

# Lab Report Guidelines

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## General Guidelines

You are expected to apply lab report writing skills that you have learned from the Intro Biology course and apply the basic lab report formatting described in the “Guidelines for Writing Lab Reports” from the Biol 105 lab manual. You are expected to review this document as you prepare the various parts of a lab report for this course. These skills are:

- Identifying the different sections of a lab report and organizing them correctly.
- Placing the correct types of information in each section; i.e., recognizing information that represents background information, procedures, results, interpretations and conclusions.
- Applying basic formatting skills to creation of figures and tables.
- Correct formatting of Citations and References, and ability to make these accurate to the source information.
- Application of good basic writing skills, including good overall organization of the composition and paragraphs with a suitable topic sentence, and well structured, grammatically correct sentences that use appropriate phrasing and terminology.

**The broad objectives of the lab reports in this course are to improve your:**

- basic writing skills.
- ability to read scientific literature and use the information effectively.
- ability to write components of a lab report in a more sophisticated style.
- ability to analyze and interpret results.
- ability to follow guidelines precisely.

1. All reports must be typed using a word processor on a microcomputer, such as those available in the computer labs in the Rickey Science Center. Use a 12pt font, 1” margins all around, and double-space your text.
2. Each student must write an independent lab report. Lab partners are encouraged to discuss the results of lab exercises, but each student must write a COMPLETELY INDEPENDENT report. Plagiarism may be rewarded with a failing grade (for the paper or the course), at the instructor's discretion.
3. There will be a 10% deduction per day for late submissions.
4. All final papers must be submitted to TII.com by the due date. Late submissions to TII.com may be docked 5% per day.
5. In all assignment you are expected to apply all rudiments of good composition: effective organization, grammar, punctuation, structuring of paragraphs, and use of topic sentences.

### Academic Dishonesty

Academic dishonesty within the academic community is a very serious matter, because dishonesty destroys the basic trust necessary for a healthy education environment. Academic dishonesty is any treatment or representation of work as if one were fully responsible for it, when it is in fact the work of another person. Academic dishonesty includes cheating, plagiarism, theft, or improper manipulation of laboratory or research data or theft of services. In scientific writing, plagiarism includes verbatim copying from literature sources whether the information is cited or not. A substantiated case of academic dishonesty may result in disciplinary action, including a ‘0’ on the assignment, a failing grade in the course, or expulsion from the College. All cases of plagiarism are reported to the Academic Dean.

# Introduction Section

## 1. Research Article Annotations (each at least 300 words + reference)

As preliminary work you will need to peruse the 1<sup>o</sup> literature on B-actin. For the preliminary assignment write annotations for three selected 1<sup>o</sup> articles:

- The complete reference
- The purpose of the study (indicate on which page and paragraph this is given)
- The hypothesis (indicate on which page and paragraph this is given)
- Summary of the system and primary types of methodologies used
- What the authors conclude about the effect of B-actin on cell metastasis or cell motility (indicate on which page and paragraph this is given)

**Comparison:** compare the results of all three articles; do they all suggest the same relationship between  $\beta$ -actin levels and the tendency of cells to display motility and/or metastasis? If not, explain why the articles may disagree.

## 2. Introduction Section

In this multi-lab experiment in which you will be comparing the amount of total  $\beta$ -actin in normal liver cells to that in metastatic B16 melanoma cells, analyzed using gel electrophoresis and immunoblotting with anti- $\beta$ -actin antibody.

- **Read “How to write an Introduction section”:** this presents essential information about writing an Introduction section
- Length should be at least 1200 words (~3 - 4 pages)
- Background information should include information on
  - Cell motility and cancer metastasis
  - Different types of actin isomers ( $\alpha$ ,  $\beta$ ,  $\gamma$ ); f- and g-actin, relationship to cell motility, with a focus on  $\beta$ -actin.
  - Actin cytoskeleton and metastasis, summarizing the findings of three previous 1<sup>o</sup> articles.

However, the presentations of background information should be concise and only include topics directly pertinent to your investigation.

- Use at least six literature sources (at least three 1<sup>o</sup>, three 2<sup>o</sup>, and no 3<sup>o</sup>). The 1<sup>o</sup> sources must include Nowak, et al., 2005 (paper we discussed in class). You should use literature placed on reserve in the library; however, you can research the topic on your own, but discuss with the instructor any new article before using it,
- When discussing the 1<sup>o</sup> literature, explain what previous studies have shown about  $\beta$ -actin expression in cancerous cells.
  - Briefly summarize the system that was examined and the conclusions drawn that are pertinent to the role of actin to cell motility and metastasis.
  - Make comparisons between the articles, indicating similarities, differences and/or contradictions in the findings. To provide context and allow some comparison, it is also acceptable to give a very brief synopsis of the system and general design.
- Discussion of the literature should lead to the statement of a purpose and hypothesis of your investigation.

**Purpose:** To study the role of a  $\beta$ -actin in cancer cell metastasis.

**Hypothesis:** Based upon the literature you have presented- your hypothesis should indicate that the B16 melanoma cells will have a higher, lower or the same level  $\beta$ -actin as normal cells.

- Include a Literature Cited section with properly formatted references.

## Articles on the Biol 309 reserve list in library

These articles are to be used when writing lab report Introduction and Discussion sections. This may not be 100% current as changes are made periodically to the reserve list.

**Secondary articles** (use to cite general principles) These are review articles on the basic properties of actin: g and f, isotypes and their distribution, changes in cancerous cells, etc.

