Preface

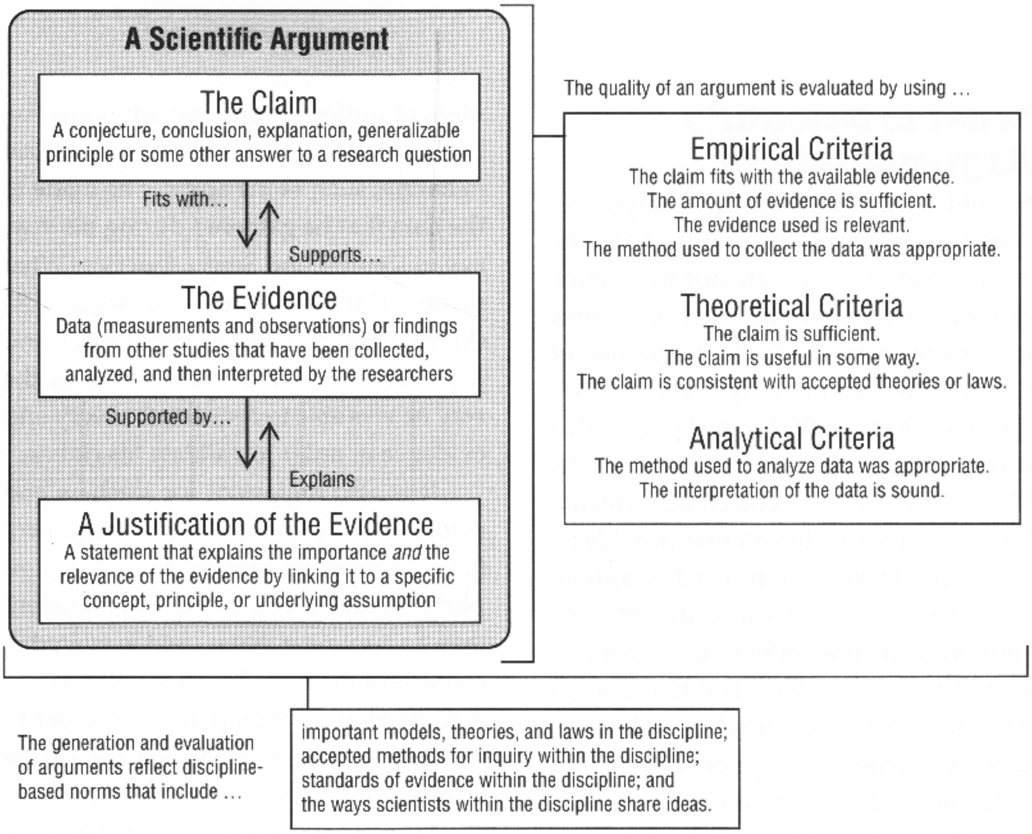
What Is Scientific Argumentation?

Scientific argumentation is an important practice in science. We define scientific argumentation as an attempt to validate or refute a claim on the basis of reasons in a manner that reflects the values of the scientific community (Norris, Philips, and Osborne 2007). A claim, in this context, is not simply an opinion or an idea; rather, it is a conjecture, explanation, or other conclusion that provides a sufficient answer to a research question. The term *reasons* is used to describe the support someone offers for a conclusion. The term *evidence* is often used to describe the reasons used by scientists, especially when the support is based on data gathered through an investigation. Yet reasons do not have to be based on measurements or observations to be viewed as scientific. Charles Darwin, for example, provided numerous reasons in *The Origin of Species* to support his claims that all life on Earth shares a common ancestor, biological evolution is simply descent with modification, and the primary mechanism that drives biological evolution is natural selection. Some of the reasons that Darwin used were theoretical in nature, such as appealing to population theory from Malthus and the ideas of uniformitarianism advocated by Lyell, while others were more empirical in nature, such as the appeals he made to the data that he gathered during his voyage to Central and South America. What made "Darwin's one long argument" (Mayr 1964, p. 459) so convincing and persuasive to others, however, was the way he was able to coordinate theory and evidence in order to validate his claims.

It is also important for teachers and students to understand how an argument (i.e., a written or spoken claim and support provided for it) in science is different than an argument that is used in everyday contexts or in other disciplines such as history, religion, or even politics. In order to make these differences explicit, we use the framework illustrated in Figure 1 (p. x).

