**Trial**: ‘trial’ has different meaning in different scientific contexts. In Biology 140, one trial refers to all the experimental measurements taken in one lab period.

***Example:*** In Trial 1, which took place on October 27, one group of Biology 140 students performed 28 replicates for Treatment 1 (4ºC) and 27 for Treatment 2 (25ºC), and recorded measurements and observations for each replicate.

## Philosophy of science

**Assumption:** a statement, supported by some prior (but usually incomplete) evidence and sound rationale, on which our inferences, conclusions, and predictions depend.

Assumptions should always be supported (validated) by some prior evidence, knowledge, experience, logic or theory; weak or lacking evidence for an assumption will lead to a weak inference or conclusion. Note that an ‘assumption’ that is not validated by some evidence is not an assumption: it is a guess. In science, it is not acceptable to make inferences or conclusions based on guesses.

***Example:*** A researcher wants to investigate whether the smell of cat urine causes fear in mice in a particular laboratory setting. It is not possible to directly test or measure fear, so the researcher measures how much time the mice spend in a crouching position after being exposed to the treatment. In order to interpret her results, the researcher needs to *assume* that time spent in a crouching position is indicative of fear in a mouse, so if a mouse spends a long time in this position, the researcher can *infer* that that mouse is experiencing fear. Importantly, the researcher’s assumption is based on prior evidence and theory that generally links time spent in a crouching position to fear in small prey animals.

**Discovery-based:** a research approach that is open-ended and exploratory in nature.

***Examples:*** Documenting the abundance of marine invertebrates that live at different tidal heights in a location in order to investigate the patterns of distribution and abundance of these animals; documenting the occurrence of a recurring condition within a family to investigate its pattern of inheritance; describing and documenting new species.

**Hypothesis-testing:** a research approach typically used to investigate questions that address the mechanisms behind a phenomenon or observation, or on cause-effect relationships. As the term suggests, this approach often aims to test a scientific hypothesis.

***Example:*** After noticing that corn plants seem to grow more quickly in years with substantial rainfall than in years in which the weather is very dry, one could use the *hypothesis-testing* approach to determine whether it is the amount of water available to the plants that causes the difference in growth rate. This could be done by measuring growth rate of two groups of corn plants exposed to identical conditions, except that one group will be watered more than the other.

**Inference:** a statement that interprets observations/data, previous hypotheses, or previous conclusions. Making an inference requires the application of logical, rigorous reasoning and the use of specific, appropriate *assumptions*. These assumptions must be based on some prior evidence, experience, logic or theory. The stronger the validating evidence for the assumption(s), the stronger the resulting inference.

***Example 1:*** A researcher counts the number of plant species present in 20 randomly selected, 1 m2 sampling location in a forest. Altogether, the researcher identifies 23 different plant species; each species identified is present in at least 16 sites. As she interprets these data, the researcher *infers* (makes the *inference*) that there are 23 different plant species in the forest. This inference is based on the *assumption* that collectively, the 20 randomly selected study sites include all the plant species present in the forest (i.e., no other species are present outside the sampled locations).

***Example 2:*** A team of students wants to investigate food preference in crickets. They perform a *simultaneous treatment* experiment where individual crickets are presented with two different food items, and each cricket’s choice (in this case defined as the food item that the cricket eats first) is recorded. In total, 47 crickets are tested and 41 of them chose lettuce, while 6 chose bananas; these data are significantly different form what we would expect of the crickets’ choice was random (p<0.05). In their data interpretation, the students *infer* (make the *inference*) that crickets prefer lettuce over banana. This inference is based on the *assumption* that if an animal chooses one *treatment* significantly more frequently than the other in a simultaneous treatments experiment, this is indicative of a preference.

**Scientific Hypothesis:** (also simply referred to as ‘hypothesis’)a testable, falsifiable statement that provides a plausible explanation (typically incorporating a cause-effect relationship) for an observed phenomenon.

***Example:*** A researcher hypothesizes that homing pigeons find their way home from distant and unknown locations by navigating using visual cues such as landmarks in the environment.

**Prediction:** in a discovery-based study, an ‘If [method], then [expected result]’ statement connected to any expected results of a study. If hypothesis-based, a statement in the format ‘If [method], then [expected result]’ that connects the hypothesis to the expected outcome of an experiment.

***Example 1:*** A biology student hypothesizes that X. This hypothesis makes the prediction that, if the student applies method A to her system, then B is observed. In other words, if X is correct, then when one does A, B is expected to happen.

***Example 2:*** Based on the hypothesis that If it is true that homing pigeons find their way home from distant and unknown locations by navigating using visual cues such as landmarks in the environment, the prediction is that if homing pigeons are blindfolded (so that they cannot see) and released at a distant unknown location, then they should be unable to navigate home.