Chhabra and dos Remedios 1998 Actin: An Overview of Its Structure and Function

-- must be referenced as book chapter

Lambrechts et al. 2004 The Actin Cytoskeleton in Normal and Pathological Cell Motility

Mitchison and Cramer 1996 Actin-Based Cell Motility and Cell Locomotion

Olson and Sahai 2009 The actin cytoskeleton in cancer cell motility

Pollard and Cooper 2009 Actin, a Central Player in Cell Shape and Movement

Rabinovitz and Simpson 2006 The Actin Cytoskeleton and Metastasis -- book chapter

Vignjevic and Montagnac 2008 Reorganization of the dendritic actin network during cancer cell migration and invasion.

Wang et al. 2007 Antibody Structure, Instability, and Formulation

-- has molecular weight of antibody heavy and light chain

**Primary articles** (use to cite specific results) These articles are studies of the levels of actin levels, forms (g or f), cellular distribution, etc., on cell motility and metastasis.

Jahn et al. 2008 Correlative fluorescence and transmission electron microscopy: an elegant tool to study the actin cytoskeleton of whole-mount (breast) cancer cells

Kobayashi, et al. 1993 Expression of Alpha-Smooth Muscle Actin in Benign or Malignant Ovarian Tumors.

Kislauskis, et al. 1997  $\beta$ -Actin Messenger RNA Localization and Protein Synthesis Augment Cell Motility

Leavitt, et al. 1987 Expression of Transfected Mutant Beta-Actin Genes: Alterations of Cell Morphology and Evidence for Autoregulation in Actin Pools

Okamoto-Inouea, et al. 1999 The induction of smooth muscle alpha-actin in a transformed rat cell line suppresses malignant properties in vitro and in vivo.

Natali et al. 1984 Heterogeneous distribution of actin, myosin, fibronectin and basement membrane antigens in primary and metastatic human breast cancer

Nowak, et al. 2005 Beta-Actin in Human Colon Adenocarcinoma Cell Lines with Different Metastatic Potentials

Peckam, et al. 2001 Specific Changes to The Mechanism of Cell Locomotion Induced by Over Expression of  $\beta$ -Actin

Rao, et al. 1991 Cellular F-Actin Levels as a Marker for Cellular Transformation: Correlation with Bladder Cancer Risk

Sadano, et al. 1990 Newly Identified Type of Beta Actin Reduces Invasiveness of Mouse B16-Melanoma

Uzquiano, et al. 2008 Metastatic Basal Cell Carcinoma Exhibits Reduced Actin Expression

Verschuereen, et al. 1994 Metastatic Competence of Bw5147 T-Lymphoma Cell Lines is Correlated with In Vitro Invasiveness, Motility and F-Actin Content.

# How to write an Introduction section

## Objectives

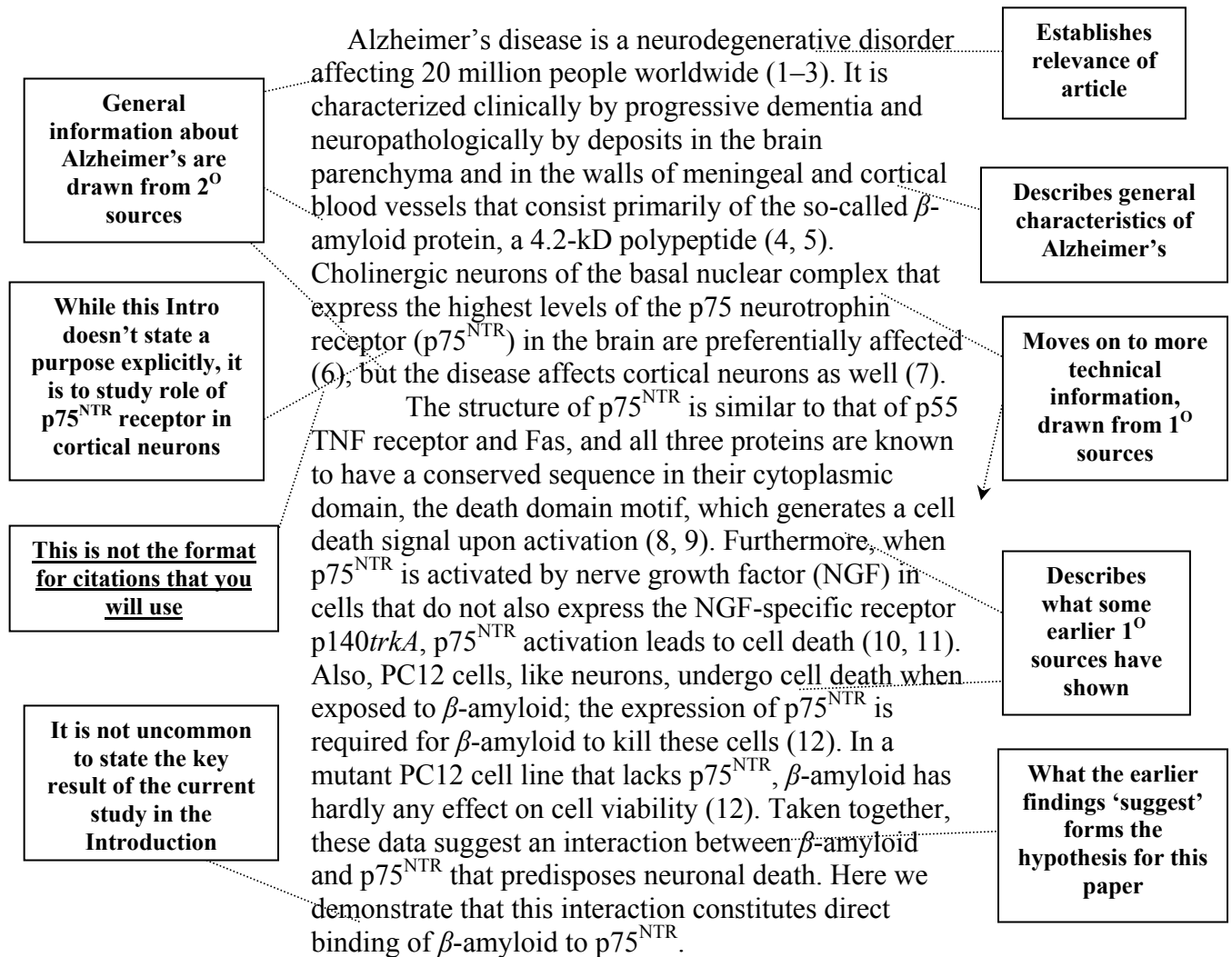
The objectives of this assignment are for you to learn how to write a properly formatted Introduction section organized from general and specific topics pertinent to the experimental topic and citing appropriately from literature sources.

