Universal Rubric for Lab Reports
developed by

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The rubric was developed as a means of measuring how well students are achieving the stated curriculum goals of the USC Biology Curriculum (http://www.biol.sc.edu/undergrad/curriculum.html). The rubric was created and refined in consultation with a wide variety of faculty, instructors and educational specialists, both within and outside the department (see acknowledgements page). The criteria were selected as the minimum framework one would expect to see in any good biology lab report or other scientific communication. The levels of student performance are intended as a roadmap of the probable learning trajectory of a typical undergraduate student. The "Proficient" level describes the performance we would hope an exceptional undergraduate or beginning graduate student would achieve. Instructors are encouraged to select and use only the criteria and levels of student performance that they feel are relevant to their student population and assignment goals. A scoring guide (rubric plus examples of student work at each level of performance) has also been developed and is available upon request. Feedback or comments would be most appreciated if sent to Briana Timmerman at the contact information listed above. The Rubric underwent formal reliability testing (Timmerman *et al.* 2007) producing a three rater reliability score of $g = 0.85$ using biology graduate students as raters and generalizability analysis. Further details are also available from Briana Timmerman.

Please cite as:
Timmerman, B.E., Johnson, R.L. and Payne, J. 2007. Development of a universal rubric for assessing students' science inquiry skills. *National Association of Research in Science Teaching 2007 Annual Meeting* New Orleans LA, April 15-18th

Criteria	Not addressed	Novice	Intermediate	Proficient
Introduction: Context				
Demonstrates a clear understanding of the big picture; Why is this question important/ interesting in the field of biology?	• The importance of the question is not addressed. • How the question relates within the broader context of biology is not addressed.	• The writer provides a generic or vague rationale for the importance of the question. • The writer provides vague or generic references to the broader context of biology.	• The writer provides one explanation of why others would find the topic interesting. • The writer provides some relevant context for the research question(s).	• The writer provides a clear sense of why this knowledge may be of interest to a broad audience • The writer describes the current gaps in our understanding of this field and explains how this research will help fill those gaps
Introduction: Accuracy and relevance				
Content knowledge is accurate, relevant and provides appropriate background for reader including defining critical terms.	• Background information is missing or contains major inaccuracies. • Background information is accurate, but irrelevant or too disjointed to make relevance clear • Primary literature references are absent or irrelevant. May contain website or secondary references **websites or review papers are not primary**	• Background omits information or contains inaccuracies which detract from the major point of the paper. • Background information is overly narrow or overly general (only partially relevant). • Primary literature references, if present, are inadequately explained.	• Background information may contain minor omissions or inaccuracies that do not detract from the major point of the paper. • Background information has the appropriate level of specificity to provide relevant context. • Primary literature references are relevant and adequately explained but few.	• Background information is completely accurate • Background information has the appropriate level of specificity to provide concise and useful context to aid the reader's understanding. • Primary literature references are relevant, adequately explained, and indicate a reasonable literature search.

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Hypotheses: Testable and consider alternatives				
Hypotheses are clearly stated, testable and consider plausible alternative explanations	• No hypothesis is indicated. • The hypothesis is stated but too vague or confused for its value to be determined • A clearly stated, but not testable hypothesis is provided. • A clearly stated and testable, but trivial hypothesis is provided.	• A single relevant, testable hypothesis is clearly stated • The hypothesis may be compared with a "null" alternative which is usually just the absence of the expected result.	• Multiple relevant, testable hypotheses are clearly stated. • Hypotheses address more than one major potential mechanism, explanation or factors for the topic.	• A comprehensive suite of testable hypotheses are clearly stated which, when tested, will distinguish among multiple major factors or potential explanations for the phenomena at hand.
Hypotheses: Scientific merit				
Hypotheses have scientific merit.	• Hypotheses are trivial, obvious, incorrect or completely off topic.	• Hypotheses are plausible and appropriate though likely or clearly taken <u>directly</u> from course material.	• Hypotheses indicate a level of understanding beyond the material directly provided to the student in the lab manual or coursework.	• Hypotheses are novel, insightful, or actually have the potential to contribute useful new knowledge to the field.