## Statistics

**Mean:** In Biology 140, mean is synonymous with average, i.e. the sum of all the data values, divided by the total number of data points.

**Standard Deviation:** a measure of the dispersion of data, or how scattered the individual data points are about the mean value.

**95% Confidence Interval of the Mean:** a range of values that we expect to include the true mean of a population with a probability of 95%. Please refer to the section ‘Introduction to statistics’ at the end of Week 1 for more details.

**Null hypothesis (H0):** in statistics, this is the hypothesis that some particular description of the population (*e.g.* the mean) **equals** a specific value.

In Biology 140 (and in many scientific investigations) this specific value is one that we would expect without some extra process happening (for example, if our factor of interest had no effect).

**Alternative hypothesis (HA)**: in statistics, this is the hypothesis that some particular description of the population (*e.g.* the mean) **does not equal** the very specific value stipulated by the null hypothesis.

In Biology 140 (and in many scientific investigations) the alternate hypothesis reflects the possibility that any deviations of the experimental results from the expectations of the null hypothesis might be due to some extra process happening (*e.g*. an effect of our treatment) and not due to chance.

**Statistical Tests**: statistical procedures that allow us to determine whether or not we should reject the null hypothesis. If our data are similar enough to the values stipulated by the null hypothesis, we fail to reject the null hypothesis, meaning that chance may be responsible for any deviations from the expectations of the null hypothesis in the results we obtained.

In contrast, if our data are dissimilar enough from the values stipulated by the null hypothesis, then we reject the null hypothesis, lending support to the alternate hypothesis. In our case, rejecting the null hypothesis means that it is likely that our results were due to the treatment (and unlikely to be due to chance alone). Note that it is not possible to reject the alternate hypothesis.

Two-sample *t*-tests, 2 tests, *etc*. are examples of statistical tests.

**Two-sample *t*-test:** a statistical test that tests for a difference between two groups by measuring the difference between their respective means.

**Chi-squared (****2) test**: a statistical test that measures the difference between an observed distribution of frequency (count) data and a distribution of these data that would be expected under particular conditions (by default, the expected distribution would be due the conditions of chance).

***p*-value:** the probability of finding a result as different from (or more different from) the expectations of the null hypothesis if the null hypothesis were in fact true. In practice, the higher your *p*-value, the more likely it is that any deviations (in your results) from the expectations of the null hypothesis could have been obtained by chance.

**Significant:** in science, when we say “significant” we generally mean “statistically significant”. A result is statistically significant when the probability (*p*-value) calculated by a statistical test falls below a certain pre-determined value. In Biology 140 (and in many scientific investigations), a statistically significant result is a result that is very unlikely to have been caused only by chance.

# SECTION 4

# Referencing in Biology 140

There are many different referencing styles in the science discipline – particularly in biology, almost every journal has a particular referencing style! To keep it simple, however, we use the **Harvard Citation and Referencing style** in Biology 140. This is a style you are possibly already familiar with and it is used across a range of different disciplines.

The University of Western Australia has a useful website that you should use for **Harvard Citations and Reference List formatting**:

<http://guides.is.uwa.edu.au/harvard>

Most resources that you will be using in Biology 140 will be Books, Journal Articles, and maybe websites. You can access information and examples on how to cite and reference each type of resource by using the ‘Reference formats’ menu bars.



##

## In-text Citations

In general, there are two main methods of citing in text that include only **author surname** and **year of publication**. For example,

According to Smith and Jones (2015), the majority of Biology 140 students have difficulty citing correctly in text.

OR

The majority of Biology 140 Students have difficulty citing correctly in text (Smith & Jones 2015)

Carefully follow the **Harvard In-Text formatting style**, since citations varies slightly depending on a number of things such as number of authors, authors with the same name, or multiple citations in one set of parentheses.

You will notice the use of the words ‘*et al.*’, which is an abbreviation of a Latin phrase that means ‘and others’. For example, ‘research by Smith *et al*. shows...’ refers to Smith and colleagues.

Page numbers are only applicable if you quote directly, which you should avoid.

## Reference List

The reference list (sometimes called Literature Cited) comes at the end of a piece of writing (on a new page) and provides the necessary information for the reader to locate any source you may have cited. Every in-text citation must be included in your reference list, and *vice versa*. (A reference list is different from a bibliography where you might include a resource you read in preparation of your paper, but did not cite directly).

Carefully follow the **Harvard In-Text formatting style**, since the format varies depending on whichtype(e.g. book chapter, journal article *etc.*) of resource you are referencing. Below is an example of how you should reference the resource cited above (under ‘In-text Citations’):

Smith, TG & Jones, DW 2015, 'Student difficulties with citing and referencing', *Journal of Biology Students*, vol. 21, no. 3, pp. 401-409. Available from: <url> [23 December 2015]