### These are the Writing Conventions that you will be expected to follow:

- A. **Include only information directly pertinent to the topic of the current investigation.** An Introduction Section it is not a general essay on the subject, but rather should present topics and previous studies necessary to understand the objectives of the study and interpretations of the results.
- B. **Organized information from general to specific topics;** i.e., from those topics that deal with broad relevance (to establish why anyone should care about the research), and progressively move to topics more related to the actual system used and properties examined.
- C. **Literature sources.**
  1. **Your text should be fully cited.** Sources of information must be cited in the text and referenced in a Literature Cited section.
  2. **Citations and references must be formatted correctly.** Follow the formats introduced in the Intro Biology courses and summarized in the Citations and References section of this manual. Citations must be accurate to reference and page number.
  3. **Use source literature appropriately:**
    - **Primary sources** should be used when citing findings/results/interpretations of the article being cited. Do not cite very general information from a primary article on some esoteric subject. Primary sources typically are used to let the reader know about earlier studies pertaining closely to the current investigation, highlighting controversies and contradictions, and establishing what is known, not known, and/or unresolved.
    - **Secondary sources** should be used for general information about the subject of your investigation.
    - **Tertiary sources** (textbooks, etc), web pages and HTML articles (i.e., non-pdf) are not acceptable reference materials.

## Sample Introduction section

You should always think about the topics covered in the Introduction section of 1<sup>o</sup> articles that you read. The following is an annotated introduction from a 1<sup>o</sup> article. It is rather brief (much briefer than yours will be), which is typical of articles published in scientific journals. In a highly concise form it illustrates many of the characteristics of a well-written Introduction section.



Yaar M, Zhai S, Pilch PF, Doyle SM, Eisenhauer PB, Fine RE, Gilchrest BA. 1997. Binding of  $\beta$ -amyloid to the p75 Neurotrophin Receptor Induces Apoptosis. A Possible Mechanism for Alzheimer's Disease. *Journal of Clinical Investigation* 100(9): 2333–2340.

**This is a commented example of a partial Introduction section highlighting key components (citations and literature cited section not included).**

**Begins by establishing relevance**

Genomic integrity is an important indicator of the progression of a cancerous state or other cellular abnormalities ( ). DNA integrity can be assessed through DNA sequence, restriction fragment, or through karyotype analysis ( ). Karyotype analysis is the preferred method for determining major chromosomal abnormalities, including chromosome duplications deletions and translocations ( ).

**Information sources are thoroughly cited**

A karyotype is prepared using M-phase chromosomes from dividing cells that are stained to allow chromosome identification and analysis. Cells to be analyzed can be obtained from serum, normal tissue, or tumor ( ). In most cases, the cells are grown under culture conditions that foster cell replication, and arrested in mid-mitosis, and the used to prepare chromosome spreads on microscope slides. Although a variety of novel staining procedures are now being employed ( ), the Giemsa is the most widely used stain for routine chromosome analysis.

**The Introduction begins with the broadest most general subjects and leads to more focused ones.**

Giesma staining yields distinctive mildly bands on chromosomes that have been suitably prepared and mildly trypsinized, and the dark staining bands are believed to represent regions of high AT density ( ). Homologous chromosomes can be distinguished by comparing the banding pattern along with other chromosomal characteristics including total size and centromere position ( ).

**The paragraph introduces the experimental system used in the investigation.**

The murine B16 melanoma is one of the most widely used model systems for cancer research, and has been maintained in culture through sequential passaging for over 50 years ( ). Many investigations have shown that cells maintained in culture over long time periods can accumulate extensive chromosomal abnormalities, and thus may not well model properties of naturally occurring tumor cells. Yet, the genomic integrity of the B16 melanoma has not been investigated in recent years ( ), and may have deteriorated significantly.

**Paragraphs are well-structured with an suitable topic sentence, and a ending segue sentence**

**The rationale for the study is presented here.**

**The final paragraph conveys some specific but key information about the cells used.**

The current investigation characterized the karyotype of B16-F10 cells (ATCC 12432) recently obtained and grown briefly in cell culture.

**This sentence conveys the purpose and hypothesis.**





## Results Section

- **Read “How to prepare Figures, Tables and Legends”**
  - you will be expected to format Figures and Tables as explained and illustrated in the examples
- **Read “How to write a Description of Results section”**
  - you are expected to apply the writing skills learned for the previous results section, while applying the specific conventions described for electrophoresis and immunoblotting data.

### **1. Figures and tables to be included:** (Make sure figures and table are formatted correctly)

- Results for electrophoresis and immunoblotting (raw image will be provided)
- MW standard curve with trendline.
- Table of three protein bands analyzed, average MW

### **2. Description of Results should include:**

- For amido black stained membrane, describe of the quality of the electrophoresis and electroblotting procedure (i.e., did the samples run straight, are bands well resolved, are there any anomalies in the lanes, etc.)
- Identify the key bands appearing on the immunoblotted nitrocellulose, describing clearly in which tissues and with which treatments the bands appear.
- Describe the relative intensities of the key bands in the immunoblot.
- Describe results for all controls, stating “(results not shown)” where appropriate.
- Description of the MW standard curve
- MW data presented in the Table.