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Methods: Controls and replication				
Appropriate controls (including appropriate replication) are present and explained. If the student designed the experiment:	• Controls and/ors replication are nonexistent, • Controls and/or replication may have been present, but just not described or • Controls and/or replication were described but were inappropriate.	• Controls consider one major relevant factor • Replication is modest (weak statistical power).	• Controls take most relevant factors into account • Controls include positive and negative controls if appropriate • Replication is appropriate (average sample size with reasonable statistical power).	• Controls consider all relevant factors • Controls have become methods of differentiating between multiple hypotheses. • Replication is robust (sample size is larger than average for the type of study).
If the instructor designed the experiment:	• Student fails to mention controls and/or replication or mentions them, but the description or explanation is incomprehensible.	• Student explanations of controls and/or replication are vague, inaccurate or indicate only a rudimentary sense of the need for controls and or replication	• Student evidences a reasonable sense of why controls/ replication matter to this experiment • Explanations are mostly accurate.	• Explanations of why these controls matter to this experiment are thorough, clear and tied into sections on assumptions and limitations
Methods: Experimental design				
Experimental design is likely to produce salient and fruitful results (tests the hypotheses posed.) Methods are:	• inappropriate • poorly explained / indecipherable	• appropriate • clearly explained • drawn directly from coursework • not modified where appropriate	• appropriate • clearly explained • modified from coursework in appropriate places • or drawn directly from a novel source (outside the course)	• appropriate • clearly explained • a synthesis of multiple previous approaches or an entirely new approach

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Results: Data selection				
Data are comprehensive, accurate and relevant.	• Data are too incomplete or haphazard to provide a reasonable basis for testing the hypothesis	• At least one relevant dataset per hypothesis is provided but some necessary data are missing or inaccurate • Reader can satisfactorily evaluate some but not all of writer's conclusions.	• Data are relevant, accurate and complete with any gaps being minor. • Reader can fully evaluate whether the hypotheses were supported or rejected with the data provided.	• Data are relevant, accurate and comprehensive. • Reader can fully evaluate validity of writer's conclusions and assumptions. • Data may be synthesized or manipulated in a novel way to provide additional insight.
Results: Data presentation				
Data are summarized in a logical format. Table or graph types are appropriate. Data are properly labeled including units. Graph axes are appropriately labeled and scaled and captions are informative and complete. Presentation of data:	• Labels or units are missing which prevent the reader from being able to derive any useful information from the graph. • Presentation of data is in an inappropriate format or graph type • Captions are confusing or indecipherable.	• contains some errors in or omissions of labels, scales, units etc., but the reader is able to derive some relevant meaning from each figure. • is technically correct but inappropriate format prevents the reader from deriving meaning or using it. Captions are missing or inadequate	• contains only minor mistakes that do not interfere with the reader's understanding and the figure's meaning is clear without the reader referring to the text. • Graph types or table formats are appropriate for data type. • includes captions that are at least somewhat useful.	• contains no mistakes • uses a format or graph type which highlights relationships between the data points or other relevant aspects of the data. • may be elegant, novel, or otherwise allow unusual insight into data • has informative, concise and complete captions.

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Results: Statistical analysis				
Statistical analysis is appropriate for hypotheses tested and appears correctly performed and interpreted with relevant values reported and explained.	• No statistical analysis is performed. • Statistics are provided but are inappropriate, inaccurate or incorrectly performed or interpreted so as to provide no value to the reader.	• Appropriate, accurate descriptive statistics only are provided. • Inferential statistics are provided but either incorrectly performed or interpreted or an inappropriate test was used. • Appropriate, correct inferential statistics are provided, but lack sufficient explanation.	• Appropriate inferential (comparative) statistical analysis is properly performed and reasonably well explained. • Explanation of significant value may be limited or rote (e.g. use of $p<0.05$ only)	• Statistical analysis is appropriate, correct and clearly explained • includes a description of what constitutes a significant value and why that value was chosen as the threshold (may choose values beyond $p<0.05$).
Discussion: Conclusions based on data selected				
Conclusion is clearly and logically drawn from data provided. A logical chain of reasoning from hypothesis to data to conclusions is clearly and persuasively explained. Conflicting data, if present, are adequately addressed.	• Conclusions have little or no basis in data provided. • Connections between hypothesis, data and conclusion are non-existent, limited, vague or otherwise insufficient to allow reasonable evaluation of their merit. • Conflicting data are not addressed.	• Conclusions have some direct basis in the data, but may contain some gaps in logic or data or are overly broad. • Connections between hypothesis, data and conclusions are present but weak. • Conflicting or missing data are poorly addressed.	• Conclusions are clearly and logically drawn from and bounded by the data provided with no gaps in logic. • A reasonable and clear chain of logic from hypothesis to data to conclusions is made. • Conclusions attempt to discuss or explain conflicting or missing data.	• Conclusions are completely justified by data. • Connections between hypothesis, data, and conclusions are comprehensive and persuasive. • Conclusions address and logically refute or explain conflicting data • Synthesis of data in conclusion may generate new insights.