In this framework, a claim is a conjecture, conclusion, explanation, or a descriptive statement that answers a research question. The evidence component of the argument refers to measurements, observations, or even findings from other studies that have been collected, analyzed, and then interpreted by the researchers. Biologists, for example, will often examine the data they collect in order to determine if there is (a) a trend over time, (b) a difference between groups or objects, or

Figure 1. A Framework That Can Be Used to Illustrate the Components of a Scientific Argument and Some Criteria That Can and Should Be Used to Evaluate the Merits of a Scientific Argument



(c) a relationship between variables, and then they interpret their analysis in light of their research question, the nature of their study, and the available literature. Finally, the justification of the evidence component of the argument is a statement or two that explains the importance and the relevance of the evidence by linking it to a specific principle, concept, or underlying assumption.

It is also important for students to understand that some forms of evidence and some types of reasons are better than others in science. An important component of scientific argumentation involves the evaluation of the acceptability and

2002). In order to help students develop science proficiency by engaging them in scientific argumentation, however, the focus and nature of instruction inside biology classrooms will need to change from time to time. This change in focus, in part, will require teachers to place more emphasis on "how we know" in biology (i.e., how new knowledge is generated and validated) in addition to "what we know" about life on Earth (i.e., the theories, laws, and unifying concepts). Science teachers will also need to focus more on the abilities and habits of mind that students need to have in order to construct and support scientific knowledge claims through argument and to evaluate the claims or arguments developed by others.

In order to accomplish this goal, science teachers will need to design lessons that give students an opportunity to learn how to generate explanations from data, identify and judge the relevance or sufficiency of evidence, articulate and support an explanation in an argument, respond to questions or counterarguments, and revise a claim (or argument) based on the feedback they receive or in light of new evidence. Science teachers will also need to find a way to help students learn, adopt, and use the same criteria that biologists use to determine what counts as warranted scientific knowledge in a particular field of biology. This task, however, can be difficult for teachers to accomplish given the constraints of a science classroom without the development of new instructional strategies or techniques (Price Schleigh, Bosse, and Lee 2011). We have therefore used the available literature on argumentation in science education (e.g., Berland and Reiser 2009; Clark, Schleigh, and Menekse 2008; McNeill and Krajcik 2008a; Osborne, Erduran, and Simon 2004; Sampson and Clark 2008; Sandoval and Reiser 2004) to develop two different instructional models that teachers can use to promote and support student engagement in scientific argumentation in the biology classroom. We have also designed several stand-alone writing activities that teachers can use to help students learn how to write extended arguments that consist of multiple lines of reasoning that will help solidify their understanding of important biology content as part of the process.

All of these activities are designed so they can be used at different points during a biology course and in a variety of grade levels to help students learn how to generate a convincing scientific argument and to evaluate the validity or acceptability of an explanation or argument in science. In fact, we have used these activities included in this book to engage learners in scientific argumentation in middle school classrooms, high school classrooms, and in science teacher education programs. The activities in this book can also be used to help students understand the practices, crosscutting concepts, and core ideas found in *A Framework for K–12 Science Education* (NRC 2012) and develop the literacy in science skills outlined in the *Common Core State Standards for English Language Arts and Literacy* (NGA and CCSSO 2010).

Development of the Activities

The integration of scientific argumentation into the teaching and learning of biology can be difficult for both the teachers and students. In fact, teachers often ask for specific instructional strategies and engaging activities based on these instructional activities that would allow students to learn how to engage in scientific argumentation as part of the inquiry process (see Sampson and Blanchard, forthcoming). We have also received many requests to help teachers develop the skills in facilitating this kind of activity inside the classroom. We have designed this book to satisfy these requests. This book's instructional strategies and the activities based on these strategies are grounded in not only current research on argumentation in science education (Berland and McNeill 2010; Clark et al. 2008; Driver, Newton, and Osborne 2000; Erduran and Jimenez-Aleixandre 2008; Jimenez-Aleixandre, Rodriguez, and Duschl 2000; McNeill and Krajcik 2008b; McNeill et al. 2006; Osborne, Erduran, and Simon 2004; Sampson and Blanchard, forthcoming; Sampson and Clark 2008, 2009; Sampson, Grooms, and Walker 2011) but also our experiences inside the classroom. Each activity has been field-tested in at least one middle school or high school (see Appendix A, p. 367, for a list of field test sites and teachers). The classrooms we used to test the activities were diverse and represented a wide range of student achievement levels (honors, general, advanced, and so on). We used teacher comments and suggestions to refine the activities and to provide the guidance teachers need to implement the activities as Teacher Notes.

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