# How to prepare Figures, Tables and legends, and write a “Description of Results”

## Objectives

You are to learn how to properly format Figures and Tables with suitable legends to present data and allow trends in the data to be visualized.

## All Figure & Table legends should include:

1. **Figure # (or Table #)** – data should be presented in a logical order.
2. **Brief declarative title** – a declarative statement naming the data
3. **General overview of methodology** – this should include only enough procedure as is necessary for the reader to interpret the data; technical details are presented only in the Procedures Section.
4. **Data series identification** – Traditionally this is done in the legend, but for graphs the Excel symbol legend can be used, but is included only if there is more than one data series.

## Formatting of line graphs

- Most commonly in Excel you will use an ‘X-Y Scatter Graph’. Unless specifically instructed otherwise, always include data-point markers with a connecting line. One exception is data with a trendline, in which case the point-to-point line can be eliminated.
- Have the independent variable on the x-axis
- Eliminate grid lines
- Make background white (eliminate gray)
- Lines and symbols should only use dark colors; absolutely no light colors
- Axes are labeled (with units in parentheses)
- Include symbol legend only if more than one data series
- Delete the Excel-generated title, since the title will be located in legend

## Formatting of histological images

- Images should be well photographed: good quality sections, focused, with correct white balance.
- Arrows and letters should:
  - be only black or white
  - have should have sufficient contrast with background
  - be large/bold enough to be clear, but not excessively so
- Scale bars should be properly proportioned for the image

## Formatting of Electrophoresis results

- Lanes are number sequentially and independently of the original sample-well numbers
- Molecular weights of protein standards are identified
- Peptides “of interest” are identified with arrows and letters

## Example Description of Results and Figures/Tables

In these examples, Description of Results are given for each Figure or Table; however, in your reports, Description of Results for all data is written as a single section.

### Example Line Graph & Description of Results

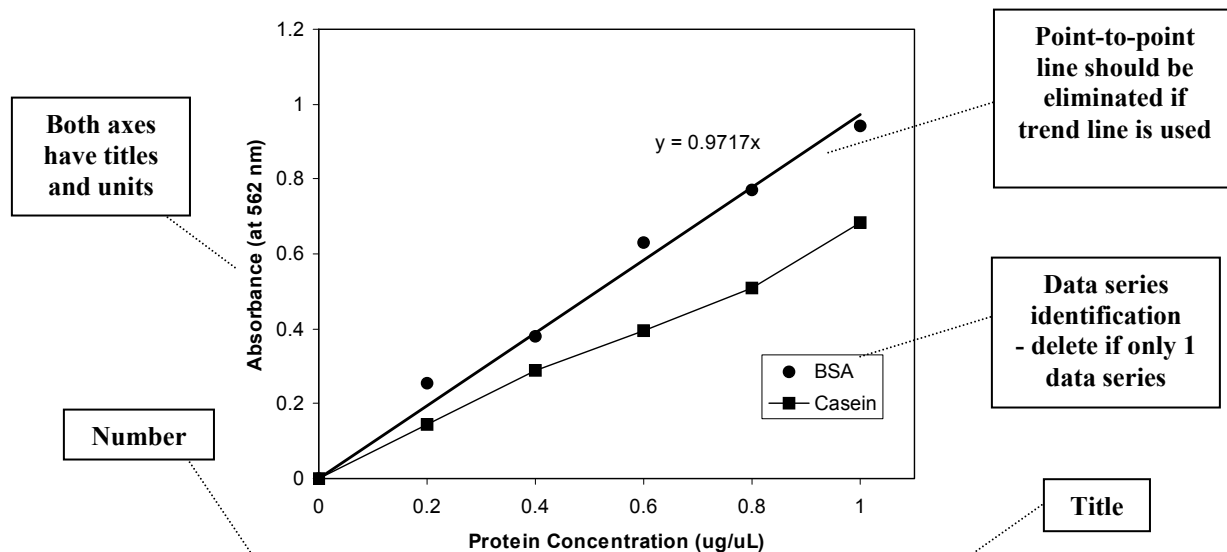


Figure 1. Bradford reagent standard curves for Bovine Serum Albumin (BSA) and Casein. Protein samples were assayed using the BCA reagent. A regression trendline for the BSA data was drawn through the origin and its equation was used to calculate protein concentration in tissue homogenates.

### Sample “Description of Results”

The results for the protein standard curve are presented in Figure 1. BSA or casein standard proteins were measured with the Bradford reagent with measurements taken at 495 nm after 30 minute incubation period. The reagent produced a bluish color for both proteins. A linear relationship was observed for both proteins; and absorbance measurements ranged from 0 (for the control) to 0.73 and 0.96 for 1 ug/ul casein and BSA, respectively. A trendline generated for the BSA data yielded a slope of 0.9127 and an  $R^2$  value of 0.9674.

Note: In the Discussion Section, one might explain that although a linear relationship was observed in its reaction with both proteins, the Bradford Reagent was more sensitive to BSA than to casein. – this is interpretation of the results.

## Example Table & Description of Results

		<u>Average number of cell junctions</u>				
		<u>CDMEM + Glu</u>		<u>CDMEM - Glu</u>		
		Desmosomes	Adheren junctions	Desmosomes	Adheren junctions	
Title	Cell type	B16	6*	4	12*	4
	MC7	7	3	8	2	

Table 1. Cell adhesions in B16 and MC7 cell lines. Cell were grown in for 3 days on coverslips in CDMEM with or without 4 mM glutamine. Adhesion points were detected with either anti-Desmin or anti-cadheren-E antibodies. Results represent averages for 8 cells counted on each of 6 slides (n = 48) for each treatment. Values marked with an \* were statistically significant at the 0.05 level.