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Discussion: Alternative explanations				
Alternative explanations are considered and clearly eliminated by data in a persuasive discussion. Alternative explanations:	• are not provided • are trivial or irrelevant • are mentioned but not discussed or eliminated.	• are provided in the discussion only • may include some trivial or irrelevant alternatives. • Discussion addresses some but not all of the alternatives in a reasonable way.	• Some alternative explanations are tested as hypotheses; those not tested are reasonably evaluated in the discussion. • Discussion of alternatives is reasonably complete, uses data where possible and results in at least some alternatives being persuasively dismissed.	• have become a suite of interrelated hypotheses that are explicitly tested with data. • Discussion and analysis of alternatives is based on data, complete and persuasive with a single clearly supported explanation remaining by the end of the discussion.
Discussion: Limitations of design				
Limitations of the data and/or experimental design and corresponding implications discussed. Limitations:	• are not discussed.	• are discussed in a trivial way (e.g. "human error" is the major limitation invoked).	• are relevant, but not addressed in a comprehensive way • Conclusions fail to address or overstep the bounds indicated by the limitations.	• are presented as factors modifying the author's conclusions. • Conclusions take these limitations into account.
Discussion: Significance of research				
Paper gives a clear indication of the significance of the research and its future directions. Future directions and significance of this research:	• are not addressed.	• are vague, implausible (not possible with current technologies or methodologies), trivial or off topic.	• are useful, but indicate incomplete knowledge of the field (suggest research that has already been done or is improbable with current methodologies) • suggest a fruitful line of research, but lack detail to indicate motivations for or implications of the future research.	• are salient, plausible and insightful • suggest work that would fill knowledge gaps and move the field forward.

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Use of Primary Literature				
Relevant and reasonably complete discussion of how this research project relates to others' work in the field (scientific context provided). Primary literature is defined as: - peer reviewed - reports original data - authors are the people who collected the data. - published by a non-commercial publisher.	• Primary literature references are not included.	• Primary literature references are limited (only one or two primary references in the whole paper) • References to the textbook, lab manual, or websites may occur. • Citations are at least partially correctly formatted. Note that proper format includes a one-to-one correspondence between in-text and end of text references (no references at end that are not in text and vice versa) as well as any citation style currently in use by a relevant biology journal.	• Primary literature references are more extensive (at least one citation for each major concept) • Literature cited is predominantly ($\geq$ 90%) primary literatures. • Primary literature references are used primarily to provide background information and context for conclusions • Primary literature references	• Primary literature references indicate an extensive literature search was performed. • Primary literature references frame the question in the introduction by indicating the gaps in current knowledge of the field. • Primary literature references are used in the discussion to make the connections between the writer's work and other research in the field clear • Primary literature references are properly and accurately cited

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Writing quality				
Grammar, word usage and organization facilitate the reader's understanding of the paper. (some elements inspired by the SC State Dept. Education Extended-Response Scoring Guide for English Language Arts.)	• Grammar and spelling errors detract from the meaning of the paper. • Word usage is frequently confused or incorrect. • Subheadings are not used or poorly used. • Information is presented in a haphazard way.	• Grammar and spelling mistakes do not hinder the meaning of the paper. • General word usage is appropriate, although use of technical language is may have occasional mistakes. • Subheadings are used and aid the reader somewhat. • There is some evidence of an organizational strategy though it may have gaps or repetitions.	• Grammar and spelling have few mistakes. • Word usage is accurate and aids the reader's understanding. • Distinct sections of the paper are delineated by informative subheadings. • A clear organizational strategy is present with a logical progression of ideas.	• Correct grammar and spelling. • Word usage facilitates reader's understanding. • Informative subheadings significantly aid reader's understanding. • A clear organizational strategy is present with a logical progression of ideas. There is evidence of an active planning for presenting information; this paper is easier to read than most.

Acknowledgements