Table headings are neatly formatted

Column values centered

Title

Procedure summary

Number

Other information necessary to understand the data

Topic sentence

### Sample “Description of Results”

The effects of glutamine on formation of cell-cell junctions was studied for both cell lines (Table 1). After culturing the cells for 3 days in the presence or absence of glutamine, junction points were detected with fluorochrome –labeled antibodies. Overall, only about 30% of the cells showed cell-cell contact (data not shown), and only these cells were used in the analysis. The number of adheren junctions was similar for both cell types under both conditions. However, there was a statistically significant greater number of desmosomes between B16 cells grown in the presence of glutamine. Glutamine caused a doubling of the number of desmosomes in the B16 cells, but had no detectable effect on the MC7 cells.

Procedure summary

Pertinent results not presented in table

Description of key values and Trend

Note: The discussion section would be the appropriate place to discuss why glutamine may have the observed effect in desmosomes in B16 cells, and how these findings relate to earlier studies – this is **interpretation** of the results.

## Example Electrophoresis & Immunoblotting Results & Description of Results

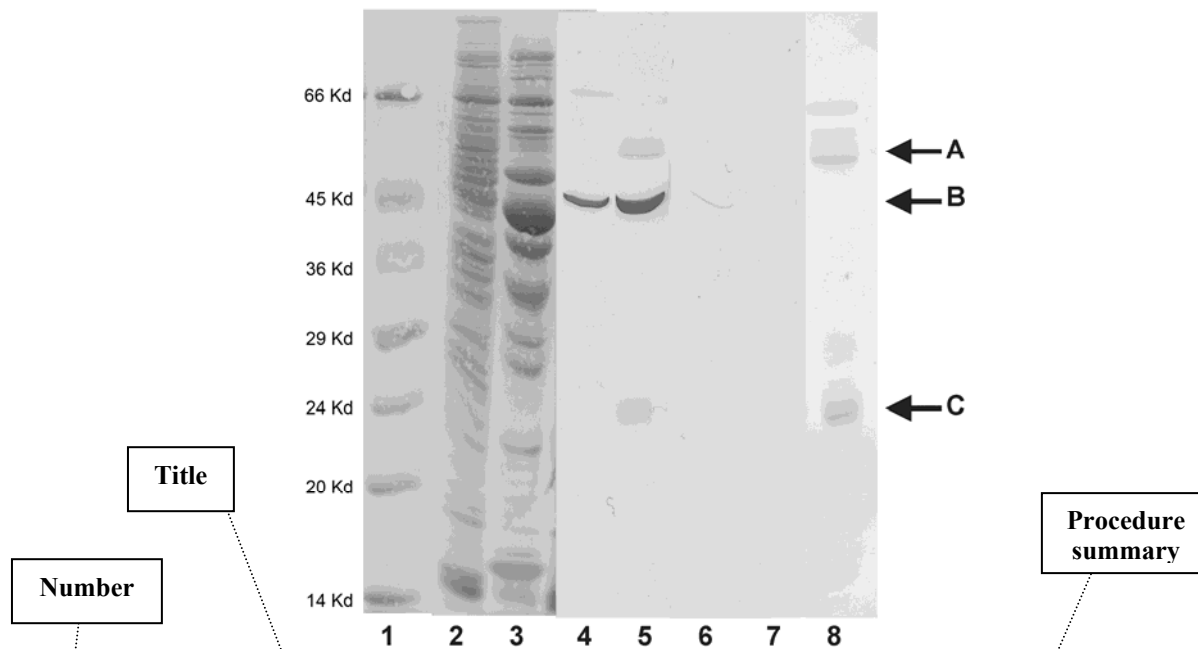


Figure 1. Results for Electrophoresis and Immunoblotting experiments. Samples were resolved by SDS-PAGE, electroblotted to nitrocellulose, and then probed with anti-xxx antibody and peroxidase conjugated secondary antibody. Lanes 1 – 3, amido black stained nitrocellulose; Lanes 4 and 5, probed with primary and secondary antibodies; lanes 6, no primary antibody; lane 7, no secondary antibody; lane 8, preimmune serum. Lane 1, molecular weight standards; lanes 2, 4 and 6, kidney homogenate; lanes 3, 5, 7 and 8 liver homogenate. Arrows identify bands subjected to further analysis.

When describing results, clearly identify samples

### Sample “Description of Results”

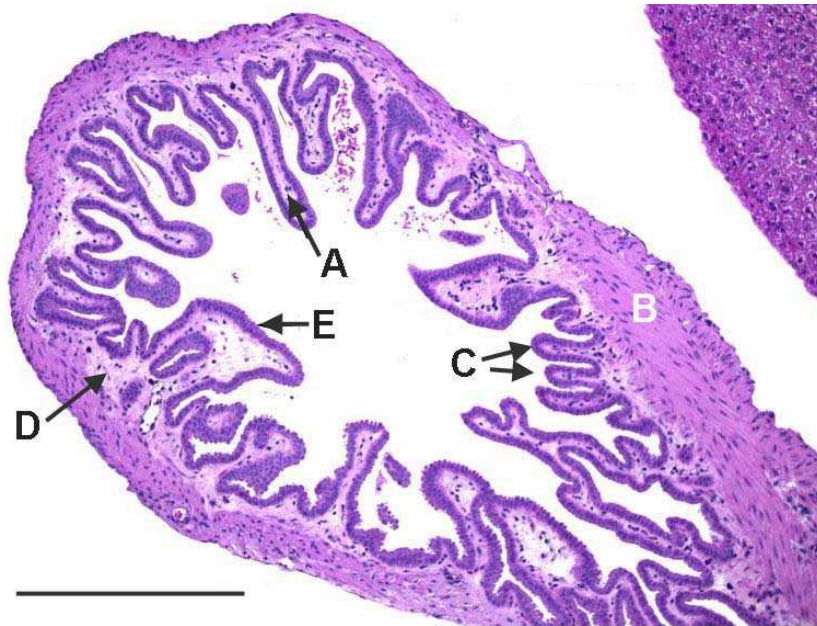
The electrophoresis and immunoblotting results are shown in Figure 1. Minor distortion of protein bands was observed in amido black stained kidney (lanes 2) and liver (lane 3) samples, although the MW standards (lane 1) resolved well and yielded a relatively linear standard curve (Figure 2). A protein band (‘B’) reactive with xxx-antibody was observed in both kidney (Figure 1, lane 4) and liver (lane 5) homogenates, and was more intense in the liver sample. Band ‘B’ did not appear in kidney sample processed without primary (lane 6) or liver sample processed without secondary antibodies (lane 7). Several other faint bands (‘A’ and ‘C’) also appeared in the immunoblotted samples including the liver probed with preimmune serum (lane 8), except for the controls processed without primary (lane 6) or secondary (lane 7) antibodies.

Data series identification

Significant results are described thoroughly, identifying samples and lanes

Note: In the Discussion Section, one might explain how the controls support the conclusion that XXX protein occurred in the tissues, possible explanations for the faint bands that appeared, and the biological significance of the presence of RAS protein in these tissues, and more RAS protein in the liver homogenate.

## Example Histology Image & Description of Results



Title

Number

Procedure  
summary

Figure 1. Mouse gall bladder longitudinal section. Tissue was fixed with 10% formalin, paraffin embedded, and sectioned at a thickness of 5  $\mu\text{m}$ . The section was stained with H & E and photographed under the 10x objective. Scale bar equals 100  $\mu\text{m}$ . A, lamina propria; B, muscular layer; C, mucosal folds; D, submucosa; E, epithelium.

Data series  
identification

**Magnification.**  
While it is OK to state the lens used, the magnification is only given as the scale bar.

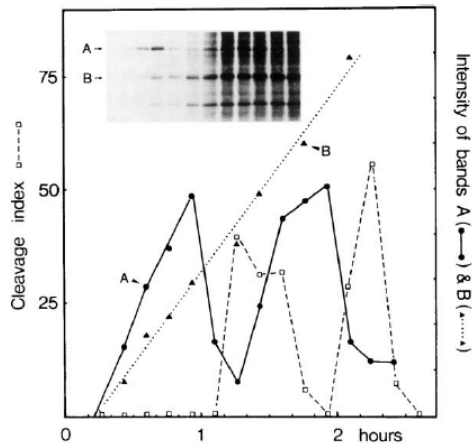
### Sample “Description of Results”

Figure 1 shows an H & E stained section of mouse gall bladder. Identifiable in the section were mucosal folds consisting of light staining lamina propria surrounded by a more darkly stained epithelium, which was underlain by a pinkish staining submucosa. The muscular layer stained more strongly with eosin, hematoxylin-stained nuclei.

## Literature example

The figure and legend and description below are from the classic paper by Evans et al. (Cell 33: 389-396, 1983) in which they first describe the occurrence of cyclin proteins in sea urchin eggs.

### Original Figure and legend



### Figure number

### Title

**Figure 2. Correlation of the Level of Cyclin with the Cell Division Cycle.** A suspension of eggs was fertilized, and after 6 min,  $^{35}\text{S}$ -methionine was added to a final concentration of 25  $\mu\text{Ci/ml}$ . Samples were taken for analysis on gels at 10 min intervals, starting at 16 min after fertilization. Samples were taken 20–30 sec later into 1% glutaraldehyde in calcium-free artificial seawater for later microscopic examination; the cleavage index is shown thus,  $\square$ ---- $\square$ . The auto-radiograph shown as an inset was scanned to yield the data plotted thus: cyclin,  $\bullet$ ---- $\bullet$ ; protein B,  $\blacktriangle$ ---- $\blacktriangle$ .

### Data series identification

**General overview of methodology.**  
In some journals, lots of specific procedural details are placed in the Figure legends. This is more than you would include in your legends.

### Part of original description of results for Figure 2

**Some procedural information is given,** but only enough to allow the reader to understand how the results relate to a particular experiment.

Figure 2 correlates the oscillations in the level of cyclin with the cleavage cycle. The experiment was conducted in the same way as the previous one, except that additional samples from the suspension of fertilized eggs were fixed in 1% glutaraldehyde for later examination under the microscope. Label accumulates more or less linearly in protein B, whereas cyclin (band A) falls precipitously at the onset of cleavage, only to rise and fall again during the second cell cycle. Label in protein C also rose linearly, but the data have been omitted from this figure for clarity.

**Topic sentence.**

**Only trends in the data are described.**  
Interpretation of the data is left for the Discussion Section.





## Discussion section

- Read “How to write a Discussion section”.
- State conclusions relative to purpose and hypothesis given in the Introduction section.

### Explanation of Results section:

- What is the evidence that the band you observed was indeed  $\beta$ -actin. Explain how the controls support your conclusion; Cite and reference appropriate sources explaining the types of actin in different tissues (Sheterline et al., 1998; Chhabra and dos Remedios, 1998) and for the MW of  $\alpha$ -actin (Chhabra and dos Remedios, 1998) in the library reserve list for Biol 309.
- Explain the identity of other bands that appeared in the immunoblot. You can find the MWs of heavy and light chains of antibodies in (Wang et al. 2007) in the library reserve list for Biol 309).
- Explain the significance in the different sizes of the bands in regards to different amounts of  $\beta$ -actin in liver and B16, and explain how this relates to the hypothesis stated in the Introduction section.
- Explain what previous studies have shown about  $\beta$ -actin expression in cancerous cells. You must cite at least three primary sources that have examined relationships between expression of actin and cell motility or metastasis.
- Explain how the results of these previous studies relate to your results –how are the studies similar and/or different (e.g., type/form of actin analyzed, system studied, analytical techniques, etc), demonstrating your understanding of the articles and underlying principles.
- What information (or lack thereof) limits to your ability to draw absolute conclusions.
- Propose a pertinent experimental extension (future experiment) to might address the limitations.
- Do not forget a Literature Cited section with properly formatted references.

# How to write a Discussion section

## Objectives

**These are the Writing Conventions that you will be expected to follow:**

The Discussion should include the following labeled subsections:

### Conclusions

- A. Begin by restating the purpose and hypothesis of your study.
- B. In a sentence or two, state whether the hypothesis is supported by the results or not.
- C. Identify any other conclusions pertaining to the hypothesis based upon the results of the experiment.

### Explanation of Results

- A. This represents the longest part of the Discussion.
- B. Interpret and draw conclusions for the experimental results, and explain how each control supports (or not) those interpretations. Discussion of controls should focus on how each rules out alternative explanations.  
Explain your results in context of literature sources directly pertinent to your results. This how you demonstrate your understanding of the articles you've read and the concepts related to the subject of the investigation. Explain:
  1. where/how results/conclusions in the other articles agree or disagree with each other and with your results.
  2. why the results may be different? Are the systems different? Are the methodologies different?
  3. what are weakness/limitations of the other articles or your own procedures. Are there missing controls?
- C. What specifically do your results, and others that agree, suggest about the subject being investigated. Cause/effect relationships or correlations might be described here. If your results did not support your hypothesis, then you should attempt to explain the discrepancy based upon scientific principles.
- D. Do not assume that your results are wrong and merely write about possible sources of error. An incorrect hypothesis will not tarnish your lab report, so a thorough discussion of what your results tell you about the biological system you are studying is still the appropriate explanation of the results.

### Future experiment

- A. In no more than two paragraphs, explain how another experiment might help to answer questions raised by the current experiment.
- B. Usually, the results of one experiment provide the basis for future related experiments, possibly in which other variables are studied. Be sure to state the PURPOSE of the future experiment, but do not include a lengthy, detailed description of procedures.

## Sample Discussion Section

This is an extract of a discussion section from an article:

[Although you must do so, explanation, conclusions and future experiments are typically not separated into distinct subsections in scientific articles.]

### Discussion

The movement system described here has several features that make it an attractive and simple movement assay for *in vitro* studies of actin-myosin interactions. The most important feature of this assay is that it gives rapid, quantitative, and reproducible myosin movement data from small samples of purified proteins. This movement does not depend on the presence of accessory factors other than the fluorescent phalloidin used to stabilize and visualize the actin filaments. Hence, this assay offers the opportunity to examine the direct effects of modifications of either actin or myosin or of added factors on the movement process.

While the advantages of this new *in vitro* movement assay over the biochemically undefined *Nitella*-based assay are clear, various other methods have been described that have demonstrated movement in systems consisting of purified actin and myosin or its subfragments (1-6). The specific advantages offered by the system described here are (i) that the movement is confined to a plane, which eliminates the possibility of parallax error in measuring rates; (ii) that it does not require unusual buffer conditions, such as those necessary to observe movement in super precipitation experiments; and (iii) that the molecules themselves are observed to move, rather than the bulk medium or attached objects.

We hope to use this system along with methods of molecular genetics to identify those aspects of actin and myosin structure that are important for coupling ATP hydrolysis to movement and to localize the regions of mobility in the myosin molecule responsible for movement and force generation. To this end, we plan to use site-directed mutagenesis of the cloned genes for *Dictyostelium* actin (23) and myosin (24) to generate modified proteins by expression in an appropriate host cell. These expressed proteins can then be characterized by a variety of techniques, including this *in vitro* movement assay.

Kron SJ and Spudich JA. 1986. Fluorescent actin filaments move on myosin fixed to a glass surface. *Biochemistry* 83: 6272-6276.

Implications  
of results

Note that  
there is no  
referencing of  
Figures in the  
Discussion

Relationship  
to and  
comparison  
with previous  
research

Future  
experiments

Statement  
of  
Conclusions

Refer to the  
results that you  
have previously  
described, but  
do not cite  
figures and  
tables in the  
Discussion  
Section

Note  
organization  
of topics and  
good use of  
topic sentences



# Citations and the Literature Cited Section

More complete discussion of Citations and References is included in the “Guidelines for Writing Lab Reports” from the Biol 105 lab manual.

## Citations

Biology Department requires the following format for all assignments.

(Author(s), year of publication, page #)

If the source has **a single author**, then the citation is written as: (Smith, 1992, 97)

If the source has **two authors**, then the citation is written as: (Smith and Jones, 1997, 184)

If the source has **three or more authors**, the abbreviation ‘et al.’ is used after the first author’s name: (Smith et al., 1997, 184)

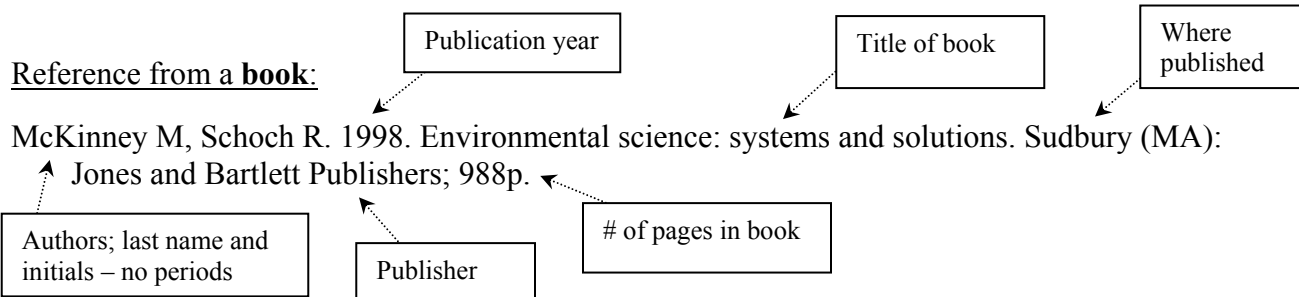
Specific page in article  
on which cited  
information occurs

## References are placed in the Literature Cited section

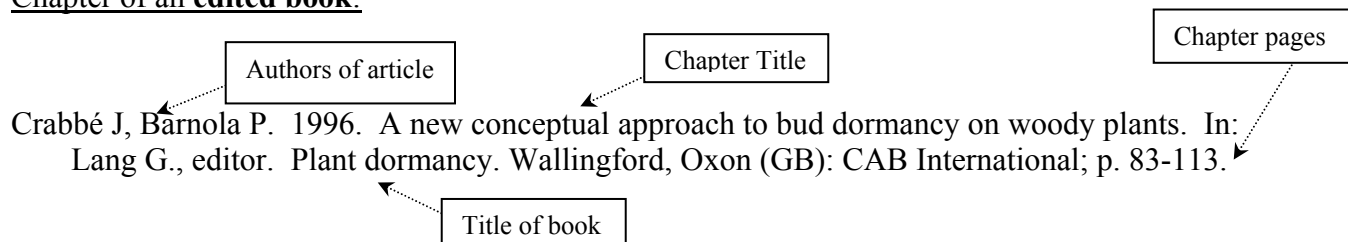
References must be included whenever the text includes citation.

Note: although ‘et al.’ is used in citations, it should *never* be used in the full reference provided in the Literature Cited section; all authors’ names must be listed in the order they occur in the original paper.

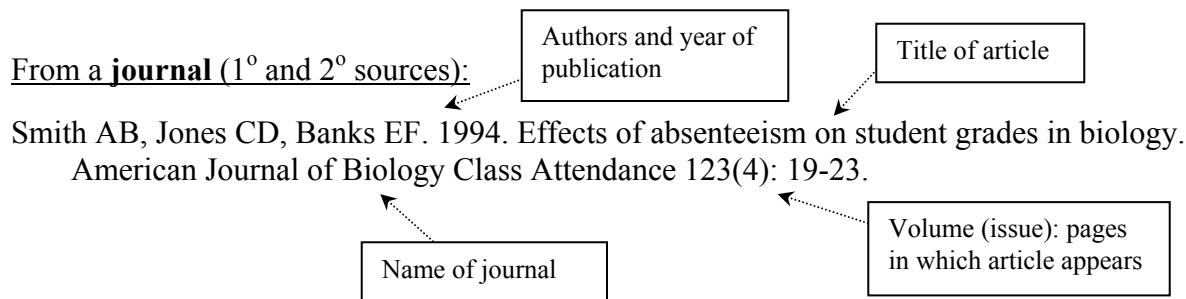
### Reference from a **book**:



### Chapter of an **edited book**:



### From a **journal** (1<sup>o</sup> and 2<sup>o</sup> sources):





Name: \_\_\_\_\_

## **Evaluation of Introduction Section**

Staple this sheet to the back of your report

Quality of writing: grammar, scientific writing conventions, organization, etc:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Range of topics covered in the background information:

|-----|-----|-----|-----|-----|  
insufficient                    some                    well  
                                 deficiencies                    done

Use of literature source material:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Primary and secondary sources used appropriately:    \_\_\_ Yes    \_\_\_ No    \_\_\_ Inconsistent

Primary sources adequately discussed actin in  
context of motility and metastasis:                    \_\_\_ Yes    \_\_\_ No    \_\_\_ Inconsistent

Citations and references

Citations properly formatted:                    \_\_\_ Yes    \_\_\_ No    \_\_\_ Inconsistent

References properly formatted:                    \_\_\_ Yes    \_\_\_ No    \_\_\_ Inconsistent

Citations are accurate:                    \_\_\_ Yes    \_\_\_ No    \_\_\_ Inconsistent

Demonstrates an understanding of concepts:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Displays attention to guidelines and detail:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Other comments:

**Overall quality of report:**

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done





Name: \_\_\_\_\_

## Results Section

Staple this sheet to the back of your report

Figures & tables are properly formatted with suitable legends:

-----	-----	-----	-----
poor	some		well
	deficiencies		done

Results for different tissues and experimental treatments fully described and cited by lane number:

-----	-----	-----	-----
poor	some		well
	deficiencies		done

Calculated values suitable described

Yes  No  Inconsistent

Results for controls adequately described

-----	-----	-----	-----
poor	some		well
	deficiencies		done

Overall, Results section contains sufficient and appropriate information:

-----	-----	-----	-----
poor	some		well
	deficiencies		done

Quality of writing: grammar, scientific writing conventions, organization, etc:

-----	-----	-----	-----
poor	some		well
	deficiencies		done

Displays an attention to guidelines and detail:

-----	-----	-----	-----
poor	some		well
	deficiencies		done

**Overall quality of report:**

-----	-----	-----	-----
poor	some		well
	deficiencies		done



## Discussion Section

Staple this sheet to the back of your report

Discussion section contains sufficient and appropriate information:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Statement of conclusions \_\_\_

Discusses elevated  $\beta$ -actin in B16 \_\_\_

Discusses absence of  $\beta$ -actin in muscle \_\_\_

Meaningful future experiment \_\_\_

Clarity of ideas, apparent understanding of concepts:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Controls adequately interpreted and related to conclusions:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Results adequately discussed in context of literature information

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Comparison between literature sources \_\_\_

Comparisons to lab results \_\_\_

Quality of writing: grammar, scientific writing conventions, organization, etc:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

Displays an attention to guidelines and detail:

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

**Overall quality of report:**

|-----|-----|-----|-----|-----|  
poor                    some                    well  
                                 deficiencies                    done

See rubrics from earlier lab reports

